ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 7, Issue 9, September 2020

EMERGING CONCEPTS AND TECHNIQUES IN IMAGE PROCESSING FOR GLAUCOMA DETECTION – A REVIEW

[1] Sujithra.B.S, [2]Dr.S. Albert Jerome
[1]Assistant Professor, Department of Electronics and Communication Engineering,
[2] Professor, Department of Biomedical Engineering

Abstract: This review paper focuses on detection of glaucoma by learning and understanding different image processing techniques used till now. Glaucoma is disease related with human eyes. It is difficult to identify glaucoma until it reaches severe vision loss, because it shows zero symptoms at the early stage. Due to this factor this disease became the second leading cause of blindness after cataract in world wide. A comprehensive dilated eye exam can reveal the risk factors of glaucoma such as high eye pressure, thickness of cornea and abnormality in optic nerve. But, the challenging factor is functional changes in fundus of the eye cannot be easily tracked and hence the only way is identifying the structural changes of eye with the help of image processing technologies. This study would be helpful and applicable to both ophthalmologists in practice and researchers in the same field to enhance the diagnosis. This paper conclude that, combining most relevant features which are notable for structural changes of eye with Retinal Nerve Fiber Layer (RNFL) thickness alone can be more effective and provide promising accuracy in glaucoma detection.

Keywords: Glaucoma, RNFL (Retinal Nerve Fiber Layer), Fundus images, Feature Extraction, Image Processing.

INTRODUCTION

Glaucoma is a neurodegenerative disease which steals vision gradually by damaging the optic nerve. Optic nerve is a neural pathway which sends image to the brain. Glaucoma is the second leading cause of blindness after cataract. WHO (World Health Organization) estimated that around 4.5 million people are affected by glaucoma globally. In India, nearly 20 million people are affected and around 1.2 million people became blind from this asymptomatic disease. Currently, treatments are available, but the disease must be detected in the early stage.

Fig 1. Glaucoma vision field

Glaucoma has categorized into two basic types: Open Angle Glaucoma (OAG) and Close Angle Glaucoma (CAG) / Angle Closure Glaucoma (ACG). The angle between iris and cornea differentiate OAG and CAG. Open Angle Glaucoma is painless and leads to gradual vision loss over by years. Whereas Close Angle Glaucoma is painful and attack the patient with total blindness within few days or weeks [1]. CAG or ACG can be detected by measuring anterior chamber angle (ACA) of the eye. It can be easily obtained from Anterior Segment Optical Coherence Tomography (AS-OCT) [2].

The two main characteristics of glaucoma are deterioration of optic nerve and astrocytes followed by high intra ocular pressure (IOP). The deterioration of the optic nerve fibers leads to decreases the thickness of retinal nerve fiber layer and the degeneration of astrocytes and axons leads to changes in the optical nerve head (ONH) configuration and thereby decreasing functional capability of retina which expands the optic cup then finally make the neuroretinal rim thinner [11].

The Glaucoma patients are mostly ignorant until the optic nerve damage increases to 63% [3]. As mentioned earlier, this optic nerve damage leads to structural changes in the optic disc, ONH and RNFL thickness. Finally, resulting a variation in optic Cup-to-Disc ratio (CDR) [3]. The process of glaucoma detection

ISSN (Online) 2394-2320

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 7, Issue 9, September 2020

are complicated because it involves different aspects like patient's medical history, regular screening to find the depth of vision loss, measuring IOP, determining CDR and measuring the thickness of RNFL through ophthalmoscopy [4].

Fundus images are most commonly used to diagnose certain eye diseases. Under high resolution, this images can highlight the important parameters of eye which are indispensable for pathology. The measurement of Optic Disc (OD) is a notable element for glaucoma screening [6]. It is already known that vessel detection and direction characteristics are key element for OD detection [5]. There are different method came into account for detecting the OD through medical image processing. Optical Coherence Tomography (OCT) is a new imaging tool which provides clear view of the fundus image [6]. Along with this, a joint segmentation of OD and Optic Cup (OC) method has developed for improving the timing efficiency. In which the polar transform is dominated to convert the original fundus image [9]. The segmentation accuracy of OC and OD can be better achieved through U-Net neural network [10]

Apart from CDR, the RNFL thickness and macula layer thickness also reduces due to destruction of ganglion cells. Thus, detecting the changes of above two parameters are also an important factors of eye to identify glaucomatous image. Also, previous studies shows that glaucoma detection with RNFL thickness alone can provide diagnostic accuracy similar. By including most relevant features, the RNFL can be a powerful discriminator to separate glaucomatous images [26].

LITERATURE SURVEY:

Liu *et al.*, [1] proposed a work of Closed/ Open angle glaucoma arrangement and is significant for glaucoma analysis. RetCam is another imaging tool that catches the picture of iridocorneal plot with the end goal of grouping. Be that as it may, manual evaluating and examination of the RetCam picture is emotional and tedious. In this paper, a framework for keen examination of iridocorneal point pictures, which can separate shut edge glaucoma from open edge glaucoma naturally is proposed. Two methodologies are proposed for the grouping and their exhibitions are looked at with a total of 1866 fundus images. First gander at the exhibition is the analysis depends on a solitary picture of the eye. At that point, it take a gander at the presentation if the conclusion depends on all the pictures caught on each eye. The exploratory outcome shows great result, particularly the width based methodology. The cost and accessibility of RetCam act as one of the major downside with this work.

A methodology of programmed foremost chamber point division and estimation technique for Angular Segment- Optical coherence Tomography (AS-OCT) symbolism has proposed by the author Fu et al., in 2017 [2]. The fundamental components of this work are the presentation of marker move from named models to produce starting markers, and division of the corneal limit and iris districts to acquire clinical Anterior Chamber Angle (ACA) estimation. The tests exhibit the adequacy and heartiness of proposed technique. For evaluating the performance efficiency, 4135 AS-OCT images were taken from a local hospital. One of the impediment in this technique is that AS-OCT picture may prompt contortions of the iris shape and another difficult case is low complexity, which may prompt mis-division in the corneal limit. This makes the work inefficient.

Zahoor and Fraz [3] built up a novel optic disc and division procedure for identification of glaucoma. The technique has utilized various leveled blend of morphological tasks and Circular Hough Transform (CHT) for the Optic Disc (OD) localization. The acquired outcomes shows that the system is computationally efficient and performs well even in shifting differentiation setting, brightening changes and also within the sight of pathologies in the picture. The publically available datasets named MESSIDOR, DIARETDB1, DRIONS-DB, HRF, DRIVE, and RIM-ONE are used for evaluation. OD segmentation algorithm had the option to accomplish just a normal spatial cover on the datasets utilized for test. This technique can be used as a back born for the upcoming strategy with progress in the time proficiency.

In 2018, Sahina *et al*., [4] proposed a work in which the G-Eye Net comprises of a profound convolutional auto encoder and a conventional convolutional neural system/network (CNN) classifier sharing the encoder structure. These multi-model system is half and half for limiting both picture remaking blunder and the classification mistake. Exploratory outcomes show that G- Eye Net gives an extensive improvement with the present learning calculations.

In a work of Fu *et al*., [6] a blend of low-

ISSN (Online) 2394-2320

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 7, Issue 9, September 2020

position reproduction blunders technique has proposed. The methodology depends on Retinal Pigment Epithelium (RPE) shape of eye. The structural and functional change from optic disc to RPE can be identified with high exactness in contrast with the present techniques. Likewise, a geometrical requirement named separation inclination that gives the smooth state of the RPE is presented here. This can be utilized to deal with the 3D-OCT volume, for which promising outcomes are additionally accomplished. One of the constraint found in this work is that investigation with glaucoma patients were excluded, just OD recognition of retinal pictures are engaged.

In 2016 a review of automated glaucoma detection techniques has been made by Nawaldgi [7]. This paper includes an audit on programmed glaucoma recognition methods. Ultimate result says that, blend of color fundus image with Optical Coherence Tomography (OCT) gives better outcome to identification of glaucoma. Be that as it may, this system is less proficient than the previous techniques. Since countless informational indexes comprising of fluctuating degree of glaucomatous and non- glaucomatous samples can test a framework all the more precisely. Here, probes increasingly number of troublesome retinal pictures were not finished with this technique.

As similar to the previous findings, Ranjoha *et al*., [8] developed a strategy in which just the optic cup to disc proportion is utilized as a concluding parameter to identify glaucoma and assists with diagnosing the instance of suspected glaucoma productively. The optic cup circle and hemorrhages are fragmented in a specific locale naturally by utilizing versatile thresholding and some geometrical highlights. There are two variables which addresses the effectiveness of the technique utilized in this work. The first is that test was finished with just barely any number of fundus pictures and the following one is a solitary parameter is considered for recognizing glaucoma.

An automated classification of glaucoma stages using higher order cumulant features was proposed by Bandary *et al*., in 2014 [11]. In this work, glaucoma has been classified into three as would be expected, mellow and serious glaucoma. This work is approved utilizing 272 fundus pictures with 100 ordinary, 72 gentle glaucoma and 100 moderate/serious glaucoma pictures with two classifiers. Grouping the fundus picture is the significant capacity accomplished by this work. The Support Vector Machine (SVM) and Naïve Bayesian (NB) are the classifiers. This framework can identify the early glaucoma stage with a normal exactness of 84.72%. Different parameters included are affectability, explicitness and positive prescient worth are assessed and acquired a normal of 92.65%.

Also a reproduction based learning method is utilized to locate optic cup for glaucoma screening. This work follows to find the optic cup to recognize the optic cup to disc proportion with the assistance of a codebook which is created by arbitrary inspecting from the physically named fundus pictures. This methodology of distinguishing glaucoma has been examined on hardly any number of datasheets which can't decide the productivity of the philosophy proposed by Navab *et al*., [12]. By, assessing with various datasets the exhibition of the comparing work can be resolved

Sruthi and Shangouda proposed a strategy for optic cup and disc detection with the assistance of morphological and dark level preparing of the picture which improves the exhibition of plate recognition utilizing CDR technique [15]. This paper breaks down the presentation of the system under the nearness of clamor and proposes an appropriate versatile middle shifting strategy for stifling the commotion and recognizing the precision of the retinal image. Recognition of CDR from Region of Interest (ROI) picture is progressively proficient at that point running the calculation over whole picture. The work examinations outcome with standard databases and demonstrate that the precision of the framework is adequate for continuous retina investigation. The exactness of proposed morphology based strategy was 95.5% in contrast with current CHT based technique whose general precision was seen to be 92.19%.

During the past few years CDR played a vital role in identification of glaucoma. Nayara Moura *et al.*, [16]introduced an approach for optic disc segmentation and texture feature extraction. At this point, from this highlights were separated in different shading models. The assessment of the identification of the OD was acted in three different picture database. The division indicated efficient results, bookkeeping a precision more prominent than 83% when assessed utilizing triumph rate prerequisite of 70%, which is the old style system found in the writing. After the division, the extraction of surface highlights of the picture was performed. At that point, it

was done the classification of the retinal pictures in glaucomatous or non-glaucomatous. Most examination measures of the consequences of a classification originates from a disarray framework which shows the quantity of right and off base classification for each class. A disarray framework is made depend upon four qualities: True Positive (TP), number of pictures effectively classified as glaucomatous; False Positive (FP), number of pictures classified as solid when really they were glaucomatous; False Negative (FN), number of pictures classified as glaucomatous when really they were sound and True Negative (TN), number of pictures classified accurately as solid.

A review on automated glaucoma detection was made on 2017 by Jamel *et al*., [17]. The point of this undertaking was to analyze existing framework on the base of ophthalmic imaging innovation, utilitarian and auxiliary highlights of the eye. Machine learning strategies, precision and informational collection utilized for assessment. Here the work focuses that Support Vector Machine (SVM) is broadly utilized for computerized glaucoma recognition through K nearest Neighbor (KNN) indicated best outcomes with 96% precision utilizing fundus picture. This paper actualized with an innovation called Optical Coherence Tomography (OCT) can be adequately utilized for location of glaucoma at beginning period because of its capacity to catch interior subtleties of eye which are not accessible in fundus pictures. At long last, the result with this work shows that artificial intelligence methods can be utilized to create productive and increasingly exact mechanized glaucoma recognition frameworks.

CONCLUSION

A brief study have done through different literatures for achieving detailed knowledge about glaucoma and its characteristics. In this paper, structure of each experiments in the survey that is useful for identifying further development required in early detection and finding notable features has presented. This review conclude that, Retinal Nerve Fiber Layer (RNFL) thickness alone can be more effective and shows promising accuracy in glaucoma detection by combining most relevant features which are vital for structural changes of eye .

REFERENCES

[1] Jiag Liu, Tin Aung, Mani Baskaran, Conference paper of IEEE Engg. In Medicine and Biology Science July, 2015.

[2]. H. Fu, Y. Xu, S. Lin, X. Zhang, D. Wong, J. Liu, and A.Frangi," IEEE Trans. Med. Image., vol. 36, no. 9, pp. 1930–1938, 2017.

[3] Muhammad Nauman Zahoor and Muhammad Moazam Fraz Volume 5, 2169-35362017 IEEE.

[4] Abhishek Pal, Manav Rajiv Moorthy and A. Shahina, Image Processing (ICIP) 2018, 25th IEEE Int.Conf. On pp. 2775-2779, 2018.

[5] H. Fu, D. Xu, S. Lin, D. W. K. Wong, and J. Liu, "Automatic optic disc detection in oct slices via low-rank reconstruction," IEEE Transactions on Biomedical Engineering, vol. 62, pp. 1874 – 1886, Apr 2015

[6] D. Zhang and Y. Zhao, "Novel accurate and fast optic disc detection in retinal images with vessel distribution and directional characteristics," IEEE Journal of Biomedical and Health Informatics, vol. 20, pp. 2168 – 2194, Jan 2016.

[7] Sharanagouda Nawaldgi,"Review of Automated Glaucoma Detection Techniques", (Wisp NET), IEEE International Conference, 2016.

[8] Namita Sengar, Malay Kishore Dutta, Radim Burget and Martin Ranjoha, "Automated Detection of Suspected Glaucoma in Digital Fundus Images", IEEE International Conference on Tele Comm. And Signal Processing, 2017

[9] H. Fu, J. Cheng, Y. Xu, D. Wong, J. Liu, and X. Cao, "Joint Optic Disc and Cup Segmentation Based on Multi-label Deep Network and Polar Transformation," IEEE Trans. Med. Image., 2018.

[10] A. Sevastopolsky, "Optic disc and cup segmentation methods for glaucoma detection with modification of U-Net convolutional neural network," Pattern Recognition and Image Analysis, vol. 27, no. 3, pp. 618–624, 2017.

[11] K. P. Noronha, U. R. Acharya, K. P. Nayak, R. J. Martis, and S. V. Bhandary, Biomedical Signal Processing and Control, vol. 10, no. 1, pp. 174–183, 2014.

[12] Xu, Y., Lin, S., Wong, T.Y., Liu, J., Xu, D.: In: Mori, K., Sakuma, I., Sato, Y., Barillot, C., Navab, N. (eds.) MICCAI 2013, Part III. LNCS, vol. 8151, pp. 445–452. Springer, Heidelberg (2013)

[13] A. Salazar-Gonzalez, D. Kaba, Y. Li, and X. Liu, IEEE Journal of Biomedical and Health Informatics, vol. 18, pp. 1874 – 1886, Nov 2014.

[14] Niladri Halder, Dibyendu Roy, Arnab Chattaraj, Tanumoy Chowdhury. Vol. 3, Issue 3, March 2015

[15] Shruti P Y, Sharangouda.N, International Journal of Advanced Research Vol. 4, Issue 6, June 2015

[16] Maı'la Claro, Leonardo Santos, Wallinson Silva Fl´avio Araujo, Nayara Moura CLEI Electronic Journal, Volume 19, Num ber 2, Paper 4, August 2016

[17] Khalil, T., Akram, M. U., Khalid, S., & Jameel, A. (2017). Computing Conference.

[18] Diptu, N. A., Khan, M. A., Debnath, S., Imam, A. A., Rakib, A. M. H., Ahmed Ador, K. A., & Rahman, R. M. (2018). *International Conference on Intelligent Systems (IS).*

[19]Pavithra, G., Manjunath, T. C., Krishnananda, & Lamani, D. (2017). *IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI).*

[20] An, G., Omodaka, K., Tsuda, S., Shiga, Y., Takada, N., Kikawa, T Akiba, M. (2018). Journal of Healthcare Engineering, 2018, 1–8.

[21]Yousefi, S., Goldbaum, M. H., Balasubramanian, M., Medeiros, F. A., Zangwill, L. M., Liebmann, J. M. Bowd, C. (2014). IEEE Transactions on Biomedical Engineering, 61(7), 2112–*2124*

[22]Nikam, S. M., & Patil, C. Y. (2017). 3rd International Conference on Advances in Computing, Communication & Automation (ICACCA*)*

[23] Khalil, T., Khalid, S., & Syed, A. M. (2014). *Science and Information Conference.*

[24]Soltani, A., Battikh, T., Jabri, I., Mlouhi, Y., & Lakhoua, M. N. (2016). International Conference on Control, Decision and Information Technologies (CoDIT).

[25] Panda, R., Puhan, N. B., Rao, A., Padhy, D., & Panda, G. (2017). IEEE 14th International Symposium on Biomedical Imaging (ISBI 2017*).*

[26]Yousefi, S., Goldbaum, M. H., Balasubramanian, M., Tzyy-Ping Jung, Weinreb, R. N., Medeiros, F. A. Bowd, C. (2014). *IEEE Transactions on Biomedical Engineering, 61(4), 1143–1154.*

[27] Kim, P. Y., Iftekharuddin, K. M., Davey, P. G., Toth, M., Garas, A., Hollo, G., & Essock, E. A. (2013). IEEE Journal of Biomedical and Health Informatics, 17(2), 269–276.

[28] Carrillo, J., Bautista, L., Villamizar, J., Rueda, J., Sanchez, M., & rueda, D. (2019). XXII Symposium on Image, Signal Processing and Artificial Vision (STSIVA)

[29]Yu, S., Xiao, D., & Kanagasingam, Y. (2018. IEEE Journal of Biomedical and Health Informatics, 22(3), 886–894.

[30]Jiang, Y., Tan, N., & Peng, T. (2019. *IEEE Access, 1–1*

[31]Orlando, J. I., Prokofyeva, E., & Blaschko, M. B. (2017). IEEE Transactions on Biomedical Engineering, 64(1), 16–27.

[32]Aloudat, M., Faezipour, M., & El-Sayed, A. (2019 IEEE Journal of Translational Engineering in Health and Medicine, 7, 1–*13.*

[33]Haleem, M. S., Han, L., van Hemert, J., Li, B., & Fleming, A. (2015). IEEE Journal of Biomedical and Health Informatics, 19(4), 1472–1482.

[34]Ashame, L. A., Youssef, S. M., & Fayed, S. F. (2018). International Conference on Computer and Applications (ICCA).

[35]Cheng, J., Liu, J., Xu, Y., Yin, F., Wong, D. W. K., Tan, N.-M., Wong, T. Y. (2013). IEEE Transactions on Medical Imaging, 32(6), 1019–1032.