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A REVIEW STUDY ON DECISION BASED SYSTEM ON FUZZY LOGIC AND IMAGE PROCESSING ALGORITHMS FOR EARLY GLAUCOMA DIAGNOSIS

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ABSTRACT. Predominantly, in the incredible medical and life sciences field, the decisions are sampled based on the images, where, the predictable images are cultured for the clinical diagnosis and research studies. Here in such circumstances, we study about the glaucoma disease in particular as we know it has a major effect on optic nerve head (ONH) which causes the eradication and sudden vision loss. This article studies the review contents on glaucoma Fuzzy expert system for early diagnosis through various medical images. Similarly, as a review study this article states the system which is tested on a real dataset of ophthalmologic images which comprises of both the normal and glaucoma affected cases. Thus, comparing and differentiating other existing systems, the study will finally emphasize with an experimental data as to encompass the proposed study and few algorithms through fuzzy logic system.

1. INTRODUCTION

Glaucoma is a single end for a composite versatile of conditions that have gradual visual pathology resulting sight misfortune [1]. Essential angle-open glaucoma is a reformist ophthalmic pathology with respect to nerves qualified by perpetual loss of retinal ganglion cells, wantonness of their hatchet seed inside optic nerve and likewise influences field of vision [2]. High measure of intra-visual weight (IOP) is one of the real peril segments of glaucoma disease.

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Accusative of present medicament gets to will be to diminish (IOP) inside eyes to avert basic human sciences harm [3]. Glaucoma has a few types yet the principle two sorts are open-point and close angle glaucoma in light of the fact that both these sorts have high intraocular weight inside the eyes. Open-edge glaucoma is regular when contrasted with edge conclusion. There are no reasonable side effects for open-edge glaucoma since it creates progressively while close-edge glaucoma is extremely excruciating and needs quick treatment [4].Valuation of retinal nerve fiber layer (RNFL) greatness and visual field contentions are significant for the discovery of glaucoma [5]. An assortment of different potential outcomes conceding mechanical and vessel systems has been used for obsessive procedure of glaucoma [6].

Glaucoma is of two unique types: Open Angle Glaucoma and Angle Closure Glaucoma. Open-angle glaucoma has a wide point between IRIS and cornea furthermore known as wide edge glaucoma. On account of this reason there's an essential need to grow progressively precise and more affordable magnum opus for early assurance of glaucoma. In this way, few existing system proposed the Fuzzy based decision making system for early finding of Glaucoma which might be one among the helpful applications with the capacity to distinguish Glaucoma in beginning period, Due to their serious lead it yields better outcomes [2].

The hypothetical fuzzy set was exhibited by Prof. Lofti Zadeh in 1965 [3], which make it feasible to describe flawed therapeutic characteristics into human sensible structure [1]. The yielding utilization of the fuzzy logic systems have been utilized for various applications. The best preferred advantage of the fuzzy expert framework and structure lies in the manner that examiners can show questionable, complex structure into direct human reasonable shape by using human experience and learning as fuzzy logical lines as set of variables [4]. Where here he mentioned about an ace structure by utilizing fuzzy logic to perceive Glaucoma from its proposed indications. The exact theory is settled by utilizing understanding informational index a record having six unique characteristics. By utilizing therapeutic master information fuzzy standards are made that might be utilized as a touch of higher psychological procedure. Where this review depicts information dependent on master framework for finding of Glaucoma. The therapeutic and diagnosing utilizing the field of synthetic knowledge has reasonably moved from clinical research focus on genuine applications. In addition, spreading out and actualizing results for examination of Glaucoma by

utilizing fuzzy interference framework is organized. By including in at least few in numbers, side effects of glaucoma fuzzy interference frameworks was made. The fuzzy guidelines based framework uses remedial therapeutic information for realizing patient's s signs and give an accurate choice for each fuzzy logic sets are made.

2. Related study

In these studies, there are various strategies utilized for recognition of Glaucoma. Inoue N. et al. [5] proposed two methodology's prejudicial examinations and edge handling to figure the extent of the domain of optic plate and the zone of optic circle cup (named C/D proportion) and overviewed this framework functions admirably, anyway there is an issue that veins in the optic circle is evaporated. To deal with these issue scientists, develop another system utilizing configuration organizing. Creator accepted that new framework will be reasonable to look at patient condition for glaucoma. Cheng J. et al. [6] proposed a splendid structure for the examination of RetCam pictures for changed close/open edge classification. Author utilized two systems which are edge acknowledgment and circular segment ID to depict open and close glaucoma. At that point they differentiated the outcomes what's more, Clinical database.

Xu Y. et al. [7] showed Image handling and learning based framework was proposed to confine and order Anterior Chamber Angle (ACA), in light of multiscale HOG features. Agarwal A. et al. [8] presented versatile thresholding procedure which breakers picture features like mean, difference and standard deviation to zone the optic circle and optic plate from the fundus picture. Later they differentiated the outcomes and clinical database and this framework gives promising outcomes over 90% exactness. Aloudat M. et al. [9] proposed Haar channel that process the edge of open and close them had eye-related infirmities. Haveesh G. et al.[9] exhibited two systems, picture handling and fluffy glaucoma as an initial step of picking the thickness of the fluid accessible on the cornea. The analysts stood out the outcome from the patients of the Jordanian Legislative emergency clinic (Al AmeeraBasma Hospital). The patients had ages going between years old, and each one of them had eye-related issues [9]. Haveesh G. et al. [10] proposed two frameworks, picture preparing and fluffy classifier to recognize Glaucoma.

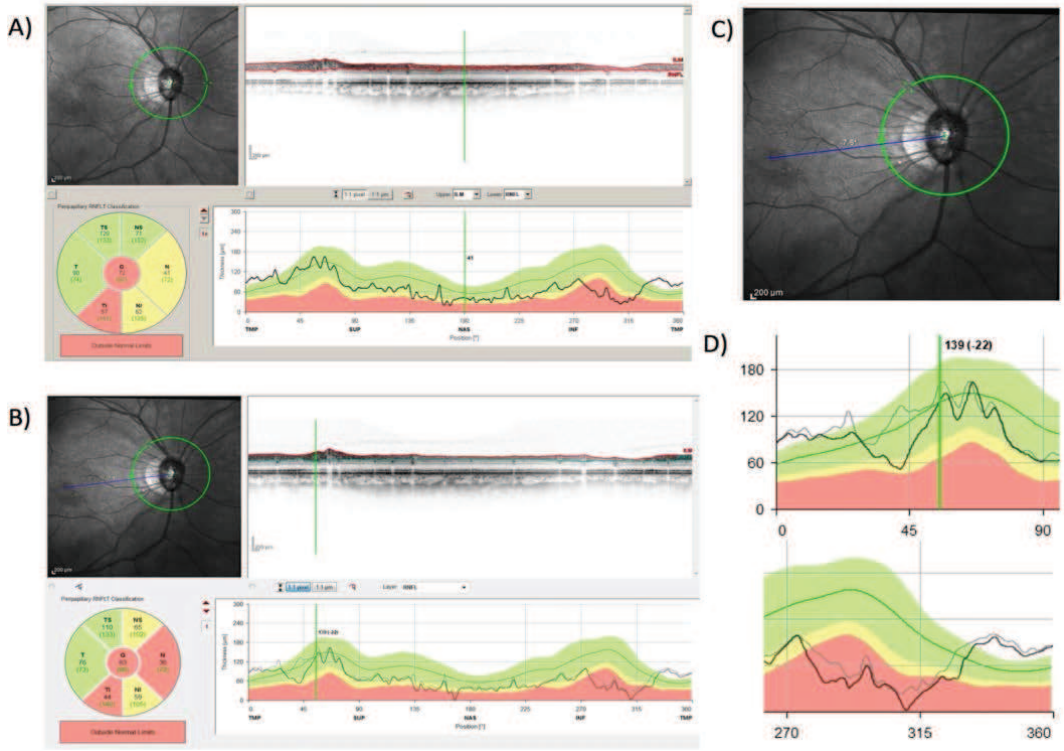

FIGURE 1. Preprocessing, contour detection and form recognition results *(a) Original eye fundus images (b) Preprocessing techniques' results (c) Contour detection (d) Elliptical form recognition. (A) Measurement at baseline. The infrared (IR) image of the disc at the upper left of the window, the original optical coherence tomography (OCT) image of the cpRNFL at the upper right, the global and sectorial thickness at the lower left, and the profile of the cpRNFL for comparison with the normative database at the lower right. (B) Measurement at follow-up. (C) Magnified IR image of the disc in (B). To examine the same location, the IR image was rotated slightly (see the upper right corner of the image). (D) The magnified image of the cpRNFL profile from the temporal to the superior sector. The gray line indicates the profile at the baseline; the the black line at follow-up. The change of the profile at approximately 45 degrees supports the development of the NFLD observed in (C)*

Fundamental purpose of this study is to register CDR then organize glaucoma in light of estimation of CDR. The goal of this audit is pre-planning of retinal fundus picture for improving the quality which is required for further managing

and to orchestrate a novel estimation to quantify the cup to plate proportion of retinal fundus picture from the online database and orchestrating the disease by its basic side effects utilizing fluffy grouping in MATLAB. Lamani D. et al. introduced differing parameters (Intraocular Pressure, Vertical Cup to Disk Ratio, Neuro Retinal Rim Thickness, Inferior Superior Nasal and Fleeting Sector Ratio, Central Cornea Thickness) to examine glaucoma and clinical instruments (Tonometry, Heidelberg retinal tomography, perimetry, pachymetry, ophthalmoscopy, optical intelligibility tomography, GDx) used to look at the Parameters.

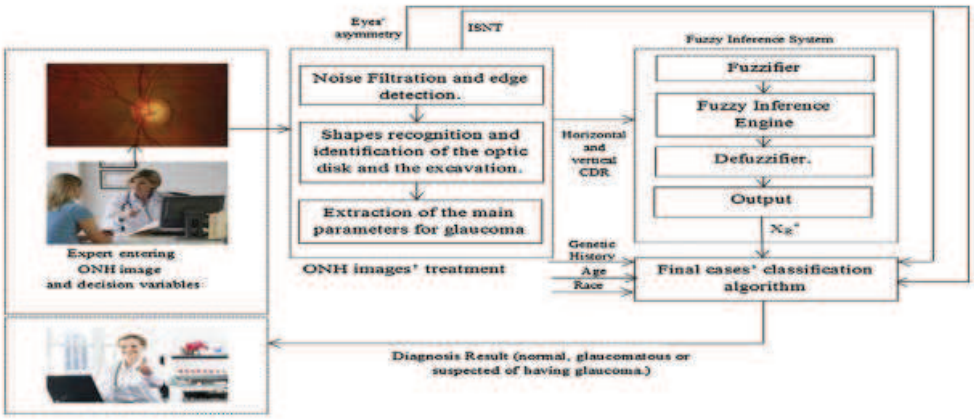

FIGURE 2. Schematic Representation of the designed decision-making system structure

These related studies and reviews portrays another procedure for PC helped investigation of ophthalmological pictures in which picture handling calculations have been produced for the identification of the optic papilla and the extraction of parameters basic for the finding of glaucoma. These parameters will fill in as contribution of the second part where scientific calculations dependent on fluffy rationale motors have been created to decide the state of a patient conceivably experiencing glaucoma.

3. DECISION-MAKING ALGORITHM BASED ON FUZZY LOGIC

The reason for this part is to process and break down the outcomes gotten in the imaging part so as to settle on a choice utilizing a fluffy rationale based calculation. The utilization of a solitary parameter for the conclusion gives us

false outcomes. To be sure, after exchanges with ophthalmologists and research regarding the matter, we understand that the determination of this pathology depends on a few parameters which we will consider in our choice emotionally supportive network.

3.1. **Design of the system based on fuzzy logic.** The Design of the system based on fuzzy logic follows the three variable steps, which as follows:

3.1.1. *Linguistic variables.* Three linguistic variables are used: two inputs and an output. The inputs are the vertical and horizontal CDR, the universe of discourse for each entry is the interval [02]. The output represents the decision whose discourse universe is the interval [01].

$$\|G\| = \|\nabla I\| = \sqrt{\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2}. \tag{3.1}$$

The contour is determined by:

$$\theta = \arctan\left(\frac{G_x}{G_y}\right), \tag{3.2}$$

where I is the light intensity of the image.

3.1.2. *Membership functions.* To represent these groups, Gaussian functions are described by the following equation:

$$f(x) = \frac{-(x-m)^2}{2\partial^2}, \tag{3.3}$$

where ∂ is the standard deviation and m is the mean of the Gaussian function. Table 2 describes the parameters, mV and mH of each membership function of respectively vertical and horizontal CDR. Fig. 8 illustrates respectively vertical and horizontal ratios membership functions.

3.1.3. *Output membership function.* The output membership function is chosen empirically after having performed tests on the inputs of the fuzzy engine and its rules of inference. It contains two classes: normal and glaucomatous. The function of the first class (Normal class) noted is a linear function; while the second class function (glaucomatous class) noted is an affine one. They are respectively described by the Eqs. (4) and (5):

$$f_N(x) = ax; a = 1; \tag{3.4}$$

$$f_G(x) = ax + b; a = -1,\ b = 1. \tag{3.5}$$

4. Fuzzy Rules

The "IF-THEN" rules are validated by ophthalmologists. Having a medical meaning, they already differentiate between free glaucoma persons vision, glaucomatous and glaucoma-suspected ones. The fuzzy engine includes six rules.

(1) IF the vertical ratio belongs to the normal class AND the horizontal ratio belongs to the normal class THEN the patients normal.
(2) IF the vertical ratio belongs to the normal class AND the horizontal ratio belongs to the glaucoma-suspected class THEN the patient is normal.
(3) IF the vertical ratio belongs to the glaucoma-suspected class AND the horizontal ratio belongs to the normal class THEN the patient is normal.
(4) IF the vertical ratio belongs to the glaucomatous class AND the horizontal ratio belongs to the glaucomatous class THEN the patient is glaucomatous.
(5) IF the vertical ratio belongs to the glaucomatous class AND the horizontal ratio belongs to the glaucoma-suspected class THEN the patient is glaucomatous.
(6) IF the vertical ratio belongs to the glaucoma-suspected class AND the horizontal ratio belongs to the glaucomatous class THEN the patient is glaucomatous.

4.1. **Final decision-making algorithm.** The fuzzy motor gives us as an output the abscissa of the resulting membership function gravity center. Based on this value and taking into account other factors, the final decision is taken.

5. Results and Diagnosis

The results were finally proposed with an efficient method of glaucoma recognition at an early stage so as to minimize the damage of optic nerve head.

Where, the system is studied based on the analysis of the instrumental parameters by taking into reference other important risk factors for glaucoma development. The application was developed in Visual Basic VB.net and uses the graphical library of Emgu.cv which allowed us to use the functions of Open CV for the image processing part. This forms a library where to develop all the functions and algorithms and exploited fuzzy logic techniques to aid diagnosis.

6. Discussion

For further validation of the process the calibration takes in few steps like performance, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy analysis is achieved and results are reported as a table or chart. For example, on the basis of the correct classification of test patterns, the following parameters are calculated using the following equations:

$$\text{Sensitivity(True Positive Rate)} = \frac{TP}{TP+FN}.$$

$$\text{Specificity(True Negative Rate)} = \frac{TN}{TN+FP}.$$

$$\text{Precision(Positive Predictive Value)} = \frac{TP}{TP+FP}.$$

$$\text{Negative Predictive Value} = \frac{TN}{TN+FN}.$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN}.$$

Here, TP, TN, FP and FN are defined as follows:

- True Positive (TP): Number of glaucomatous images classified as glaucomatous by our proposed classifier.
- True Negative (TN): Number of normal images classified as normal by the proposed classifier.
- False Positive (FP): Number of normal images classified as glaucomatous by the proposed classifier.
- False Negative (FN): Number of Glaucomatous images classified as normal by the proposed classifier.

REFERENCES

[1] A. SOLTANI , T. BATTIKH ET.AL.: *A new expert system based on fuzzy logic and image processing algorithms for early glaucoma diagnosis*, Biomedical Signal Processing and Control, **40** (2018), 366–377.

[2] A. AGARWAL, S. GULIA, S. CHAUDHARY, M.K. DUTTA, R. BURGET, K. RIHA: *Automatic Glaucoma Detection using Adaptive Threshold based Technique in Fundus Image*, 38th International Conference on Telecommunications and Signal Processing (TSP), Prague, 2015, 416-420. doi: 10.1109/TSP.2015.7296295

[3] V. BALANCIA, W. RAE, I. DUMITRACHE, M. CARAMIHAI: *Evaluation ofBreast Cancer Risk by using Fuzzy Logic*, University Politehnica of Bucharest Scientific Bulletin, Series C, **73**(1) (2011), 53-64.

[4] J. CHENG, J. LIU, B.H. LEE, D.W.K. WONG, F.Y.T. AUNG, M. BASKARAN: *Closed Angle Glaucoma Detection in RetCam Images*, Annual International Conference of the IEEE Engineering in Medicine and Biology, Buenos Aires, 2010, 4096-4099. doi: 10.1109/IEMBS.2010.5627290

[5] M. FAEZIPUR, M. andALOUDAT: *Determining the Thickness of the Liquid on the Cornea for Open and Closed Angle Glaucoma Using Haar Filter*, Long Island Systems, Applications and Technology, Farmingdale, NY, 2015, 1-6. doi: 10.1109/LISAT.2015.7160182

[6] G. HAVEESH, G. HEGDE, B. BHATKALKAR, S. PRABHU: *Glaucoma detection and its classification using image processing and fuzzy classification*, Proceedings of4th World Conference on Applied Sciences, Engineering & Technology. Kumamoto University, Japan, 24-26 October 2015. BRCORP. (2015), 291-295.

[7] N. INOUE, K. YANASHIMA, K. MAGATANI, T. KURIHARA: *Development of a simple diagnostic method for the glaucoma using ocular Fundus pictures*, IEEE Engineering in Medicine and Biology 27th Annual Conference, Shanghai, 2005, 3355-3358. doi: 10.1109/IEMBS.2005.1617196

[8] A. JOHN, A. SHARMA, H. SINGH, V. REHANI: *Fuzzy based decision making for detection of Glaucoma*, 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), Delhi, 2017, 1-6. doi: 10.1109/ICCCNT.2017.8204187

[9] B.N. KUMAR, R.P. CHAUHAN, N. DAHIYA: *Detection of Glaucoma using Image processing techniques*, International Conference on Microelectronics, Computing and Communications (MicroCom), Durgapur, 2016, 1-6. doi: 10.1109/MicroCom.2016.7522515

[10] K. VENGATESAN, S.B. MAHAJAN, P. SANJEEVIKUMAR, S. MOIN: *The Performance Enhancement of Statistically Significant Bicluster Using Analysis of Variance*, In: Konkani A., Bera R., Paul S. (eds) Advances in Systems, Control and Automation. Lecture Notes in Electrical Engineering, **442**. Springer, Singapore. https://doi.org/10.1007/978-981-10-4762-6_64

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