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A Proposed Framework for diagnosis of Glaucoma - A Data mining Approach

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Abstract—Glaucoma is one of the leading diseases of eye which leads to vision loss in patients. The early detection of glaucoma can help prevent the loss of vision in the patient. Here, we propose a framework which will be able to help in early detection and diagnosis of glaucoma using perimetry data and Optical Coherence Tomography (OCT) images. The co-relation between perimetry and OCT data will be evaluated and the resultant data will be used as an input for the diagnostic system. The system will be able to identify the normal and glaucomatous eye, it will also be able to predict the progression of glaucoma.

Keywords—Glaucoma, OCT image, Perimetry, Data mining techniques.

I. INTRODUCTION

Glaucoma is the second leading cause of blindness after cataracts and its detection is essential to prevent visual damage. Glaucoma causes 12.8 per cent of the total blindness in the country. In India, more than 90 per cent of glaucoma in the community is undiagnosed. In India, it is estimated that glaucoma affects 12 million people and by 2020, this is expected to be 16 million. Statistics say one in eight persons above the age of 40 years in India is either suffering from glaucoma or is at risk of the disease [1].

Diagnosis of glaucoma is dependent on various findings such as elevated intra Ocular Pressure (IOP > 23 mm Hg is considered as a suspicious case for glaucoma), optical nerve cupping and visual field loss. Detection of Glaucoma is carried out by various tests such as Tonometry, Ophthalmoscopy, Perimetry, OCT, Gionoscopy, Pachymetry.

II. GLAUCOMA DIAGNOSIS

Glaucoma diagnosis is greatly researched topic. Various Methods such as Image processing, Artificial Neural Network, Neuro–Fuzzy etc have been applied for successful diagnosis of Glaucoma. Images obtained from OCT and fundus have been used widely for developing diagnosis [11][12].

Glaucoma is an optic neuropathy which is characterized by a gradual loss of retinal ganglion cells and thinning of the retinal nerve fibre layer. The functional assessment of glaucoma progression is determined by visual field testing. Glaucomatous Visual Field abnormality is detectable only after significant Retinal Nerve Fibre Layer (RNFL) loss has already occurred. In addition, Visual Field testing is prone to short- and long-term fluctuations as it is patient dependent and thus multiple testing is required to confirm any abnormalities. Assessment of the Optic Nerve Head (ONH) and the peripapillary RNFL can provide earlier indications of glaucomatous damage. However, the wide range of variation and the subjective nature of examination limit their reliability.

OCT is a non-contact, non-invasive imaging technology that uses light to create high resolution, cross-sectional tomographic images of the retina and the ONH. The device differentiates layers in the retina due to the differences in time delay of reflection from various components of the tissue. Previous studies have shown that OCT data are highly reproducible and that the device has the capability to differentiate glaucomatous from non glaucomatous eyes [7].

But, as the RNFL thins to the point that there is almost no residual ganglion cell layer, it becomes very difficult to detect significant change with OCT. OCT tends to perform worse in patients with advanced glaucoma compared to visual fields. In advanced disease, it may be more beneficial to detect progression using threshold visual fields [3].

Perimetry and OCT are the widely performed tests due to their high sensitivity and specificity. OCT is an imaging technique based on interferometry that provides three-dimensional imaging of the retina at a very low cost. Polarization Sensitive Optical Coherence Tomography (PS-OCT) provides additional imaging modalities. Clinically, these high-resolution images can be used for better diagnosis and monitoring of disease. Similarly, Standard Automated white-on-white Perimetry (SAP) is the standard for examining the visual field. Perimetric tests are able to provide quantitative measurements of differential light sensitivity at many test point locations in the visual field, and commercially available statistical analysis packages help clinicians in identifying significant visual field loss. The diagnostic performance of both OCT and SAP in glaucoma as well as the correlation between SAP and OCT measurements has been investigated [2].

According to Gardiner SK et al [10], the relationships between VF sensitivity (VFS) at 52 tested locations using SAP and optic disc configuration using confocal scanning laser Ophthalmoscopy were tested. In this study, VFS at each test point was significantly correlated with neuro retinal rim narrowing of the optic disc. As another way of analyzing structure and function, dividing the VF by grouping VFS points into several areas and averaging the threshold values of the clustered VFS points were documented.

Garway-Heath proposed a map of SAP test locations relating to positions of entry into the optic disc using RNFL defects recorded by photographs [11].

D C Hoffman proposed fuzzy model to detect visual field progression. The fuzzy logic model had a sensitivity of 75% and a specificity of 74% to detect visual field progression in a series compared with AGIS. A neural network had a sensitivity of 74% and a specificity of 85%. The agreement between the two was 72.6 % percent agreement, kappa =.4 [13].

III. PROPOSED METHOD

The proposed system deals with the Image obtained from Stratus OCT and report generated from Humphrey Standard Automated Perimetry.

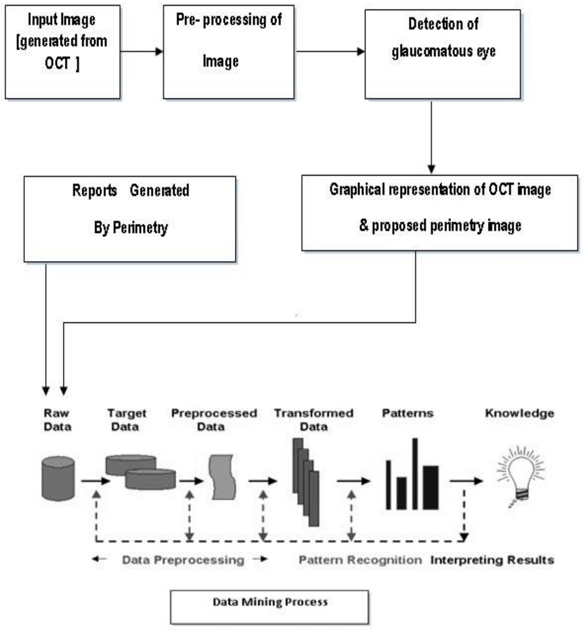

Fig. 1. Proposed System

The system is divided into 4 stages 1] Image Pre-processing 2] Classification of the Image 3] Generation of Proposed Graphical Perimetric Graph 4] Data mining Process.

A. Pre -Processings

Image of the patient's eye obtained from OCT test will be pre processed for the removal of noise. Image pre processing will be carried out in 2 steps:

- Pre processing
- Image based feature extraction

Pre-processing:- This process will eliminate disease independent variations from the input image. The Process is aimed at removal of vessels and illumination corrections.

Image based Feature Extraction: - This step will transform the pre processed data to characteristic and compact representation of the data.

Existing computer aided analysis of retina images are based on segmentation which is mostly done manually or by semi-automated methods. Different research groups investigate in the field of getting and selecting segmentation measurements from HRT images. Segmentation based techniques have one major drawback like small errors in segmentation may lead to significant change in the measurements and thus the diagnosis.[14]

Before applying any image processing algorithm removal of noise from the image is important. A filter based on anisotropic diffusion is used because, the advantage of anisotropic diffusion is that there is no need to know about the noise pattern or power spectrum previously and also it will provide better contrast while removing the noise. The filter iteratively uses diffusion equation in combination with information about the edges. As a consequence, the homogenise (but noisy) areas are blurred and the edges are preserved. The anisotropic diffusion equation [5] is defined as:

$$It = div\left(c\left(* x, y, t\right)\nabla l\right) = c\left(x, y, t\right)\nabla l + \nabla c.\nabla l \qquad (1)$$

Where div is the divergence operator,

∇ is a gradient and

Δ is a Laplacian operator,

c is the conduction coefficient function. Index t denotes the time (iterations).

Anisotropic diffusion filtering introduces a partial edge detection step into the filtering process so as to encourage intra-region smoothing and preserve the inter-region edge. Anisotropic diffusion is a scale space, adaptive technique which iteratively smoothes the images as the time t increases. The time t is considered as the scale level and the original image is at the level 0. When the scale increases, the images become more blurred and contain more general information.

B. Detection /Classification of the Glaucomatous eye image

Classification of the glaucomatous eye will depend on the features selected and then the decision rules will be applied. The rules will help classify the image into glaucomatous and normal eye image. Data mining Classifier such as Support Vector Machine (SVM) , Machine Learning Classifiers (MLC) will be tested during this phase for classifying the eyes as NORMAL or GLAUCOMATOUS eye

C. Generation of Proposed Graphical Perimetric Graph

Co-relation between the RNFL thickness and Actual Perimetric Data will need to be interpreted . The Glaucomatous eye image will be used to predict proposed Graphical Perimetry report.

D. Data Mining Process

Data mining process is an interactive and iterative process. Pre-processing of the data is a very important stage in any data mining process. The field of data mining addresses the question of how best to use this data to discover new knowledge and improve the process of decision making.

Mining problems can be grouped in three categories: identifying classifications, finding sequential patterns, and discovering associations. Although data mining is a powerful knowledge discovery technique, there are constraints in the way it can be applied: it is application dependent, different applications usually require different mining techniques, and data must be of a certain size and format. Most fundamental mining algorithms (rule-based learning systems, neural networks, decision trees, Bayesian networks, logistic regressions, and so on), which have been used with great success in medicine. It is important, therefore, to consider how to pre process images so that we can transform them to data representations which are amenable to data mining techniques. Although there are algorithms for classifying images, there is a lack of effective algorithms for learning from images directly. Machine learning classifiers (MLC) are the data mining techniques used to train the data for the learning process and used for automated diagnosis of glaucoma. Machine learning classifiers such as Linear discriminant analysis (LDA), Support Vector Machine (SVM) and recursive partitioning and regression tree (RPART) have been used extensively for diagnosis of glaucoma,[7][12] Trained classifiers can be used to predict the diagnosis of new cases. Thus, Proposed Graphical perimetry data, Actual Graphical Perimetry data and the data obtained from OCT will be tested for appropriate data mining algorithm like SVM, Naive Bayesian . The algorithm giving higher sensitivity and specificity for detecting and diagnosing the progression of glaucoma will be used in the data mining process.

IV. CONCLUSION

Early detection of Glaucoma can prevent early vision loss in the patient. Thus, we aim to develop a system which can help the ophthalmologist in diagnosing the disease which provides a detail analysis of the progression of glaucoma with the help of graphical representation of the Perimetric as well as OCT data. Machine classifiers will help in providing a simple and accurate index for diagnosing the presence or absence of glaucoma as well as its severity. A grading system for the severity of glaucoma can be developed. A long-term prospective study is needed to determine the utility of this grading index in assessing glaucoma progression. Last but not the least, Remember the key to maintaining your eyesight with glaucoma is:
To diagnose it at the earliest possible time
Lowering eye pressure in glaucoma's early stages slows progression of the disease and helps save vision.

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