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A Survey on Retinal Area Detector for Classifying Retinal Disorders from SLO Images

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Abstract

The retina is a dainty layer of tissue that lines the back of the eye within. It is situated close to the optic nerve. The reason for the retina is to get light that the focal point has centered, change over the light into neural flags, and send these signs on to the cerebrum for visual acknowledgment. The retina forms a photo from the engaged light, and the mind is left to choose what the photo is. Since the retina assumes crucial part in vision, harm to it can likewise bring about issues, for example, perpetual visual impairment. So we have to see if a retina is healthy or not for the early discovery of retinal sicknesses. Scanning laser ophthalmoscopes (SLOs) can be used for this purpose. The most recent screening innovation, gives the upside of utilizing SLO with its wide field of view, which can picture a vast part of the retina for better finding of the retinal ailments. On the opposite side, the artefacts, for example, eyelashes and eyelids are additionally imaged alongside the retinal zone, amid the imaging procedure. This delivers a major test on the best way to exclude these artefacts. The current systems has disadvantage that should be engaged. The proposed methodology includes feature extraction and feature matching techniques and construction of classifier to finally detect the retinal area and classifying the retina whether it's healthy or not. The survey presents different techniques that are used to segment the artefacts and detect those artefacts.
Keywords- Feature selection, retinal artefacts extraction, retinal image analysis, scanning laser ophthalmoscope (SLO).

I. INTRODUCTION

Early detection and treatment of retinal eye diseases is critical to avoid preventable vision loss. Conventionally, retinal disease identification techniques are based on manual observations. Optometrists and ophthalmologists often rely on image operations such as change of contrast and zooming to interpret these images and diagnose results based on their own experience and domain knowledge. These diagnostic techniques are time consuming. Automated analysis of retinal images has the potential to reduce the time, which clinicians need to look at the images, which can expect more patients to be screened and more consistent diagnoses can be given in a time efficient manner.

The 2-D retinal scans obtained from imaging instruments [e.g., fundus camera, scanning laser ophthalmoscope (SLO)] may contain structures other than the retinal area; collectively regarded as artefacts. Exclusion of artefacts is important as a pre-processing step before automated detection of features of retinal diseases. In a retinal scan, extraneous objects such as the eyelashes, eyelids, and dust on optical surfaces may appear bright and in focus. Therefore, automatic segmentation of these artefacts from an imaged retina is not a trivial task. The purpose of performing this study is to develop a method that can exclude artefacts from retinal scans so as to improve automatic detection of disease features from the retinal scans.

The works related to differentiation between the true retinal area and the artefacts for retinal area detection in an SLO image are very rare. The SLO manufactured by Optos produces images of the retina with a width of up to 200◦ (measured from the centre of the eye). This compares to 45◦ to 60◦ achievable in a single fundus photograph. Examples of retinal imaging using fundus camera and SLO are shown in Fig. 1. Due to the wide eld of view (FOV) of SLO images. Structures such as eyelashes and eyelids are also imaged along with the retina. If these structures are removed, this will not only facilitate the effective analysis of retinal area, but also enable to register multi view images into a montage, resulting in a completely visible retina for disease diagnosis.

In this study, we have constructed a novel framework for the extraction of retinal area in SLO images. The main steps for constructing our framework include:

- Determination of features that can be used to distinguish between the retinal area and the artefacts;
- Selection of features which are most relevant to the classication
- Classifier construction which can classify out the healthy and unhealthy retina
- Construction of the classifier which can classify out the retinal area from SLO images.
- Determination of features that can be used to distinguish between the healthy and unhealthy retinal area;
- Selection of features which are most relevant to the classication

For differentiating between the healthy and unhealthy retina, we have determined different image-based features which react textural information at multiple resolutions. Then, we have selected the features among the large feature set, which are relevant to the classication. The feature selection process improves the classifier performance in terms of computational time. Finally, we have constructed the classifier for discriminating between the retinal area and the artefacts. Our prototype has achieved average classication accuracy of 92% on the dataset having healthy as well as diseased retinal images. For differentiating between the healthy and unhealthy retina.

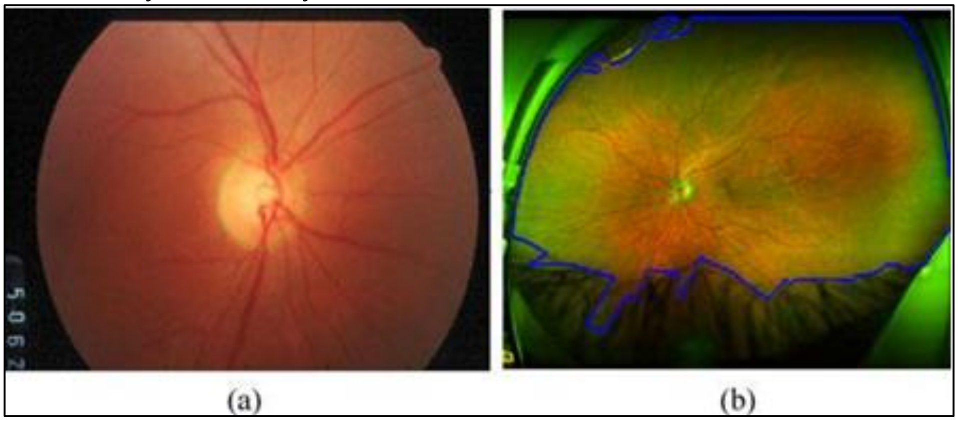

Fig. 1: Example of (a) a fundus image and (b) an SLO image annotated with true retinal area and ONH.

II. RELATED WORKS

Our literature survey is initiated with the methods for detection and segmentation of eyelids and eyelashes applied on images of the front of the eye, which contains the pupil, eyelids, and eyelashes. On such an image, the eyelashes are usually in the form of lines or bunch of lines grouped together. Therefore, the first step of detecting them was the application of edge detection techniques such as Sobel, Prewitt, Canny, Hough Transform and Wavelet transform. .Since eyelashes can be in either separable form or in the form of multiple eyelashes grouped together, Gaussian filter and Variance filter were applied in order to distinguish among both forms of eyelashes [6].

A. Hough Transform

Amit Madhukar Wagh et al. [1] proposes a novel biometric system that is based on human's behavioural and physical characteristics. Among all of these, iris has unique structure, higher accuracy and it can remain stable over a person's life. Iris recognition is the method by which system recognize a person by their unique identical feature found in the eye. Iris recognition technology includes four subsections as, capturing of the iris image, segmentation, extraction of the needed features and matching. Generally, eyelids and eyelashes are noise factors in the iris image. To increase the accuracy of the system we must have to remove these factors from the iris image. Eyelashes detection algorithm can be used for detecting eyelids and eyelashes. To improve the overall performance of the iris recognition system, we can use canny edge detection algorithm. The canny edge detection algorithm first smooth's the image to eliminate noise. Then the image gradients are calculated to point out those regions where the gradient difference is maximum, which have high spatial differences. Finally, it then tracks along these regions and discards any pixel that weakly defines an edge (non- maxima suppression) in order to make the edges thinner. To further reduce the gradient array, it performs hysteresis which tracks along the remaining pixels that have minimum grey level values but have not been suppressed .Then, Hough Transform can be applied on these images to identify the circles of specific radii and lines on iris image. Eyelids and eyelashes detection method is more accurate. This system will reduce the time for detecting the inner and outer edges of the iris with the help of linear Hough transform and circular Hough transform. The major disadvantage is the computation of Gradient calculation for generating the angle of suppression. The main disadvantage is Time consumption because of complex computation.

B. Wavelet Transform

In [3] D. Zhang et.al proposes a novel iris recognition method. In the method, the iris features are extracted using the oriented separable wavelet transforms (direction lets) and they are compared in terms of a weighted Hamming distance. The generated iris Code is binary, whose length is fixed (and therefore commensurable), independent of the iris image, and comparatively short. The novel method shows a good performance when applied to a large database of irises and provides reliable identication and verification. At the same time, it preserves conceptual and computational simplicity and allows for a quick analysis and comparison of iris samples. The iris features are extracted using the oriented separable wavelet transforms (direction lets) and they are compared in terms of a weighted Hamming distance. The iris recognition method consists of the three phases:

Iris region localization: The annular iris region is bounded by two borders :(a) the inner border (with the pupil) and(b)the outer border (with the sclera) feature extraction and encoding: The iris region is analysed using direction lets and the corresponding binary code is generated with a predetermined and fixed length. The extraction algorithm consists of the three parts: (i)altering (or transforming) the original iris image using oriented lters based on the 9-7 wavelet later-bank (ii)sampling the corresponding wavelet coefficients at specified sampling coordinates and (iii) generating a binary code. Feature comparison. In the novel method, the iris localization is adopted from Daugman with few modifications. The novel feature extraction method is based on direction lets. Finally, the feature comparison is computed as the best hamming distance corresponding to relative angular shifts between two iris codes. The method is shift-, size- and rotation-invariant to the iris images. The computational complexity of the method is retained low in all phases. The disadvantage of the method is that feature vectors consist of unbounded real numbers, inconvenient for binary encoding.

C. Histogram Analysis

In [3]D. Zhang et.al proposes a novel iris recognition method. In the method, the iris features are extracted using the oriented separable wavelet transforms (directionlets) and they are compared in terms of a weighted Hamming distance. The generated iris Code is binary, whose length is fixed (and therefore commensurable), independent of the iris image, and comparatively short. The novel method shows a good performance when applied to a large database of irises and provides reliable identication and verification. At the same time, it preserves conceptual and computational simplicity and allows for a quick analysis and comparison of iris samples.The iris features are extracted using the oriented separable wavelet transforms (directionlets) and they are compared in terms of a weighted Hamming distance. The iris recognition method consists of the three phases:

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D. Vector Dierence Matching Algorithm

In [4] Archana V Mire et.al proposes a novel iris recognition technique which uses textural and topological features. Converting circular iris pattern into rectangular pattern makes it rotation invariant. For encoding topological feature Euler vector can be utilized while for encoding textural feature histogram is used. Histogram is matched by using Du measure whose origin belong in Hyper spectral Image Analysis while for matching Euler vector Vector Difference Matching algorithm is developed. To reduce false acceptance rate and false rejection rate two way encoding of iris is performed once by using histogram and other by using Euler number. Both histogram and Euler vector are orientation independent so this approach provides orientation independency to iris encoding and recognition. The disadvantage is that even though the method achieves a low false acceptance rate, the rejection rates have remained high. False rejection rate should be as low as possible to make the iris recognition system more practical and adaptable to diverse applications.

E. 2-D Gabor Filters

In [5] B.J.Kang et.al proposes a human iris recognition system in unconstrained environments in which an effective method is proposed for localization of iris inner and outer boundaries. The proposed method consists of the following steps:

Image acquisition in which the image of the iris is captured. Pre-processing which involves edge detection using canny edge detection, contrast adjustment and multiplier. Segmentation that includes localization of iris inner and outer boundaries and localization of boundary between iris and eyelids Normalization which involves transformation from polar to Cartesian coordinates and normalization of iris image Feature extraction, including noise removal from iris image and generating iris code. The extraction of features is done using the two-dimensional Gabor Filters.

Classification and matching, involving comparing and matching of iris code with the codes already saved in database. The proposed method had a high accuracy rate. The disadvantage is that it reduces the accuracy in finding out the orientation of edges and malfunctioning at the corners, curves, where the gray level intensity function variations.

F. Point Distribution Model (PDM) method

In [6] Marios Savvides et.al proposes a supervised learning approach to investigate regions around eyelashes and extract useful information which helps us to perform ethnic classification. The proposed algorithm is easy to implement and effective. First, we locate eyelash region by using ASM (active shape model) to model eyelid boundary. Second, we extract local patch around local landmarks. After image processing, we are able to separate eyelashes and extract features from the directions of eyelashes. Those features are descriptive and can be used to train classifiers. The algorithm consists of five stages mainly. Firstly Eyelids boundary localization in which Active Shape Model (ASM) is used to recover the eyelid boundaries. The shape model can be obtained from Principal Component Analysis (PCA). This process is known as the Point Distribution Model (PDM), which is a method for representing the mean geometry of a shape and some statistical modes of geometric variation inferred from a training set of shapes. .Then local eyelashes sampling and enhancement and eyelashes direction quantization is done in which we differentiate eyelashes from other parts of the image, like eyelid or sclera. After eyelashes are identified and localized, analysis of their directions are done. Creating global descriptors for eyelashes direction distribution is next step. The classification is done using one-nearest-neighbour (1NN) method. The method has got the high recognition rate. The disadvantage is that the computation time of the proposed method is high. Further the ASM uses the shape constraints and not the texture of the image.

G. Partial Least Square Classifier

In [7] Simon Barriga et.al proposes a system that can automatically determine whether the quality of a retinal image is sufficient for computer-based diabetic retinopathy (DR) screening. The system integrates global histogram features, textural features, and vessel density, as well as a local non-reference perceptual sharpness metric. A partial least square (PLS) classifier is trained to distinguish low quality images from normal quality images. The retinal image quality evaluation system presented here in consists of two main processing phases: feature extraction and PLS classification. Four categories of features are used to evaluate the image quality: histogram features, textural features, vessel density, and local sharpness metrics Partial least squares (PLS) classifier was used to develop a predictor of image quality. PLS is a very powerful method for eliciting the relation ship between one or more dependent variables and a set of independent (predictor) variables, especially when there is a high correlation between the input variables. The same feature when applied to different colour channels tends to be highly correlated even if their magnitudes are quite different. The proposed method has the potential to provide an efficient, objective and robust tool in retinal image quality evaluation for broad screening applications. Partial least squares is preferred as predictive technique and not as an interpretive technique.

H. Rectinal Image Quality Assessment Algorithm

In [8] J. A. M. P. Dias et.al proposes a retinal image quality assessment algorithm based on image quality indicators. Features such as colour and focus are used as quality indicators and are computed using novel image processing techniques. These quality indicators are also classified to evaluate the image suitability for diagnosis purposes. It also evaluates retinal image quality through classification of features derived from generic image quality parameters. The methodology includes pre-process ing,focus assessment algorithm and colour assessment algorithm. The method focuses on the eye vasculature and not on the entire eye structure. It has got 100 % sensitivity and 96% specificity. The disadvantage is that it shows a decrease in accuracy.

I. Feature Matching Algorithm: BRIEF

In [9] Suraya Mohammad, et al. proposes a new method for segmenting the optic disc in retinal images using texture analysis. In this method, optic disc in retinal image is segmented using pixel classification and circular template matching. The pixel property used for classification is based on texture. Two texture measurements were used, Binary Robust Independent Elementary Features (BRIEF) and a rotation invariant BRIEF (OBRIEF). This texture measurement is chosen because it can address the illumination issues of the retinal images and has a lower degree of computational complexity than most of the existing texture measurement methods. This method consists of 3 main steps. Firstly feature extraction in which each pixel from each colour (red, green and blue) channel is transformed into its BRIEF/OBRIEF representations or descriptors. In addition to all the three channels, to ensure the utilization of all the available colour information in the retinal image, combine the BRIEF/OBRIEF descriptor from those separate channels into an RGB descriptor.

To form the RGB descriptor, each descriptor from each channel is concatenated into a single binary string. Secondly the classification in which naive bayes is the selected classifier used to classify each pixel into one of two classes: optic disc and background. Thirdly circular template matching. This last stage is to obtain the final circular approximation of the optic disc.This method has better computational simplicity and also addresses the illumination issue of the retina images by using the illumination invariance texture measurement. Also this method exploit the knowledge of the characteristics of the optic disc in the segmentation process by making the use of machine learning technique. This method also prove to be reliable in segmenting the optic disc. But the problem is that the method prove to be reliable in segmenting the optic disc especially in an image with good contrast around the optic disc boundary and where the blood vessels are not very thick. Also it has high value of classification error rate. The poor performance of this method is observed in images with the presence of severe per papillary atrophy especially when the optic disc boundary is completely missing.

J. Classification Using SVM (Simple Virtual Machine)

In [10] Herbert F. Jelinek et.al proposes a method based upon two-tiered feature extraction (low-level and mid-level) from images and Support Vector Machines. The main contribution of this work is the evaluation of BossaNova, a recent and powerful mid- level image characterization technique, which we contrast with previous art based upon classical Bag of Visual Words (BoVW). The new technique using BossaNova achieves a detection performance (measured by area under the curve AUC) of 96.4% for hard exudate and 93.5% for red lesions using a cross-dataset training/testing protocol. This method characterize retinal images in order to obtain powerful lesion classifiers without the requirement of additional pre-processing or post-processing operations. The disadvantage is that the method takes so much computational time.

III. CONCLUSION

Different methodologies and techniques are discussed in this paper for the detection of retinal area and classification of healthy and unhealthy retina. The first step of retinal area detection includes the exclusion of the artefacts such as the eyelashes and eyelids. For this we need to have the extraction of textural features and classification based on the classifiers constructed.

Various transforms such as the Hough, Sobel, Prewitt, Canny and Wavelet transforms were used to do the edge detection techniques for detecting the artefacts. For those images in which eyelashes were present active shape modelling is applied for localization of eyelashes followed by the eight directional filter bank. The eyelashes are of two types either separable forms or in form of multiple eyelashes grouped together. To remove such eyelashes Gaussian filter and variance filter were applied. The above discussed methodologies are applied mostly for iris detection or the retinal fundus images. The application of these methodologies in case of SLO images are very rare. The extraction of features are done for a group of pixels known as super pixels. The extraction of features vectors for super pixels are computationally efficient compared to feature vector extraction for each super pixel. From the above discussed methods the ANN classifier proves to have the highest performance and during the training the the super pixels from the training set images are assigned the class of either retinal area or artefacts depending upon the majority of pixels in the super pixel belonging to particular class. The above discussed methods has been very useful in the implementation of the the proposed methodology of retinal area detection and classification of healthy or unhealthy retina.

REFERENCES

[1] Amit Madhukar Wagh , "Eyelids, Eyelashes Detection Algorithm and Hough Transform Method for Noise Removal in Iris Recognition ", Biomedical Signal Processing and Control 25 (2016) 108117.
[2] M.J.Aligholizadeh,S.Javadi,R.S.Nadooshan, and K.Kangarloo, "Eyelid and eye lash segmentation based on wavelet transform for iris recognition", in Proc.4thInt.Congr.ImageSignalProcess. 2011, pp.12311235.
[3] A.V.Mire and B.L.Dhote, "Iris Recognition System with Accurate Eyelash Segmentation Improved FAR, FRR using textural Topological Features", IEEE Trans.Med. Imaging, vol. 7, pp. 09758887, 2010.
[4] D. Zhang, D. Monro, and S. Rakshit, "Eyelash removal method for human iris recognition",in Proc. IEEE Int. Conf. Image Process., 2006, pp. 285288.
[5] J. Xu, O. Chutatape, P. Chew, "Human Iris Segmentation for Iris Recognition in Unconstrained Environments ", nternational Journal of Computer Science Issues Vol. 9, Issue 1, No 3, January 2012 473482.
[6] Y.-H.Li,M.Savvides,and T.Chen, "Investigating useful and distinguishing features around the eyelash region",in Proc. 37th IEEE Workshop Appl. Imag. Pattern Recog. 2008, pp. 16.
[7] H. Yu, C. Agurto, S. Barriga, S. C. Nemeth, P. Soliz, and G. Zamora "Automated image quality evaluation of retinal fundus photographs in diabetic retinopathy screening", Proc. IEEE Southwest Symp. Image Anal. Interpretation, 2012, pp. 125128.
[8] J. A. M. P. Dias, C. M. Oliveira, and L. A. d. S. Cruz"Retinal image quality assessment using generic image quality indicators", IEEE Trans. Inf. Technol.Biomed. 16 (4) (2012) 644657.
[9] Suraya Mohammad, et al., "Texture analysis for the segmentation of optic disc inretinal images", in: IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2013, pp. 42654270.
[10] R.Pires, H.Jelinek,J.Wainer ,and A.Rocha., "Retinal image quality analysis for automatic diabetic retinopathy detection", in: IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2013, pp. 42654270.