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Using Artificial Neural Network to Detect Glaucoma with the Help of Cup to Disk Ratio

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***Abstract* - Glaucoma is one of the major causes of blindness in the world. It is due to the increase in intra ocular pressure within the eyes. The detection and diagnosis of glaucoma is very important. There are various manual and automatic detection methods available. This paper proposes novel method to detect Glaucoma. This method makes use of feed forward Artificial Neural Network and Cup To Disk ratio to detect Glaucoma. It is observed that this method gives more accurate results than prior methods available. This paper talks about detail process of new method, its applications and future scope.**

***Index Terms*— Glaucoma detection, image processing, segmentation, feature extraction, classification, ANN, CDR**

I. INTRODUCTION

Glaucoma is a condition that causes damage to your eye's optic nerve and gets worse over time. It's often associated with a buildup of pressure inside the eye. Glaucoma tends to be inherited and may not show up until later in life. High amount of intra-ocularpressure (IOP) is one of the major danger components ofglaucoma disease.Accusative of present medicament access is to reduce (IOP) inside eyes to preventstructural anthropology damage [1].
The increased pressure, called intraocular pressure, can damage the optic nerve, which transmits images to the brain. If damage to the optic nerve from high eye pressure continues, glaucoma will cause permanent loss of vision. Without treatment, glaucoma can cause total permanent blindness within a few years.

There are two main types of glaucoma:

Open-angle glaucoma: Also called wide-angle glaucoma, this is the most common type of glaucoma. The structures of the eye appear normal, but fluid in the eye does not flow properly through the drain of the eye, called the trabecular meshwork.

Angle-closure glaucoma: Also called acute or chronic angle-closure or narrow-angle glaucoma, this type of glaucoma is less common in the West than in Asia. Poor drainage is caused because the angle between the iris and the cornea is too narrow and is physically blocked by the iris. This condition leads to a sudden buildup of pressure in the eye.

Valuation of retinal nerve fiber layer (RNFL) heaviness and ocular field arguments are important for the detection of glaucoma [2]. A variety of various possibilities admitting mechanical and vessel frameworks has been utilized for pathological process of glaucoma [3]. Glaucoma is the diagnosis given to a group of ocular conditions that contribute to the loss of retinal nerve fibers with a corresponding loss of vision. Glaucoma is said to be one of the leading causes of blindness in people over the age of 40. Loss of peripheral vision is the earliest symptom. Left untreated the field of vision will continue to narrow leading to tunnel vision. If detected early, loss of vision can most often be prevented. Low awareness and high costs connected to glaucoma are reasons to improve methods of screening and therapy. However due to latest technology now it is possible to stop the progression of glaucoma in patients [4].Usually we measure the optic nerve head (ONH) from four sides of regions such as inferior, superior, nasal and temporal and particularly on nasal side ONH is less important for observing the optic nerve damage than the rest of other regions of ONH.

There are various approaches available for glaucoma diagnosis among which cup-to-disc ratio (CDR) measurement is one of the major essential psychological arguments for early diagnosis of glaucoma [5]. Depending upon the size and shape of optic disc boundary, it is possible to detect glaucoma. Once optic disc has been identified, other regions of retinal images like fovea and macula can be easily determined [6]. Glaucoma can be derogated by proper treatment and early detection in fundus images [7]. Retina is a component of eye which acquires images and sends pictures to the brain. Optic disc segmentation helps in the identification of exudates because the colour of optic disc and lustrous exudates are same [9]. Due to glaucoma optic cup shape enlarges and thus ophthalmologists can easily identify glaucoma from fundus images [8].

II. DIFFERENT IMAGE PROCESSING METHODS TO DETECT GLAUCOMA

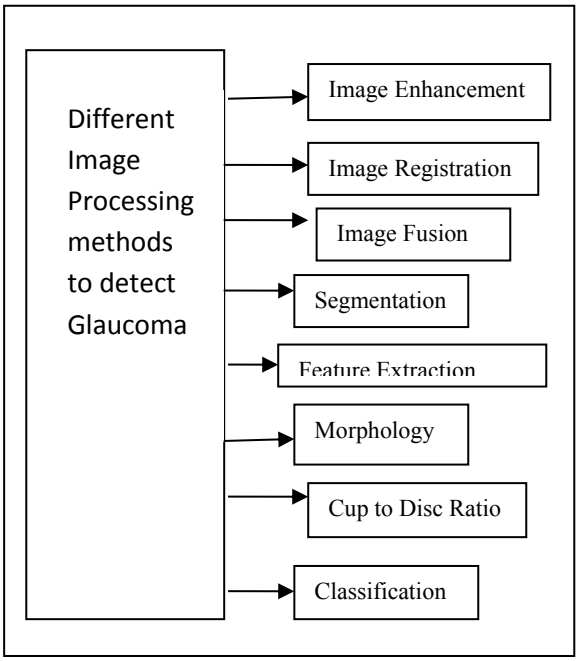


Fig. 1 Different Image Processing methods to detect Glaucoma

Various image processing techniques used in automated early diagnosis and analysis of various eye disease are Enhancement, Registration, Fusion, Segmentation, Feature extraction, Pattern matching, Classification, Morphology, Statistical measurements and Analysis.

Image Enhancement- Image enhancement includes varying brightness and contrast of image. It also includes filtering and histogram equalization. It comes under pre-processing step to enhance various features of image.

Image Registration- Image Registration is an important technique for change detection in retinal image diagnosis. In this process, two images are aligned onto a common coordinate system. Images may be taken at different times and with imaging devices In medical diagnosis, it is essential to combine data from different images and for better analysis and measurements images are aligned geometrically.

Image Fusion- Image fusion is a process of combining information acquired from number of imaging devices. Its goal is to integrate contemporary, multi sensor, multi-temporal or multi-view information into a single image, containing all the information so as to reduce the amount of information.

Feature Extraction- It is the process of identifying and extracting region of interest from the image.

Segmentation- Segmentation is the process of dividing an image into its constituent object and group of pixels which are homogenous according to some criteria. Segmentation algorithms are area-oriented instead of pixel oriented. The main objective of image segmentation is to extract various features of image which can be merged or split in order to build object of interest on which analysis and interpretation can be performed. It includes clustering, thresholding etc. .

Morphology - Morphology is the science of appearance, shape and organization. Mathematical morphology is a collection of non-linear processes which can be applied to an image to remove details smaller than a certain reference shape. Various morphological operations are erosion, dilation, opening and closing.

CDR (Cup to disc ratio) - The vertical cup-to-disc ratio (CDR) is one of the most important risk factors in the diagnosis of glaucoma [9].It is defined as the ratio of the vertical cup diameter over the vertical disc diameter. The optic disc is the location where the optic nerve connects to the retina. In a typical 2D fundus image, the optic disc is an elliptic region which is brighter than its surroundings. The disc has a deep excavation in the center called the optic cup. It is a cup-like area devoid of neural retinal tissues and normally white in color, OC of a glaucomatous eye tends to grow over time due to persistently increased intraocular pressure. As the OC grows, the neuroretinal rim located between the edge of the OD and the OC which contains optic nerve fibers becomes smaller in area. If the neuroretinal rim is too thin, vision will be deteriorated. Thus, quantitative analysis of the optic disc cupping can be used to evaluate the progression of glaucoma [10]. As more and more optic nerve fibers die, the OC becomes larger with respect to the OD, which corresponds to an increased CDR value. For a normal subject, the CDR value is typically around 0.2 to 0.3. Typically, subjects with CDR value greater than 0.6 or 0.7 are suspected of having glaucoma and further testing is often needed to make the diagnosis [11].

Neural Network for Classification

The Probabilistic Neural Network was developed by Donald Speech. Classification refers to the analysis of the properties of an image. Depending upon the analysis, the dataset is further referred into different classes. Input features are categorized as 0 and 1.The classification process is divided into two phases: training phase and testing phase . In the training phase, known data is given and in the testing phase, an unknown data is given. Classification is done by using classifier after the training phase [10].The Probabilistic Neural Network provides a general solution to pattern classification problems [11].

Classification - Classification is an important technique of image analysis for estimation of statistical parameter according to the gray level intensities of pixels. It includes labeling of a pixel or group of pixels based on the grey values and other statistical parameters. For understanding

the contents of an image, image analysis functions are used [4]. The proposed method focuses on optic disk and cup segmentation.

III. LITERATURE REVIEW

Many researchers proposed their work by using above mentioned image processing methods to detect Glaucoma. Review of few is as below –

Mary et al. [12] implemented a technique for glaucoma detection where optic disc segmentation via pyramidal decomposition is carried out on the retinal images which gives a better performance than other algorithms. It is important to note that although Pyramidal decomposition method with the help of Hough transform is guaranteed to converge though it is very sensitive to noise. So, multiple initializations are being used to yield a better performance. Finally, they have proposed a model approach using discriminant analysis which has shown an improvement over the rest.

L´aszl´o G. Ny´ul [13] devised a novel automated glaucoma classification technique, depending on image features from fundus photographs. In this study, data-driven technique does not need any manual assistance. The system does not depend on explicit structure segmentation and measurements. First of all size differences, non uniform illumination and blood vessels are eliminated from the images. They then extracted the high dimensional feature vectors. Finally compression is done using PCA and the combination before classification with SVMs takes place. The Glaucoma Risk Index (GRI) produced by the proposed system with a 2-stage SVM classification scheme achieved 86% success rate. This is comparable to the performance of medical experts in detecting glaucomatous eyes from such images. Since GRI is computed automatically from fundus images acquired by an inexpensive and widely available camera it is suggested that the system could be used in glaucoma mass screenings.

Grau et al. [14] developed a new segmentation algorithm, depending on the expectation-maximization. This algorithm used an anisotropic Markov random field (MRF). In this study, structure tensor had been used to characterize the predominant structure direction as well as spatial coherence at each point. This algorithm had been tested on an artificial validation dataset that is similar to ONH datasets. It has shown significant improvement over an isotropic MRF. This algorithm provides an accurate, spatially consistent segmentation of this structure.

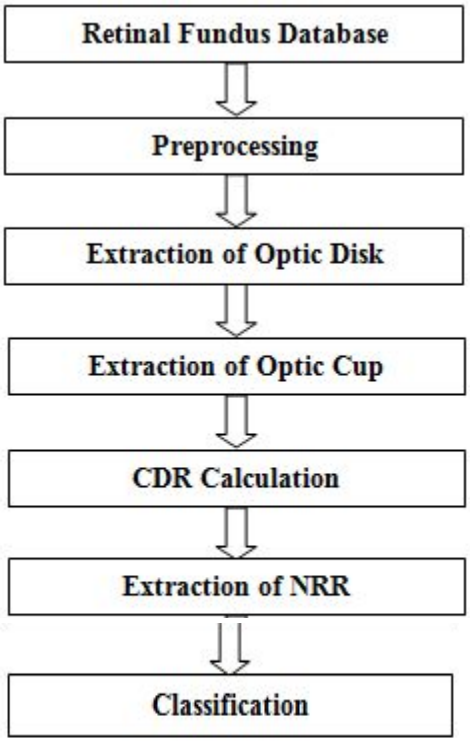
Bock et al. [15] developed an automated glaucoma classification system that does not at all depend on the segmentation measurements. They had taken a purely data-driven approach which is very useful in large-scale screening. This algorithm undertakes a standard pattern recognition approach with a 2-stage classification step. In this study, various image-based features were analyzed and integrated to capture glaucomatous structures. There are certain disease independent variations such as size differences, illumination in homogeneities and vessel structures which are removed in the preprocessing phase. This system got 86% success rate on a data set of 200 real images of healthy and glaucomatous eyes.

IV. PROPOSED METHOD

This paper proposes new method which improves end results of detecting glaucoma. This method makes use of Artificial Neural Network and Cup to Disk Ratio to process the fundus image.

Below sections give brief about this method.

V. FUNCTIONAL FLOW DIAGRAM OF THE SYSTEM



Let's discuss each step in detail.

1. Retinal Fundus Database

To develop the algorithm for automatic detection of glaucoma, the first essential step was to obtain the effective

database and for that purpose 90 retinal images were collected in total from various online databases. In which, 30 images from High Resolution Fundus image database and 20 from optic-disc.org database images and rest all from other different online databases including DROINS. The 2D fundus digital image is taken by a fundus camera, which photographs the retinal surface of the eye. In comparison with OCT/HRT machines, the fundus camera is easier to operate, less costly, and is able to assess multiple eye conditions. Many researchers have utilized the fundus images to automatically analyze the optic disc structures.

2. *Image Preprocessing*

In color retinal images, Optic disc appears to be the brightest part having pink or light orange color and is considered to be Region of Interest (ROI). ROI is the region around the optic disc that must first be delineated, as the optic disc generally occupies less than 5% of the pixels in a typical retinal fundus image. While the disc and cup extraction can be performed on the entire image, localizing the ROI would help to reduce the computational cost as well as improve segmentation accuracy. The ROI from all images is crop down and is resized to 256×256 as shown in Fig.2 [1]

Fig. 2 Resized Image

3. *Extraction of Optic Disk and Cup*

To suspect glaucoma, evaluation of CDR is one of the key elements, which is calculated by the extraction of optic disc and cup. Firstly, the original colored fundus image was cropped and resized. In next step, blood vessels are removed from the image. For this morphological operation such as the dilation, erosion, is performed as defined in equation (1) and (2). Dilation causes objects to grow in size by adding pixels to the boundaries of the object in the input image. Image is dilated by using the structuring element "DISK". This dilation results in filling all internal gaps and lighting blood vessels but increasing the size of optic disc which will affect the CDR. For this after dilation the image is being eroded by same structuring element and size. Erosion is done to contrast the boundary of the object. The result of this operation has a smooth image without any blood vessels.

The dilation of A by B is defined by:

$$A \oplus B = \bigcup_{b \in B} A_b \quad ---(1)$$

The erosion of A by B is defined by:

$$A \Theta B = \bigcup_{b \in B} A_{-b} \quad ---(2)$$

Where A: binary image

B: Structuring element

After that, a number of images were analyzed and it was concluded that optic disc has a better contrast in V plane extract from HSV image. After calculating the mean value of the V plane image; this value was set as threshold for converting it to binary image. The unwanted objects obtained in resultant binary image were labeled and removed by applying another morphological operation which removes from a binary image all connected components (objects) that have fewer than some pixels value. This helps in removing all the unwanted objects except the optic disc.Further the Gaussian filter is applied to the resultant image to smoothen the boundaries of the images as shown in fig. 3

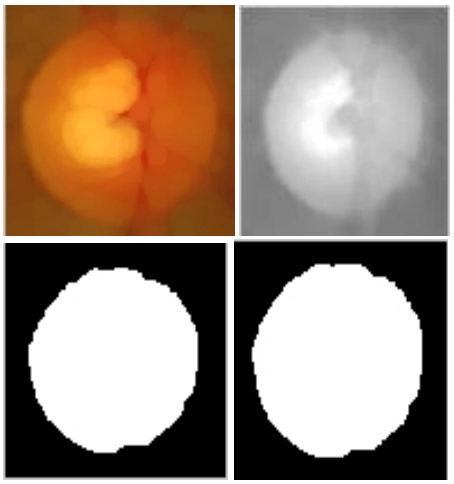


Fig. 3 Extraction of optic disk

(a) Morphological operations(b) V plane image (c) Binary Image(d) Gaussian filtered image

For the extraction of cup, green plane is extracted from the eroded image; the cup has much brighter contrast as compared to other regions of fundus image. In next step, green plane is converted into gray scale image by using global threshold which chooses the threshold to minimize the intraclass variance of the black and white

pixels. After extracting the binary optic cup morphological operation i.e. for removal of small objects is applied same as optic disk but with less pixel value as cup size is small. To smoothen the boundaries of optic cup, Gaussian filter is applied to the resultant binary image of the optic cup

4. *CDR Calculation*

The area is calculated by counting the number of white pixels after that, the area of cup is divided by the area of disc to calculate CDR. [1]

CDR = Cup Area/ Disk Area

5. *Extraction of Neuroratinal Rim*

Extraction of NRR is another feature used for the detection of glaucoma. Loss of axons in Glaucoma is reflected as abnormalities of the neuroretinal rim. Identification of the neuroretinal rim width in all sectors of the optic disc is of fundamental importance for detection of diffuse and localized rim loss in glaucoma. The rim width is calculated using ISNT rule. [1]

6. *Feed Forward Neural Network*

A feed forward neural network is an artificial neural network wherein connections between the units do not form a cycle. This is different from recurrent neural networks.

The feed forward neural network was the first and simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network.[12]

7. *Classification*

Classification has been done on bases of two features i.e. CDR and NRR ratio in ISNT quadrants. Disc which is normal has CDR less than 0.5 and it obeys the ISNT rule i.e. the sum of the area in inferior and superior region is more than nasal and temporal region whereas the glaucoma tic disc violates ISNT rule and has CD ratio greater than 0.5. After that, images are feed into the neural network is which classify them on the basis of above features. [1]

VI. ANN TRAINING

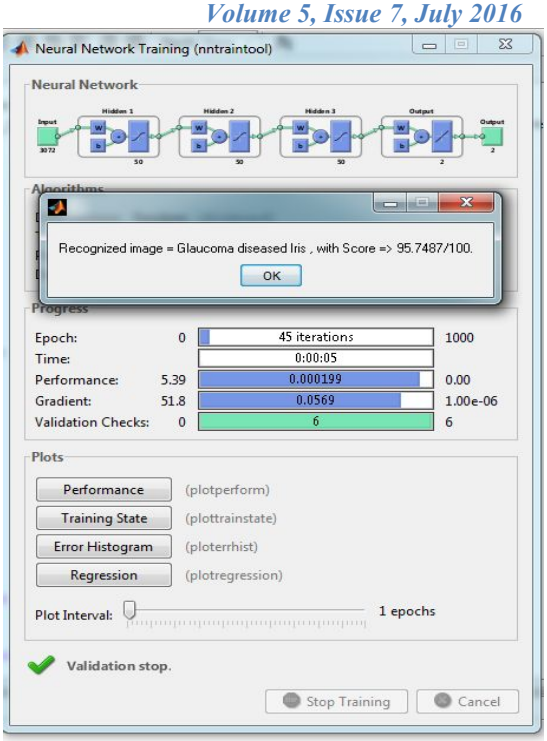


Fig. 4 Window of Neural Network Training

Once the network weights and biases are initialized, the network is ready for training. The training process requires a set of examples of proper network behaviour network inputs and target outputs. During training the weights and biases of the network are iteratively adjusted to minimize the network performance function. The default performance function for feed forward networks is mean square error (mse), the average squared error between the networks outputs and the target outputs. All these algorithms use the gradient of the performance function to determine how to adjust the weights to minimize performance. The gradient is determined using back propagation, which involves performing computations backward through the network.

There are generally four steps in the training process:

1) Assemble the training data.

2) Create the network object.

3) Train the network.

4) Simulate the network response to new inputs. [2]

VII. CONCLUSION

In this paper we have done the detection of Glaucoma disease. Here MATLAB has been used for training & simulating the ANN to detect the glaucoma. The CDR &feed forward propagation artificial neural network has been used & these parameters are extracted using MATLAB & are compared with standard values & the result is given.

The ANN provides simplicity of operation in the system. This software will help the doctors to easily detect the glaucoma disease.

VIII. APPLICATIONS

Application areas include the system identification and control (vehicle control, trajectory prediction, process control, natural resources management), quantum chemistry, game-playing and decision making (backgammon, chess, poker), pattern recognition (radar systems, face identification, object recognition and more), sequence recognition (gesture, speech, handwritten text recognition), medical diagnosis, financial applications (e.g. automated trading systems), data mining (or knowledge discovery in databases, "KDD"), visualization and e-mail spam filtering.

Artificial neural networks have also been used to diagnose several cancers. An ANN based hybrid lung cancer detection system named HLND improves the accuracy of diagnosis and the speed of lung cancer radiology.These networks have also been used to diagnose prostate cancer. The diagnoses can be used to make specific models taken from a large group of patients compared to information of one given patient. The models do not depend on assumptions about correlations of different variables. Colorectal cancer has also been predicted using the neural networks. Neural networks could predict the outcome for a patient with colorectal cancer with more accuracy than the current clinical methods. After training, the networks could predict multiple patient outcomes from unrelated institutions [12]

IX. FUTURE SCOPE

By taking more eye parameters the ANN can be used to detect more eye diseases in the future

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