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Consideration of Canny Edge Detection for Eye Redness Image Processing: A Review

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Abstract. Eye redness can be taken as a sign of inflammation which may suggest severity and progression of a specific disease. In image processing, there is apportioning a digital image into relevant features in sets of pixels where is called image segmentation. The image that consists of numerous parts of different colors and textures need to be distinguished in this process. In each digital image, the transformation of images into edges was using edge detection techniques. It represents the contour of the image which could be helpful to recognize the image as an object with its detected edges. The Canny edge detector is a standard edge detection algorithm for many years among the present edge detection algorithms. This paper focuses on important canny edge detection for detecting a region of interest (ROI) in eye redness images.

1. Introduction

Eye redness is a symptom that can be associated with a broad group of ocular diseases [1]. The excess of blood vessels with increased diameter may cause an effect in ocular surface [2]. The clinician can diagnose ocular surface clues earlier and the development of validated ocular disease scales can be purified [3-4]. Bulbar redness is the occurrence of an inflammation in a blood vessel in the sclera (white area), which causes conjunctivitis, ocular xerosis, glaucoma, scleritis and keratitis [1]. Pterygium is a wing-shaped, vascular and fleshy growth which encroaches from bulbar conjunctiva and progresses toward central cornea. Pterygium has been established as one of the factors which cause induced-corneal astigmatism, alteration of the anterior corneal parameter, and changes in corneal topography findings. However, based on [5] findings, the exact etiologies of pterygium are still debated.

The manual process that optometrists have to face is tedious, time-consuming, highly subjective, and nonrepeatable [6]. The first step is to obtain an image acquisition of the patient eye. Then, the images must be analyzed in detail, searching for indicators of the symptom, such as the aforementioned red hue. Finally, the optometrist compares the patient's eye with a given grading scale, in order to obtain the final evaluation. Grading scales are collections of images that show the ocular disease grading scales [15-17].

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Segmentation may also depend on various features that are contained in the image. It may be varying by color or texture [7]. Redness can be taken as a sign of inflammation which may suggest severity and progression of a specific disease. Several attempts have been made to quantify redness of the eye and to demonstrate the importance of automating the redness grading which will reduce individual variability due to low inter-grader repeatability [8-9]. A standard objective grading can ensure the reliabilities of the grading as individual variance are still needed to be considered. Subjective grading based on redness is somewhat extremely difficult to reproduce; hence the repeatability also can be questionable [5].

Image analysis techniques are crucial in measuring redness objectively [10]. The advantage of using image analysis method is that we can eliminate the individual variability and bias, which might happen in subjective grading [18-19].

Image processing algorithms involved in many various areas in order to detect the true edges of the image. Hence, edge detection is very crucial tasks in image processing because it might bring the major information contributors to an image. It represents the contour of the image which could be helpful to recognize the image as an object with its detected edges [11]. Among the present edge detection, the Canny edge detector was the best-selected edge detection algorithm. This paper focuses on important canny edge detection for detecting a region of interest (ROI) in eye redness images.

This paper outlines as follows: Image processing in eye redness briefly discussed in section 2. Section 3, shows the eye redness segmentation by applying the canny edge detection and region of interest in eye redness. Finally, section 4 presents the conclusion and potential improvement.

2. Image Processing in Eye Redness

The fundamental development of image processing in eye redness involves five phases which are image acquisition, image pre-processing, image segmentation, description and representation, and recognition and interpretation.

The first phase is image acquisition which needs the real experimental data to be analyzed. The second phase is image pre-processing that will be used to normalize image brightness, correction of non-uniform illumination, reduce noise and reduce image artifacts.

The image segmentation which defined in phase 3 is to partitioning digital image with relevant features where is easier for further process. This process will partition an image into regions or set of pixels. Edge detection and region of interest (ROI) are one of the ways in the segmentation process also known as image analysis. This phase is very tedious and crucial in image processing because it might affect the phase 4 to obtain significant features.

Description and Representation defined in phase 4 involved the most relevant features contributed to an image. In this phase, description is referred to feature extraction process where the feature (color or texture) has been applied to the image. Whilst, Feature selection process where the not relevance features will be eliminated is referred to as representation.

Finally, phase 5, involves the recognition and interpretation that employed the meaningful features created in phase 4. Recognition is assigning to Classification, which is a label to an image. Interpretation is assigning the meaning to an ensemble of the image. In this phase, the experimental image data will be classified according to the eye redness grading scales.

3. Eye Redness Segmentation

As the edge is one of the major information contributors to eye redness image, hence the edge detection is a very important step in many of the image processing algorithms [12]. For the edge detection, eye redness image is given as input and the edge map is obtained as output. It represents the contour of the image, which could be helpful to recognize the image as an object with its detected edges [13]. In the ideal case, applying the edge detector to an image gives the different edges that are connected to form the outline of the object [14].

From the literature by [11], there are three main criteria belongs to canny edge detection:

i) Low error rate: All edges in images should carefully be a response.

ii) Good Localization: Distance between the actual edges found should be minimum.

iii) Single Response: Response to a single edge. The algorithm mainly has five steps [11].
Step 1: A horizontal and vertical gradient can be computed for every pixel in an image.
Step 2: The calculation of each pixel in the images was based on image information in step 1.
Step 3: Non-Maximal Suppression is counted as zero in this step.
Step 4: The gradient magnitude either high or low threshold is depending on histogram calculations.
Step 5: Hysteresis thresholding is used to obtain the weak and strong edges. It is important to measure the proper edge map. Strong edge is referred to superior pixel with high threshold while those pixel whose lays between the weak and high threshold is referred to as a weak edge.

A region of interest (ROI) is a portion of an image defined for further analysis or processing. ROI of pterygium fibrovascular tissue was selected manually and was defined as the visible area of pterygium which is from the limbus to apex of pterygium [5]. Figure 1 shows examples of pterygium ROI in all range of redness grading. Blue lines indicate the pterygium ROI.

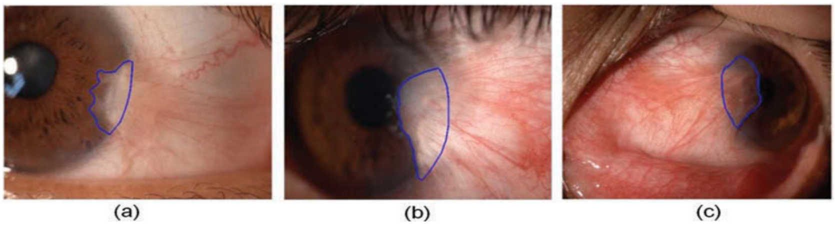
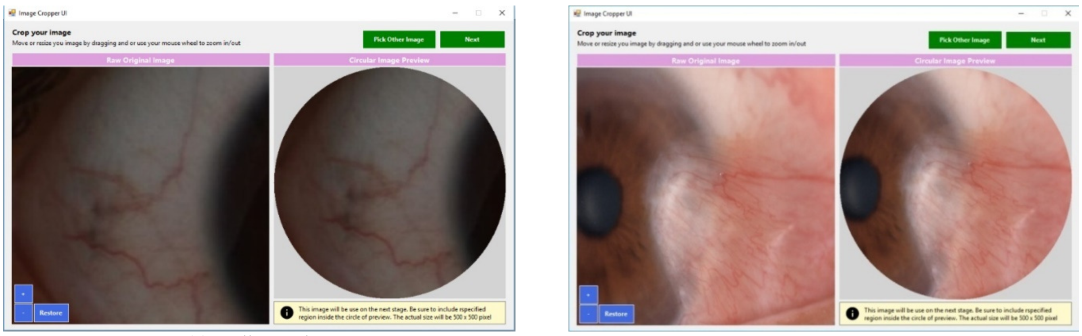


Figure 1. Examples of pterygium fibrovascular tissue. Blue lines indicate the pterygium ROI: (a) Grade 1, (b) Grade 2, and (c) Grade 3 [5].

Figure 2 shows the system to detect ROI. The development of the software is applying platform dot net framework with C# language. The extent of the software will be made for the next phase which is feature extraction and feature selection of the eye redness image.



(a) Bulbar redness ROI (b) Pterygium redness ROI

Figure 2. The system developed to detect ROI

Figure 3 shows the image segmentation of bulbar redness. The first step depicts the original photograph was taken of bulbar redness. Image enhancement and remove noise have been implemented to remove eyelashes and pupil. Next, the canny edge detection has been applied. Strong edge is referred to superior pixel with high threshold while those pixel whose lays between the weak and high threshold is referred to as a weak edge (non-edge). In the final step, the reddish color (dashed rectangle) is the ROI of the eye redness image. The most relevant features will be selected based on the final step.

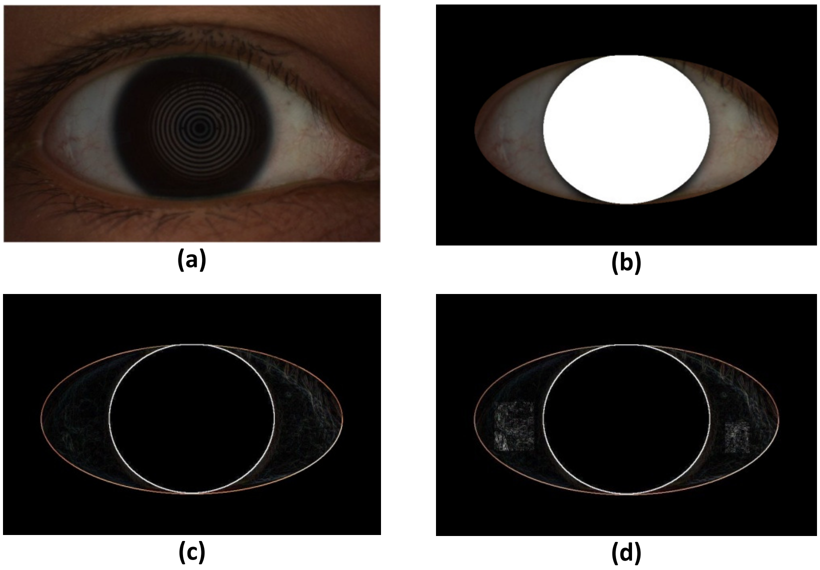


Figure 3. Image segmentation of bulbar redness. (a) Original image of bulbar redness. (b) Image enhancement and remove noise. (c) Illustrates of canny edge detection. (d) Redness color (dashed rectangle) are the ROI area was assessed.

4. Conclusions

The ability of canny edge detection has been widely used in order to extract the ROI of eye redness. Image segmentation leads to partitioning the eye redness images with better edge map. A future line of research will be on the development of improvement in edge detection, feature extraction, and feature selection in order to quantify the redness through most relevant features because it provides much more distinct marked edges and thus has better visual appearance than the standard existing.

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