Biomedical Signal Processing and Control 42 (2018) 162–189

Contents lists available at ScienceDirect

Biomedical Signal Processing and Control

journal homepage: www.elsevier.com/locate/bspc

Survey on segmentation and classification approaches of optic cup and optic disc for diagnosis of glaucoma

Niharika Thakur*, Mamta Juneja

Computer Science and Engineering, UIET, Panjab University, Chandigarh, India

ARTICLE INFO

Article history:
Received 2 November 2016
Received in revised form
21 December 2017
Accepted 24 January 2018

Keywords:
Segmentation
Optic cup
Optic disc
Classification
Glaucoma

ABSTRACT

Over the past years, use of the retinal fundus images has increased for diagnosis of retinal diseases. Glaucoma is a disease which causes damage to the optic nerve of the eye resulting in deteriorated vision. Once diagnosed, the disease cannot be treated completely, but timely detection can further control the effect of glaucoma. Detection is usually performed by analyzing the optic disc followed by optic cup present on an exit of ganglion cells in the eye. Using retinal fundus images and image processing approaches, various research studies have been published till date, but the problem of accurate segmentation of disc and cup is still a major concern. This paper aims to analyze various segmentation approaches used by different researchers for optic disc followed by the optic cup and its classification for diagnosis of glaucoma. Also, the paper addresses various research gaps and challenges which need to be dealt with for improving the accuracy of segmentation and classification.

© 2018 Published by Elsevier Ltd.

Contents

1. Introduction 163
   1.1. Glaucoma 163
   1.2. Retinal fundus image 163
      1.2.1. Optic disc 164
      1.2.2. Optic cup 164
      1.2.3. Retinal vessels 164
      1.2.4. Fovea 164
      1.2.5. Macula 164
      1.2.6. Exudates 164
2. Diagnosis parameter of glaucoma 164
   2.1. CDR (Cup to disk ratio) [5] 164
   2.2. ISNT rule [6] 165
   2.3. DDLS (Disk damage likelihood scale) [7] 165
   2.4. GRI (Glaucoma risk index) [8] 165
3. Datasets 165
   3.1. Dhristi retinal dataset [9] 165
   3.2. Rim-one dataset [10] 165
4. Literature survey 165
   4.1. Optic disc and optic cup segmentation 166
      4.1.1. Level set approach 166
      4.1.2. Thresholding based approach 167
      4.1.3. Active contour modeling approach 169
      4.1.4. Active shape modeling approach 170

* Corresponding author.
E-mail addresses: niharikthakur04@gmail.com (N. Thakur), mamtajuneja@pu.ac.in (M. Juneja).

https://doi.org/10.1016/j.bspc.2018.01.014
1746-8094/© 2018 Published by Elsevier Ltd.

4.1.5. Clustering based approach 171
4.1.6. Component-based approach 172
4.1.7. Hybrid segmentation approach 173
4.2. Classification of abnormality 180
5. Performance metrics 182
5.1. CDR acceptability [16] 182
5.2. Mean error [17] 182
5.3. Standard deviation [17] 182
5.4. Rms error [20] 182
5.5. Relative absolute area difference [26] 182
5.6. Dice metric [50] 185
5.7. F-score [48] 185
5.8. Sensitivity [55] 185
5.9. Specificity [55] 185
5.10. Accuracy [57] 185
5.11. Overlap area ratio [67] 185
5.12. Non-overlap area ratio [74] 185
5.13. Correlation coefficient [80] 185
6. Results and discussions 185
6.1. Research gaps 185
6.2. Findings 186
7. Conclusion 187
References 187

1. Introduction

1.1. Glaucoma

Early diagnosis and treatment for glaucoma is of utmost importance for preventing irreversible vision loss. Traditional method of diagnosis include extraction of features which are manual, time-consuming and may be prone to human errors. Hence, there is a need for improved and automated machine learning approaches for diagnosing the disease precisely in shorter time span.

Glaucoma is an eye disease in which damage to the optic nerve of eye leads to irreversible and progressive vision loss. The optic nerve carries visual information from the retina to the brain, which allows humans to visualize the outside world. The rise in the pressure of an eye known as intraocular pressure is the main cause of glaucoma. Pressure is increased in an eye when the amount of fluid produced in the eye increases and as a result blockage occurs in the drainage or outflow channel of an eye. Glaucoma is detected by identifying damage to the optic nerve which starts with deteriorating of vision and finally resulting in blindness. In many cases, drainage of the eye is jammed due to which fluid cannot drain out through an eye and hence lead to dropping of vision due to pressure build-up of fluid inflicting the optic nerve of the eye. Initially, the glaucoma affects both the eyes but the progression of the disease to one eye is more rapid than other in case of injury or use of steroids in the one eye [1]. Glaucoma is mainly classified as Open-angle and Angle-closure. Open-angle glaucoma is one of the prevalent types of glaucoma, which rises with an increase in age. The rise in the pressure of an eye is due to clogging of drainage which opens the drainage angle. Most of the times, an increase in pressure is without any pain and symptoms. Loss of vision starts from the side of the eye and approaches towards the center of an eye. Whereas, Angle-closure glaucoma is a type of glaucoma in which all the drainage angles become closed due to which fluid cannot reach to other parts of the eyes. In case of angle closure glaucoma, there is a sudden increase in pressure of eye resulting in closing and blocking of drainage angle which enlarges or widens the pupil. Glaucoma may be characterized by eye pain, nausea, headache, blurry vision and red eye. Surgery is used to recover from glaucoma by creating a hole in the iris with the help of laser to maintain the normal flow of fluid [1].

In general, patients with glaucoma initially have no symptoms, but with the passage of time symptoms can be detected by the experts. A person with variation in intraocular pressure may have vision haziness and appearance of haloes in the presence of light generally, at the time of morning. Glaucoma is often called theft of sight because it increases the pressure of eyes without any symptoms and can cause blindness. Prevention of the disease depends on the type of glaucoma, which is detected by experts and accordingly the suitable treatment is given to the patient [1]. Hence, accurate and timely detection of glaucoma can limit its progression not completely but to a certain extent.

According to statistics of the World health organization (WHO), glaucoma is the second most prevailing cause of irreversible blindness next to cataract. Glaucoma has affected nearly 3 million people in the America out of which 1.5 million are unaware of the disease. Although, the glaucoma cannot be cured completely once occurred, but its progression can be halted by medicines or surgery to protect the eye from vision loss. Since every age group is at the risk of glaucoma, the best way to protect eyes from glaucoma is to take immediate consultation of ophthalmologists when any sight related problem is observed [2].

Diagnosis of glaucoma using retinal imaging is carried out by calculating Cup to disc ratio (CDR), Inferior Superior Nasal Temporal (ISNT) rule, Disk damage likelihood Scale (DDLS) and Glaucoma risk index (GRI) which are achieved by extracting optic disc and optic cup to calculate ratios of their vertical heights. The optic disc is the starting of the optic nerve which is the location from where the nerves of retinal cells come close to each other. It is the entering point of blood vessels which pass blood to the retina. On the other hand, the optic cup is the central depression of variable size present on the optic disc. A pale disc is the indication of a disease which varies in color from orange to pink. Details about the retinal images and its features are given in Section 1.2.

1.2. Retinal fundus image

Retinal fundus image is a special type of eye image taken using a special retinal fundus camera for diagnosis of various eye diseases. Retinal images are taken by clinical experts to check various abnormalities present in the retina. Retinal fundus image has various features which are used to diagnose different diseases such

Download English Version:

https://daneshyari.com/en/article/6950903

Download Persian Version:

https://daneshyari.com/article/6950903

Daneshyari.com