Design of algorithms for diagnosis of primary glaucoma through estimation of CDR in different types of Fundus Images using IP techniques

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Abstract-- Glaucoma is a silent thief of sight which is characterized by elevated intraocular pressure, slow vision loss leads to permanent blindness. Although the disease is incurable but its symptoms can be minimized therefore early detection of the disease is essential. It is a very expensive process to detect the disease using the modern tools as a result of which we are developing a methodology for detection such that it is affordable by all the sections of the society, also it can be detected at the early stage and prevention can be taken. Hence, proposing a novel methodology for primary glaucoma detection by developing software algorithms in Matlab, which focuses on automated detection of glaucoma from fundus images using CDR calculation.

1. INTRODUCTION

In this section, a brief review of the concepts relating to the glaucoma disease, its detection, etc... & its types are being presented.

1.1 OVERVIEW OF GLAUCOMA

Glaucoma damages the optic nerve which leads to permanent blindness. It cannot be cured, so detecting the disease in time is very important. Glaucoma is one of the most severe eye diseases according to the number of blindness causes in India and western countries and is the second most leading eye disease. Therefore, the early detection, long-term monitoring of the patients and the decision about the appropriate therapy at the correct time are the serious tasks for the ophthalmologist. This earlier detection of deadly diseases has been proposed using advanced image processing, analysis and recognition techniques. This state of art techniques had already been assisted doctors in various fields such as earlier detection and diagnosis of diseases, clinical decisions, remote sensing surgeries and so forth. In short to say, glaucoma is a chronic eye disease in which optic nerve is progressively damaged & slowly starts to cause sight loss. In its early stages, there is no pain and patients often have no symptoms. Over time glaucoma starts to affect your side/peripheral vision and slowly works its way to the middle if left undetected. According to World Health Organization (WHO), Glaucoma is the second leading cause of vision loss; that contributes to approximately 5.2 million cases of blindness (15% of total blindness cases reported) and can potentially affect ~80 million people in the next decade. To date, there is no cure for glaucoma. Fortunately, it is usually a slow progressing condition, and if it is detected early, it can be treated successfully. Early detection is the key for preventing sight loss. It is characterized by the progressive degeneration of optic nerve fibers and leads to structural changes of the optic nerve head, which is known as optic disk, the nerve fiber layer and a simultaneous functional failure of the visual field. Progression of the disease leads to loss of vision, which occurs gradually over a long period of time. Glaucoma cannot be cured, but its progression can be slowed down by treatment. Therefore, detecting glaucoma in time is critical. However, many glaucoma patients are unaware of the disease until it has reached its advanced stage. In India, there are now an estimated 12 million people affected by glaucoma, the majority of whom are undiagnosed.

Fig. 1: Normal Disc, Glaucomatic Disc, ISNT Quadrants
By 2020, this is expected to be 16 million. Since glaucoma progresses with few signs or symptoms and the vision loss from glaucoma is irreversible, screening of people at high risk for the disease is vital. The difference between the normal eye & the affected eye is shown in the Fig. 1 & 2 respectively. The Fig. 3 shows the enlarged view of the normal eye & the affected eye with glaucoma.

1.2 Anatomy of the Normal Eye

An anatomy of human eye is approximately a spherical organ & is shown in the Fig. 4. The protective outer layer of the eye is called the sclera. The other components of the eye are regions such as cornea, lens, iris, and the retina. The retina is the light-sensitive tissue that lines the inside of the eye. The optical elements within the eye focus an image onto the retina of the eye, initiating a series of chemical and electrical events within the retina. Nerve fibers within the retina send electrical signals to the brain, which then interprets these signals as visual images. Retina is approximately 0.5 mm thick and covers the inner side at the back of the eye. The center of the retina is the optical disc, a circular to oval white area measuring about 3 mm² (about 1/30 of retina area). The mean diameter of the blood vessels is about 250 μm. The main retinal components numbered in Fig. 4 could be listed as:

1. Superior temporal blood vessels,
2. Superior nasal blood vessels,
3. Fovea,
4. Optic disc,
5. Inferior temporal blood vessels and
6. Inferior nasal blood vessels.

In the work considered, our ROI (Region of Interest) is the optic disc or optic nerve head, which is shown in in the Fig. 5. This is the location where ganglion cell axons exit the eye to form the optic nerve. There are no light sensitive rods or cones to respond to a light stimulus at this point. This causes a break in the visual field called “the blind spot” or the “physiological blind spot”.
The optic disc represents the beginning of the optic nerve and is the point where the axons of retinal ganglion cells come together. The optic disc is also the entry point for the major blood vessels that supply the retina. The optic nerve head in a normal human eye carries from 1 to 1.2 million neurons from the eye towards the brain. Glaucoma is a term that describes a group of eye conditions that affect vision. Glaucoma often affects both eyes, usually in varying degrees. One eye may develop glaucoma quicker than the other. Glaucoma occurs when the drainage tubes within the eye become slightly blocked. This prevents eye fluid from draining properly. When the fluid cannot drain properly, pressure builds up. This is called intraocular pressure. This can damage the optic nerve (which connects the eye to the brain) and the nerve fibres from the retina (the light-sensitive nerve tissue that lines the back of the eye), thus leading to loss of vision.

The cup-to-disc ratio is a measurement used in ophthalmology and optometry to assess the progression of glaucoma. The optic disc is the anatomical location of the eye’s blind spot. It is the area where the optic nerve and blood vessels enter the retina. The optic disc can be flat or it can have a certain amount of normal cupping. But glaucoma, which is due to an increase in intraocular pressure, produces additional pathological cupping of the optic disc. The pink rim of disc contains nerve fibers. The white cup is a pit with no nerve fibers. As glaucoma advances, the cup enlarges until it occupies most of the disc area. The cup-to-disc ratio compares the diameter of the ‘cup’ portion of the optic disc with the total diameter of the optic disc. The hole represents the cup and the surrounding area the disc. If the cup fills 1/10 of the disc, the ratio will be 0.1. If it fills 7/10 of the disc, the ratio is 0.7. The normal optic disc cup-to-disc ratio if less than 0.3 and greater than 0.3 cup-to-disc ratio also implies glaucoma. However, cupping by itself is not indicative of glaucoma; rather, an increase in cupping as the patient ages also is an indicator for the cause of glaucoma.

1.3 Types of Glaucoma:
In this section, different types of glaucomas are discussed as below. These are marked by an increase of intraocular pressure (IOP) or pressure inside the eye. **Open-Angle Glaucoma:** It is the most common form of glaucoma, accounting for at least 90% of all glaucoma causes: It is caused by the slow clogging of the drainage canals, resulting in increased eye pressure it has a wide and open angle between the iris and cornea it develops slowly and is a long life condition its symptoms and damages are not noticed. Open-angle means that the angle where the iris meets the cornea is as wide and open as it should be. Open-angle glaucoma is also called primary or chronic glaucoma. **Angle-Closure Glaucoma:** It is a less common form of glaucoma caused by blocked drainage canals; resulting in a sudden rise in intraocular pressure it has a closed or narrow angle between the iris and cornea. Develops very quickly it has symptoms and damage that are usually very noticeable. Demands immediate medical attention. It is also called acute glaucoma or narrow angle glaucoma. Unlike open-angle glaucoma, angle-closure glaucoma is a result of the angle between the iris and cornea closing.

**Normal Tension Glaucoma:** It is also called as low tension or normal-pressure glaucoma. It is a form of glaucoma in which damage occurs to the optic nerve without eye pressure exceeding the normal range (10-20mmHg). Congenital Glaucoma: This type of glaucoma occurs in babies when there is incorrect or incomplete development of the eye’s drainage canals during the parental period. This is a rare condition that may be inherited. It is also referred as childhood glaucoma, pediatric or infantile glaucoma. It is usually diagnosed within the first year of baby life. **Primary Glaucoma:** The primary glaucoma is mainly due to increase in the Intra Ocular Pressure (IOP). The regions affected are Optic cup, Optic Nerve Head, Neuroretinal Rim and Retinal Nerve Fiber Layer. **Secondary Glaucoma:** Secondary glaucoma (SG) arises due to certain complicated conditions like serious eye injury, tumour, diabetes, etc. Neuro-vascular glaucoma is a type of secondary glaucoma which is a resultant of Diabetic Retinopathy.

**Neovascular glaucoma:** Neovascular glaucoma is caused by the abnormal formation of new blood vessels on the iris and over the eye's draining channels. Neovascular glaucoma is always associated with diabetes. It never occurs on its own. The new blood vessels block the eye's fluid from exiting through the trabecular meshwork causing an increase in eye pressure.

**Exfoliate Glaucoma:** occurs when a flaky, dandruff-like material peels off the outer layer of the lens within the eye.
The material collects in the angle between the cornea and iris and can clog the drainage system of the eye, causing eye pressure to rise.

**Pigmentary Glaucoma:** occurs when the pigment granules that are in the back of the iris break into the clear fluid produced inside the eye. These tiny pigment granules flow toward the drainage canals in the eye and slowly clog them, causing eye pressure to rise. A brief review of the various types of glaucoma was discussed in the previous sections. In this context, we are going to find out the CDR for healthy & unhealthy images along with the establishment of some relationships between various parameters.

The following sections discuss the conventional methods for glaucoma detection and the associated drawbacks.

### 1.4 Conventional Glaucoma Diagnosis Methods

The methods adopted by ophthalmologists to detect glaucoma are: (1) Intra Ocular Pressure (IOP) measurement (2) Estimation of Cup to Disk Ratio (CDR) (3) Assessment of the Retinal Nerve Fiber Layer (RNFL) loss and (4) Visual Field Test. All together these methods give information on both structural and functional deficits.

### 1.5 Drawbacks of Conventional Methods

IOP is measured using a Tonometer. For a healthy eye, the IOP range is 10-20 mmHg, whereas for the unhealthy eye the range exceeds the upper limit. In some cases, even though the IOP is within the healthy range, the eye might be affected with glaucoma (Normal tension glaucoma). This is a failure of the conventional existing method. Cup Disk Ratio (CDR) is also a parameter for the glaucoma detection. Specified range of CDR for healthy retina is within the range of 0.1-0.5, whereas for glaucomatous (Unhealthy) retina, the CDR is in the range of 0.6-1.0. Sometimes glaucoma was found within the normal range of CDR. This contributes to the failure of existing clinical (conventional) method. The quantification of Retinal Nerve Fiber Layer (RNFL) thickness is also an efficient parameter for the detection of glaucoma. The specified thickness of RNFL for healthy retina is in the range of 70-140 µm, whereas for glaucomatous retina, the thickness is below 70 µm. This approach demands the usage of costly equipments like Optical Coherence Tomography (OCT). Also, the availability of such image acquisition systems is limited to only corporate hospitals. Common people are deprived of these facilities. The procedure of Visual Field Testing is an indicator of the visual functional characteristics. It also takes various examinations to arrive at the baseline and further follow ups to determine the visual characteristics. Moreover the glaucoma disease is detected through this procedure only after 40% of the progression. The accuracy of this method is still in question.

### 1.6 Modern Glaucoma Diagnosis Methods & Lacunas

Various modern methods are being developed currently for the efficient detection of glaucoma using CDR, to name them, OCT, HRT. A brief overview of the same is presented in the following sentences. Optic nerve assessment is thus able to detect glaucoma early and is currently performed by a trained glaucoma specialist, or using specialized expensive equipment such as the OCT (Optical coherence tomography) and HRT (Heidelberg Retinal Tomography) systems. However, optic disc assessment by an ophthalmologist is subjective and the availability of OCT/HRT is limited because of the cost involved. 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. Couple of drawbacks exists in the modern glaucoma diagnosis detection methods such as requirement of trained personnel, specialists for the operation of the equipments, cost involvement is very high, which is not a feasible factor in the rural areas & the poorer section. As a contrary, we are trying to develop a low cost strategy for the detection of glaucoma using the CDR concept.

#### II. Literature Survey

Glaucoma disease in human beings is considered as one of the important diseases which affects the nervous systems & may lead to the loss of vision. Glaucoma damages the optic nerve which carries visual information to the brain. The brain can recognize the objects in the foreground and in the background or at a certain distance with the help of eyes. The damage to the optic nerve leads to permanent blindness or to loss of vision. So, detection of glaucoma plays an important role in order to prevent the loss of vision. It is often, but not always, associated with increased pressure of the fluid in the eye. The nerve damage involves loss of retinal ganglion cells in a characteristic pattern. There are many different sub-types of glaucoma but they can all be considered as a type of optic neuropathy. Raised intraocular pressure is a significant risk factor for developing glaucoma (above 22 mmHg or 2.9 kPa). One person may develop nerve damage at a relatively low pressure, while another person may have high eye pressure for years and yet never develop damage. Untreated glaucoma leads to permanent damage of the optic nerve and resultant visual field loss, which can progress to blindness. Extensive research is being carried out on the glaucoma issues in the world at various research centres till date. A number of researchers have worked on the topic so far, some of them have advantages & some of them dis-advantages. A brief exhaustive review of the similar work done in the relevant chosen field by different authors is summarized as follows…….

Currently, ophthalmologists use 3 methods to detect glaucoma, viz.,

- **One is the assessment of increased pressure inside the eyeball.**
- **Second is the assessment of abnormal vision.**
- **The third method is assessment of the damage to the head of the optic nerve.**
The first method is not sensitive enough to detect glaucoma early and is not specific to the disease, which sometimes occurs without increased pressure. The assessment of abnormal vision requires specialized equipment rendering it unsuitable for widespread. It is the most reliable but requires a trained professional and is time consuming, expensive and highly subjective. Third assessment of the damaged optic nerve head is more promising and superior to IOP measurement or visual field testing for glaucoma diagnosis. Optic nerve head assessment can be done by a trained professional. Early detection and prevention is the only way to avoid total loss of vision. In healthy eyes, there is normal balance between the fluids, one that is produced in the eye, and the second that leaves the eye through eye’s drainage system. This balance of fluids keeps Inter Ocular Pressure (IOP) within the eye constant but in glaucoma, the balance of fluids produced within the eye is not maintained properly which in turn causes an increase in IOP, resulting in the damage of optic nerve.

The diagnostic criteria for primary glaucoma include:
- intraocular pressure measurement,
- optic nerve head evaluation,
- retinal nerve fibre layer and
- visual field defect.

The concept of ANN Glaucoma Detection using Cup-to-Disk Ratio and Neuroretinal Rim was developed by Kurnika & Shamilik in their research paper. In this paper glaucoma is classified by extracting two features using retinal fundus images.

- **Cup to Disc Ratio (CDR).**
- **Ratio of Neuroretinal Rim in inferior, superior, temporal and nasal quadrants that is to say ISNT quadrants.**

Madhusudhan Mishra et al., proposed a method to detect the glaucoma of the retinal color funds image by calculating the Cup-to-Disk Ratio (CDR). In order to estimate the CDR, the authors had employed active counter algorithm & they tested their algorithm for 25 images, which yielded excellent results. However, they didn’t attempt for loss of retinal nerve fiber layer, which was a high risk factor in glaucoma as this would have led to diabetics and myopia (these problems were not dealt with here).

K. Narasimhan & K. Vijayarekha described the early detection of glaucoma relating to the increase in the optic disc cup size. They developed a K-mean clustering algorithm to extract region of interest, that is optic-disc and region of optic cup. Then, their proposed method (elliptical fitting method) was applied to determine the cup to disc ratio. It was observed from their result that if the ratio is \(< 0.3\), then it was considered as a healthy retina. If the ratio is \(> 0.3\), then it is suspected to be glaucoma. The authors used 4 different masks to segment and to compute ISNT ratio. However, they did not attempt for large data base and also did not try for retinal nerve fiber.

Chisako Muramatsu, et al. worked extensively on the determination of cup and disc ratio of optical nerve head for diagnosis of glaucoma on stereo retinal fundus image pairs. The disc areas determined by the computerized method agreed relatively well with those determined by the ophthalmologist, whereas the agreement for the cup areas was somewhat lower. When C/D ratios were employed for distinction between the glaucomatous and non-glaucomatous eyes, the area under the receiver operating characteristic curve (AUC) was obtained as 83 %. The computerized analysis of ONH was found to be useful for diagnosis of glaucoma. However, authors did not try for large database and medulated RNFL loss images.

Feroui A., M. Messadi, I. Hadjid J. & A. Bessaid indescribed a new segmentation method for exudate detection in color fundus images using mathematical morphology and the k-means clustering algorithm. This approach was tested on a set of 50 ophthalmologic images. The obtained results were compared with manual segmentation by an ophthalmologist. However, authors didn’t attempt on glaucomatous retinal image segmentation.

Kittipol Wisaeng, et al. developed algorithms for automatic optic disc detection from low contrast retinal images. The OD detection algorithm was based on combination of mathematical morphology and Otsu’s algorithms. The proposed method was evaluated using the publicly available STARE project’s dataset, containing 81 retinal images of both normal and diseased retinal images. 91.35 % of the STARE database images were detected correctly, but using the local dataset, the percentage detection of OD was 97.61 %. But, the authors didn’t try for retinal images like high myopia, diabetes and hyper tension images.

Gopal Datt Joshi, Jayanthi Sivaswamy and S.R. Krishnadas developed a novel method for optic disk and cup segmentation from monocular color retinal images for glaucoma assessment. The authors adopted an automatic OD parameterization technique which was based on segmented OD and cup regions that were obtained from monocular retinal images. A novel OD segmentation method was proposed by them which integrated the local image information around each point of interest in multi-dimensional feature space. This was used to provide robustness against variations found in and around the OD region. They also proposed a novel cup segmentation method which was based on anatomical evidences such as vessel bends at the cup boundary, which is considered the most relevant evidence by the glaucoma experts.

Bends in a vessel are robustly detected using a region of support concept, which automatically selects the right scale for analysis. A multi-stage strategy was employed to derive a reliable subset of vessel bends called r-bends. This was followed by a local spline fitting which was used to derive the desired cup boundary. The estimation error of the method for vertical cup-to-disk diameter ratio was 0.09/0.08 (mean/standard deviation), while for cup-to-disk area ratio, it was 0.12/0.10.
H. Yu, E.S. Barriga, et al. developed a novel method to diagnose the retinal diseases by using fast & automatic optic disk location and segmentation methods. Vessel patterns on the optic disk (OD) were used to determine the OD locations. Optic disk radius was computed after locating the center of OD. The optic disk was segmented using hybrid level-set model, which combined the local gradient information along with region information of the optic disk. The algorithm in their case was tested on a messidor database and they achieved 99% accuracy. However, they didn’t attempt on the classification of glaucoma or non-glaucoma retinas.

Tatijana Stosic and Borko D. Stosic showed that vascular structures of the human retina represented geometrical multi-fractals which were characterized by a hierarchy of exponents rather than a single fractal dimension. Multi-fractal behavior w.r.t. the human retina was observed, where capacity dimension (CD) was found to be larger than the information dimension (ID). The ID obtained in turn was found to be larger than the correlation dimension (COD). Finally, all the three dimensions were found to be significantly lower than the diffusion limited aggregation (DLA) fractal dimension method. However, they did not attempt for classification of healthy and glaucoma retinal images. In majority of the work done by the various authors presented in the previous paragraphs, there were certain drawbacks / disadvantages / lacunas such as consideration of only vertical cup-disc ratio, fractional CDR, use of conventional methods, noisy images, dimension concepts, etc. Couple of these drawbacks are going to be considered in our project work & new algorithms are going to be developed to detection the full diameter of the cup to disc for healthy & unhealthy images along with the establishment of relationship between various eye parameters.

2. OBJECTIVES OF THE PROJECT WORK

The main objective of the M.Tech. dissertation work is to develop some novel algorithms for

- The diagnosis of primary glaucoma through estimation of CDR in different types of fundus images (healthy & unhealthy images).
- Determination of RNFL using OCT techniques.
- To develop the relation between CDR & RNFL (Retinal Nerve Fiber Layer Thickness).
- Developing relationship between age and CDR & effective detection of glaucoma.

The above mentioned objective of our dissertation work is achieved using the following steps:

1. Collecting images of human eyes (Both healthy and unhealthy) using appropriate image capturing devices.....a large number of samples (data base of image collection) from various sources from hospitals & image databases.
2. Preparation of desired image data bases using state-of-art techniques.
3. Performing Image pre-processing (segmentation, enhancement), processing, and analysis and application of mathematically developed equations in spatial & frequency domains.
4. Preparation of features vectors, extracting from step 3.
5. Extracting and preparing features vector, for query eye image as followed in step 3, and 4.
6. Diagnosis of eye glaucoma by comparing of data base feature vector (step 3) and currently obtained feature vector (step 5).
7. Using OCT (an sophisticated instrument), determination of the RNFL.
8. Establishing a relation between the determined CDR & RNFL for different types of images, the same strategy to be adopted w.r.t. age of human beings & the CDR.

Retinal Image 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 from www.optic-disc.org database images and rest all from other different online databases including DROINS& DRISHTI GS Database.

Image Pre-processing : 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

Extraction of Optic Disc 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.

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.
RNFL: The retinal nerve fiber layer (nerve fiber layer, stratum opticum, RNFL) is formed by the expansion of the fibers of the optic nerve; it is thickest near the porus opticus, gradually diminishing toward the ora serrata. Structural changes in glaucoma can be detected with different imaging tools, including optical coherence tomography (OCT).

Software tool used: The software tool that is used for the project work is Matlab 14 with Simulink modeling & the Image Processing tool box & the same thing could be implemented in Labview & Scilab also.

III. MOTIVATION / PROBLEM STATEMENT DEFINITION

The motivation for carrying out the project work is depicted in this section along with the problem statement. Doctors are finding problems in the earlier detection of infected region in case of eye glaucoma disease as it is the 2nd most affected disease in the world to which many people are falling victims. At the same time it is a very expensive process to detect the disease using the modern tools as a result of which we are developing a methodology for detection such that it is affordable by all the sections of the society, also it can be detected at the early stage & prevention can be taken. Hence in continuation, with zeal of this work, we are proposing a novel methodology for primary glaucoma detection by developing some software algorithms in Matlab; the problem finally, being defined as “Design & implementation of algorithms to diagnose of primary glaucoma through estimation of CDR in different types of fundus images”.

IV. PROPOSED METHODOLOGY

The proposed methodology that is going to be used in our project work is presented in this section. The proposed methodology adopted in the present project work is depicted in the Fig. 6 in a very highly abstracted manner with various blocks numbered as 1 through 9, which are explained as follows.

Fig. 6 : Block-diagram of the proposed methodology

1. Block 1 gives the information about the data base stage (explains procedure adopted to collect set of eye images).
2. In block 2 the data base stage is pre-processed.
3. Further, the pre-processed stage is segmented using some novel segmentation algorithm in stage 3 (block-3).
4. Block-4 stage explains the further segmentation of the optic cup.
5. The feature extraction of the CDR (cup to disc ratio) is determined in the stage-5 (block-5).
6. Using the segmented data from the block-5, the relation between the CDR & the age is determined in stage 6.
7. The relation between the CDR & RNFL is also determined in the stage-7.
8. In block-8, the classification using different types of novel algorithms is done.

Finally, the result is obtained and will be presented in the stage-9, which concludes the effectiveness of proposed methodology developed by us.

V. POSSIBLE OUTCOME / EXPECTED RESULT

The outcome of this project work has got wide application in the earlier detection of eye glaucoma using state of art of image technologies with cost-effectiveness. This is one the approach where very less human interaction giving rise to highly hygienic process & making the system identification fully automatic. The expected results or the outcome of the project work could be summarized as follows...

- **Primary glaucoma can be detected using CDR (considering the whole area of the cup-disc of the healthy & unhealthy eye).**
- **Relations can be developed between CDR & RNFL, whether the relationship between CDR & RNFL is directly proportional or indirectly proportional.**
- **Relations can be developed between age of humans & the CDR, whether the relationship between CDR & age is directly proportional or indirectly proportional.**

VI. APPLICATIONS OF OUR PROJECT WORK

The project work can be developed w.r.t. rural community with less experienced doctors even in the field of eye diagnosis. It can also be used in public places so that the human being who is affected with glaucoma can be detected immediately, precaution could be given so that the proper diagnosis can be done.
VII. CONCLUSIONS

A brief review of the work related to the project undertaken was depicted in the previous sections in the form of introduction, followed by literature survey. The objectives of the project work was also explored & arrived at the definition of the problem that had to be tackled with. Methodology is proposed in the form of a block diagram to solve the above defined problem using Matlab and to arrive at the expected results.

REFERENCES