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International Journal of Current Research
Vol. 7, Issue, 04, pp.15034-15037, April, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

REVIEW ARTICLE

OPTIC DISK SEGMENTATION USING SUPERPIXEL CLASSIFICATION

***Shraddha Shantinath Kavathekar and Shamala R. Mahadik**

Department of Electronics and Tele Communication, Dr. J. J. Magdum College of Engineering, Jaysingpur, India

ARTICLE INFO

Article History:
Received 10th January, 2015
Received in revised form
02nd February, 2015
Accepted 10th March, 2015
Published online 30th April, 2015

Key words:

Glaucoma Screening,
Optic Disc,
Optic Cup,
optic disc segmentation

ABSTRACT

Glaucoma is a chronic eye disease in which the optic disc becomes progressively cupped, as axons die off. Curiously, this is the only optic nerve disorder in which severe cupping takes place. Vision loss takes place due to progression of the disease. Very few signs or symptoms are present in progression of disease and the vision loss from glaucoma is irreversible. Detecting the disease in time is important, as it cannot be cured. Current tests using intraocular pressure (IOP) are not sensitive enough for population based glaucoma screening. A more promising and superior method for glaucoma detection than other current methods is Optic nerve head assessment in retinal fundus images. Optic nerve head assessment can be done by a trained professional. However, manual assessment is subjective, time consuming and expensive. Therefore, automatic optic nerve head assessment would be very beneficial.

INTRODUCTION

Glaucoma which is the second leading cause of blindness is a chronic eye disease in which the optic nerve is progressively damaged as shown in fig.1. Because healing of died retinal nerve fibers is not possible early detection and prevention is essential. Progression of the disease leads to loss of vision, which occurs gradually over a long period of time (Bock *et al.*, 2007). When the disease is quite advanced, then the symptoms get occurred, therefore glaucoma is called the silent thief of sight. Progression of disease can be slowed down by treatment but Glaucoma cannot be cured. Therefore, detecting glaucoma in time is critical. Screening of people at high risk for the disease is vital, since glaucoma progresses with few signs or symptoms and the vision loss from glaucoma is irreversible. Glaucoma leads to (i) structural changes of the optic nerve head (ONH) and the nerve fiber layer and (ii) a simultaneous functional failure of the visual field. The structural changes are manifested by a slowly diminishing neuroretinal rim indicating a degeneration of axons and astrocytes of the optic nerve (Bock *et al.*, 2010). There are three methods to detect glaucoma.

Assessment of raised intra ocular pressure (IOP): The IOP measurement using non-contact tonometry (also known as the "air puff test") is neither specific nor sensitive enough to be an effective screening tool because glaucoma can be present with or without increased IOP.

Assessment of abnormal visual field: A functional test through vision loss requires special equipments only present in territory hospitals and therefore unsuitable for screening.

Assessment of damaged optic nerve head: Assessment of the damaged optic nerve head is both more promising, and superior to IOP measurement or visual field testing for glaucoma screening. Optic nerve head assessment can be done by a trained professional (http://nla.gov.au/nla.arc-86954, 2008).

The third method is more promising and suitable than other two. However, manual assessment is subjective, time consuming and expensive. Therefore, automatic optic nerve head assessment would be very beneficial. One strategy for automatic optic nerve head assessment is to use image features for a binary classification between glaucomatous and healthy subjects. In this features are normally computed at the image-level. The other strategy is to follow the clinical indicators. There are many glaucoma risk factors which are considered for glaucoma diagnosis such as the vertical cup to disc ratio (CDR), disc diameter, ISNT rule, parapapillary atrophy (PPA), notching, etc. Different ophthalmologists have different opinions on the usefulness of these factors; but CDR is well accepted and commonly used. The Cup to Disc Ratio (CDR) of the color retinal fundus camera image is the primary identifier

****Corresponding author: Shraddha Shantinath Kavathekar,***
Department of Electronics and Tele Communication, Dr. J. J. Magdum College of Engineering, Jaysingpur, India

to confirm Glaucoma for a given patient. A larger CDR indicates a higher risk of glaucoma (Cheng *et al*., 2013).

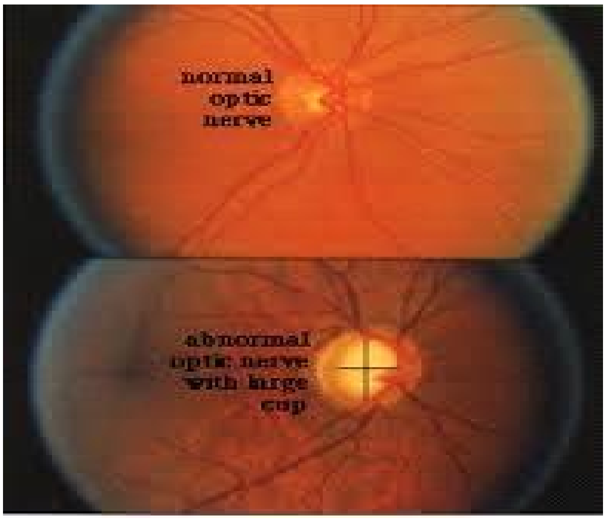

Fig. 1. Damaged optic nerve

Optic Disc and Optic Cup

The optic disc represents the beginning of the optic nerve and is the point where the axons of retinal ganglion cells come together, which visual information of the photo-receptors is transmitted to the brain. Because there are no rods or cones overlying the optic disk, it corresponds to a small physiological blind spot in each eye (Bock *et al*., 2010). It is also the entry point for the major blood vessels that supply the retina. In a normal human eye the optic disc carries from 1 to 1.2 million neurons from the eye towards the brain (Cheng *et al*., 2013). In Anatomical word the definition of optic disc is, the optic disc is placed 3 to 4 mm to the nasal side of the fovea. It is a vertical oval, with average dimensions of 1.76mm horizontally by 1.92mm vertically. There is a central depression, of variable size, called the optic cup (Esther M. Hoffmann). The disc can be divided into two parts; namely: a central bright zone which is called as optic cup (in short, cup) and a peripheral region called the neuroretinal rim. The neuroretinal rim is composed of astrocytes and nerve fibers while the brighter cup or excavation exclusively consists of supporting tissue (Bock *et al*., 2010).

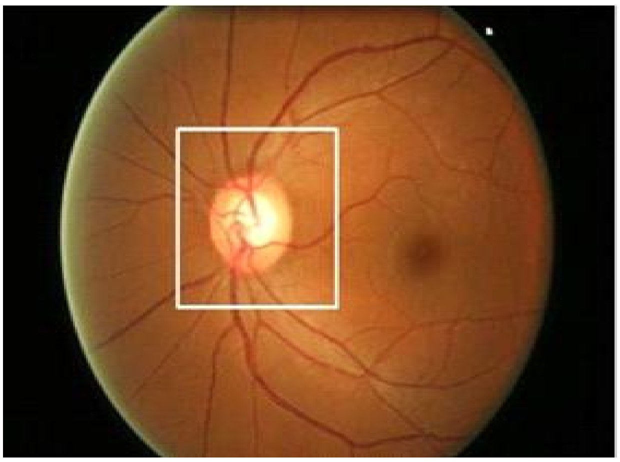

Figure 2. Original image of the eye

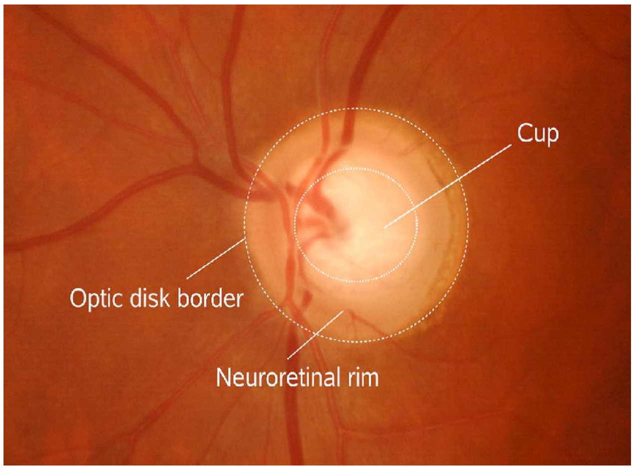

Figure 3. Major structures of the optic disc

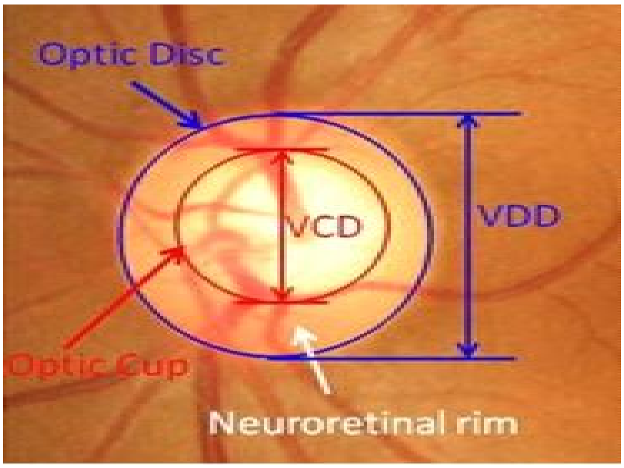

Fig 4. CDR calculation

Fig.3 shows the major structures of the disc. The ratio of vertical disc diameter to the vertical cup diameter is called as a “cup to disc ratio” as shown in Fig 4. Generally a cup to disc ratio of 0.3 is considered normal, and an increased ratio indicate a decrease in the quantity of healthy neuro-retinal tissue and hence, glaucomatous change (Esther M. Hoffmann)

Optic Disc and Optic Cup Segmentation

Accurate segmentations of disc and cup are important for CDR measurement. In many computer aided diagnosis systems, including glaucoma screening, localization and segmentation of disc are very important. Finding a disc pixel, very often the center is the main purpose of the localization. Estimating disc boundary by segmentation is a challenging task due to blood vessel occlusions, pathological changes around disc, variable imaging conditions, etc.Therefore super pixel classification is proposed for optic disk and cup segmentation which works well than other current approach (Centre for Eye Research Australia).

Superpixel Generation

Superpixels are local, coherent and provide a convenient primitive to compute local image features. They capture redundancy in the image and reduce the complexity of subsequent processing. For an initialization of disc boundary, the superpixel classification is used. Superpixel algorithms group pixels into perceptually meaningful atomic regions which can be used to replace the rigid structure of the pixel grid (Esther M. Hoffmann). They have been proved to be useful in image segmentations in various images of scene, animal, human etc. The SLIC algorithm uses CIELAB color space instead of RGB color space. Unlike the RGB and CMYK color models, *Lab* color is designed to approximate human vision. The CIE Lab color model encompasses the entire spectrum, including colors outside of human vision (Moore *et al*., 2008).

SLIC Algorithm

Simple linear iterative clustering (SLIC) algorithm is used for generating superpixels. This adapts k-means clustering to generate superpixels for generating superpixels which is faster than existing methods, more memory efficient, exhibits state-of-the-art boundary adherence, and improves the performance of segmentation algorithms.

Algorithm: SLIC superpixel segmentation

/_ Initialization _/ (step 1)

Initialize cluster centers Ck = [lk; ak; bk; xk; yk] ^T by sampling pixels at regular grid steps S.
Move cluster centers to the lowest gradient position in a 3 *3 neighborhood.
Set label l (i) = -1 for each pixel **i.**
Set distance d (i) = ∞ for each pixel **i.**
Repeat

/_ Assignment _/ (step 2)

For each cluster center Ck **do**
  For each pixel i in a 2S * 2S region around Ck **do**
    Compute the distance D between Ck and i.
      If D < d (i) then
        Set d (i) = D
        Set l (i) = k
    End if
  End for
End for
/_ Update _/ (step 3)

Compute new cluster centers.
Compute residual error E.
Until E < threshold (Achanta *et al*., 2012).

Optic Disc Segmentation

The segmentation estimates the disc boundary. There are three processes are involved in the optic disc segmentation. They are feature extraction, clustering algorithm and morphological operations.

K-Means Clustering Algorithm

K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them (Hunter, Richard and Harold, Richard, 1987).

Feature Extraction

Gabor Filter: The problem with cup and disc segmentation is that the visibility of boundary is usually not good especially due to blood vessels. Gabor wavelets can be tuned for specific frequencies and orientations which is useful for blood vessels. They act as low level oriented edge discriminators and also filter out the background noise of the image. Since vessels have directional pattern so 2-D Gabor wavelet is best option due to its directional selectiveness capability of detecting oriented features and fine tuning to specific frequencies (Prakash H. Patil, Seema V. Kamkhedkar, 2014).

RESULTS

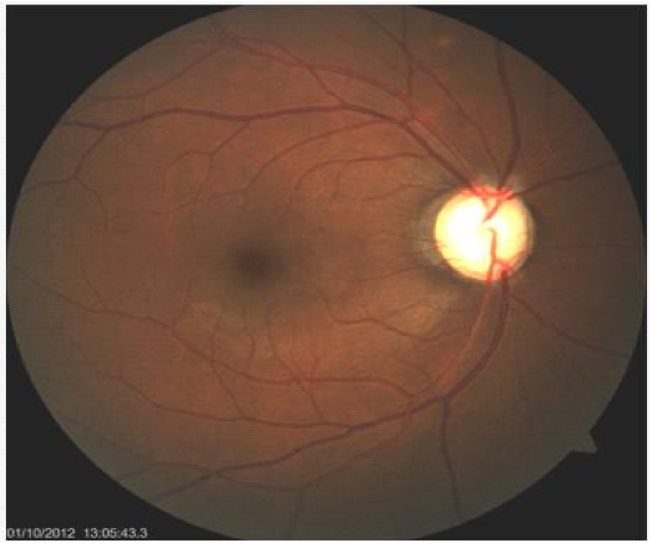

Fig. 5. Original image

Fig. 6. Original cropped image

Fig. 7. LAB color space image

Fig. 8. LAB space with cluster centers

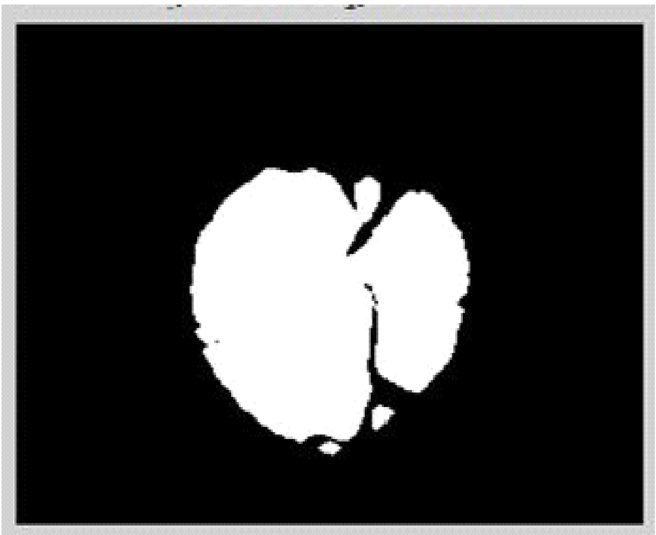

Fig. 9. Segmented optic disk

Conclusion

In this paper we presented super-pixel classification based optic disc for glaucoma screening. We concluded that for detection and diagnosis of glaucoma, firstly, optic disk need to be segmented. This paper is presented and evaluated for Glaucoma detection in patients using multimodalities including simple linear iterative clustering (SLIC) algorithm, K-Means and Gabor wavelet transformation of the color fundus camera image to obtain accurate boundary delineation. Using structural features like CDR (Cut to Disc Ratio), the ratio value exceeds 0.6 shall be recommended for further analysis of a patient to the ophthalmologist. This shall help in patients worldwide by protecting further vision deterioration through timely medical intervention**.**

REFERENCES

Achanta, R., A. Shaji, K. Smith, A. Lucchi, P. Fua and S. Susstrunk, 2012. "Slic superpixels compared to state-of-the-art superpixel methods," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 34, no. 11, pp. 2274–2281.

Bock, R., J. Meier, G. Michelson, L. G. Nyl and J. Hornegger, 2007. "Classifying glaucoma with image- based features from fundus photographs," *Proc. 29th DAGM Conf. Pattern Recognit.*, pp. 355–364.

Bock, R., J. Meier, L. G. Nyl and G. Michelson, 2010. "Glaucoma risk index: Automated glaucoma detection from color fundus images," *Med. Image Anal.*, vol. 14, pp. 471–481.

Centre for Eye Research Australia, *Tunnel vision: the economic impact of primary open angle glaucoma. [Electronic resource]*, 2008, http://nla.gov.au/nla.arc-86954.

Cheng, J., J. Liu, Y. Xu, F. Yin, D. Wong, D. Tao, C. Cheng, T. Aung and T. Wong, 2013. "Superpixel Classification Based Optic Disc and Optic Cup Segmentation for Glaucoma Screening" ieee transactions on medical imaging, vol. 32, no. 6.

Detecting the Optic Disc Boundary in Digital Fundus Images Using Morphological, Edge Detection, and Feature Extraction Technique–- Arturo Aquino, Manuel Emilio Gegúndez-Arias, and Diego

Esther M. Hoffmann, MD, Linda M. Zangwill, PhD, JonathanG.Crowston, MD, PhD, and Robert N. Weinreb, MD. "Optic Disk Size and Glaucoma".

Hunter, Richard, S. and Harold, Richard, W. 1987. The Measurement of Appearance, 2nd ed., John Wiley and Sons, Inc. New York, NY USA.

Moore, A., S. Prince, J. Warrell, U. Mohammed and G. Jones, 2008. "Super pixel lattices," in *Proc. IEEE Conf. Comput. Vis. Pattern Recognit.*, pp. 1–8.

Prakash H. Patil and Seema V. Kamkhedkar, 2014. "Analysis of Human Retinal Images for Automated Glaucoma Screening" Volume 2 Issue XII.

The Effect of Disk Size on Optic Disk Morphology -Robert N. Weinreb, Hamilton Glaucoma Center, Department of Ophthalmology, University of California, San Diego, 9500 Gilman Drive, La Jolla, California 92093-0946

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