An Automated System The Diagnosis of Glaucoma For Hybrid LSTM-RNN

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Abstract- *One of the leading retinal diseases which cause vision loss is Glaucoma. This paper presents the methodology to detect Glaucoma using wavelet based contourlet transform with Gabor filters. The input retinal fundus image is localized for its region of interest and enhanced using adaptive Gamma correction with weighted Distribution function (AGCWD). The blood vessels in ROI are removed using the Gabor filter and morphological operators. To the Region of Interest the wavelet based contourlet transform (WBCT) is applied to extract the features and then given to the LSTM-RNN classifiers for detecting the normal and glaucomatous image.*

Keywords- Adaptive Gamma Correction with Weighted Distribution Function, Wavelet Based Contourlet Transform, Gabor filter, Morphological operator, classifier

I. INTRODUCTION

Glaucoma is the second leading progressive ocular disorder after cataract caused by degenerative Optic Nerve Head (ONH) structure. It causes irreversible vision loss if it is untreated on time. Despite the great amount of heterogeneous data that has become available for monitoring glaucoma, the performance of tests for early diagnosis is still insufficient to minimize the risk of visual loss and impairment. As glaucoma is asymptomatic, the patients are unaware until noticeable vision loss occurs. Due to its insidious nature, it is critical to detect glaucoma at the earliest. Moreover, early detection of glaucoma is particularly significant since it allows timely treatment to prevent major visual field loss and prolongs the effective years of usable vision. Among the various image structural cues for glaucoma detection, most of the clinician considered Cup-to-Disc Ratio (CDR) as a major factor.

In this study, an automated and non-invasive system is developed for early glaucoma prognosis through the accurate measurement of CDR. CDR is defined as the ratio of the vertical height of the Optic Cup (OC) or the area of the OC to the vertical height of the Optic Disc (OD) or the area of the OD. However, the determination of the appropriate disc and cup area is very difficult due to the presence of blood vessel around them. Hence, texture spectrum model based Local Binary Pattern (LBP) is adapted for OD segmentation and three unsupervised clustering approaches; Expectation Maximization (EM), *k*-means and Fuzzy C-Means (FCM) are employed for OC segmentation.

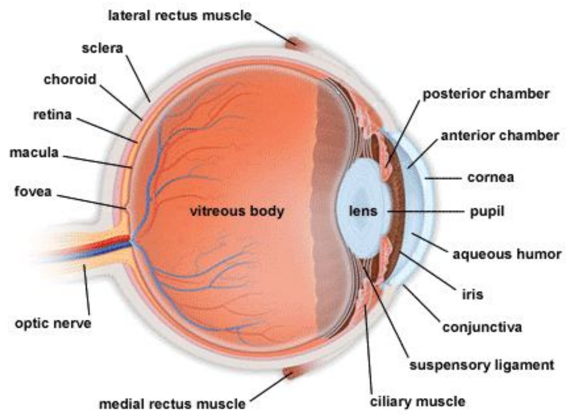


Figure 1 the anatomy of the human eye

A cross-section of the eye and the structures involved in the image formation are presented in Figure 1.1. There are three important features in the camera which can be seen analogous to the function of the eye: aperture, camera lens, and the camera sensor. In the eye behind the transparent cornea, the colored iris regulates the amount of light entering the eye by changing the size of the pupil. In the dark, the pupil enlarges allowing the maximum amount of light to enter, and in the bright, the pupil becomes small preventing the eye from receiving an excess amount of light. This is similar to the way the camera regulates the amount of light entering the camera with the aperture. When the ciliary muscle is relaxed, the zonular fibers stretch the lens into the thin shape, and the distant objects are in focus. This corresponds to the function of focal length, i.e. the distance between the lens and sensor when focusing the camera. If the eye is properly focused, the light passes through the vitreous gel to the camera sensor of the eye, which is the retina.

Glaucoma is an eye disease characterized by the loss of retinal ganglion cells and their axons. Clinically, this loss becomes apparent by cupping, also called excavation, of the OD and concomitant visual field loss. There are many subgroups of glaucoma, separated by causes, genetics, or morphology, and within each group, there may be tens of different glaucoma types. Among which two main types are open-angle and angle-closure glaucoma. Generally Three Types of

- Primary open angle glaucoma
- Angle closure glaucoma
- Secondary Glaucoma

The rest of the proposed paper is referred as follows: - A review of existing works is done in Section II. Section III includes the proposed technique. Simulation results and performance analysis is done in Section IV.. Section includes the network model and proposed energy harvesting technique. Simulation results and performance analysis is done in Section IV.

II. LITERATURE REVIEW

Currently, there is an increasing interest in establishing automatic systems that screen a huge number of people for vision threatening diseases like glaucoma and diabetic retinopathy and to provide an automated detection of the disease. Image processing is now becoming practical and a useful tool for screening. Digital imaging offers a high quality permanent record of the fundus images, which are used by ophthalmologists for the monitoring of progression or response to the therapy.

Prevalence of Glaucoma in India is estimated to be about 11.9 million and 60.5 million. Glaucoma has been declared to be the second common cause of blindness in adult population in India. The high rate of blindness in the Indian population is due to the high rate of undiagnosed glaucoma in the community [1-3].

Early symptoms are not evidenced with glaucoma, which at its later stage affects the vision. A manual method of screening the eye also sometimes leads to wrong diagnosis. Automated and accurate diagnosis of retinal disease helps to prevent the loss of vision. A complete eye examination to detect glaucoma includes Tonometry, Ophthalmoscopy, Perimetry, Gonioscopy, and Pachymetry.

Imaging the retina with appropriate and automated decision tools enhances the detection of the glaucoma at its early stage and prevents loss of vision. Fundus photography helps to visualize various structures of retina that are significant indicators of Glaucoma. In the retinal fundus image the Optic disc is the brightest region where the optic nerve leaves the retina to the brain. The optic disc region is to be analyzed for detecting the presence of glaucoma at its early stage to overcome the loss of vision. The input retinal fundus images are initially enhanced to discriminate the retinal structures Analysis on detection and classification of glaucoma using retinal fundus image is influenced by the feature detection and extraction techniques. Morphological and non-morphological features are used to detect the progression of glaucoma. The morphological features for glaucoma detection includes Retinal Nerve Fiber Layer, Cup to Disc Ratio, Peri Papillary area. Morphological features involved segmentation of the retinal structures for geometric measurement of the features.

Glaucoma detection using CDR feature was performed by Xu et al. [4], Muramatsu et al. [5], Joshi et al. [6], Yin et al. [7]. On the other hand the non-morphological features do not involve the segmentation of the retinal structures. From earlier research it has been studied that the non–morphological features like colour, pixel intensity, histogram, texture are used for Glaucoma detection [8-11]. Muthu Rama Krishnan et al. [12] have proposed a system based on hybrid feature extraction from fundus image using higher order spectra, trace transform, and SVM classifier. Celina rani George [13] suggested a system to classify glaucoma using wavelet based energy features and neural network. Farnaz Farokhian at.al [14] used bank of 180 filters for the detection of blood vessels and thresholding applied to the total response obtained from the maximum response of each filter. Yi Wang et al. [15] have introduced face recognition using contourlet and support vector machine. Lei Zhang et al. [16] segmented the blood vessels using Gabor filter bank and textons. Lamani et al. [17] attempted to show that the fractal dimension (FD) of the image feature could be adopted as parameter to detect the glaucoma.

Detection and prediction of glaucoma has been done using several machine learning techniques like neural networks, Support Vector machine, K-Nearest neighbor, Naïve Bayes classifier [18]. In this paper, the input image is enhanced using Adaptive Gamma correction with Weighted Distribution Function from which the ROI, optic Disc region is segmented. Gabor filter is applied to the optic disc region to remove the retinal blood vessels. From the vessel free optic disc region Wavelet based contourlet transform is applied to obtain the coefficients of the decomposed subsample. The statistical features are computed from the coefficients of WBCT and fed to the Naive Bayes, SVM classifiers for detecting the presence of glaucoma [19–22]. The presented methodology is implemented in FAU database that consists of 15 normal and 15 glaucoma images. From the survey An effective tool should therefore be developed to analyze fundus images to detect features such as exudates comparable to that of an ophthalmologist in order to provide decision support and reduce ophthalmologist's work load.

III. SYSTEM DESIGN

Digital color fundus images are used to notice many eye diseases by clinicians. The important anatomical structures; optic disc, optic cup, and blood vessels are very clearly captured by the fundus camera. Hence, the proposed system uses fundus images for the detection of glaucoma. The abnormality in the retina is observed by the changes in the optic disc and optic cup. Automated detection of glaucoma is performed by computing CDR of the given fundus image. In this chapter, an efficient system is described to detect glaucoma automatically based on LSTM features and RNN approaches

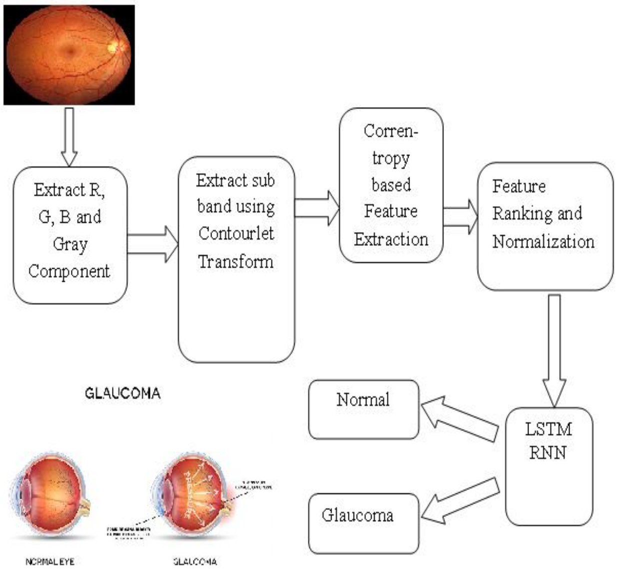


Figure 2 Block diagram for earlier detection of glaucoma

The automated segmentation of OD and OC are crucial processes in the design of a computer-aided diagnosis system for glaucoma. In this study, OD is first segmented by LSTM approach and then supervised segmentation approaches such as *k*-means, RNN are applied for OC segmentation. The risk of glaucoma is finally assessed by computing CDR value. The proposed system to detect glaucoma automatically consists of two modules.

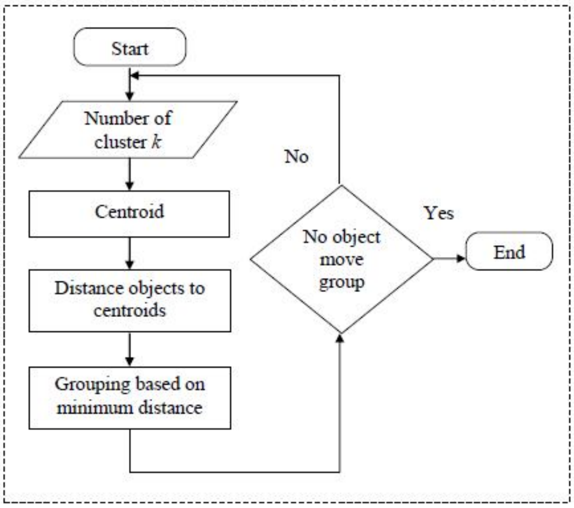
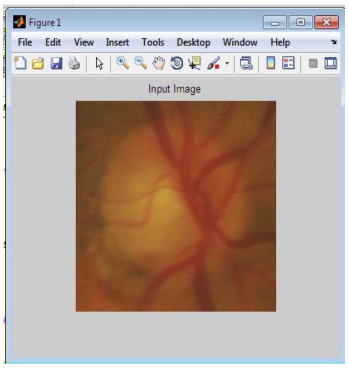


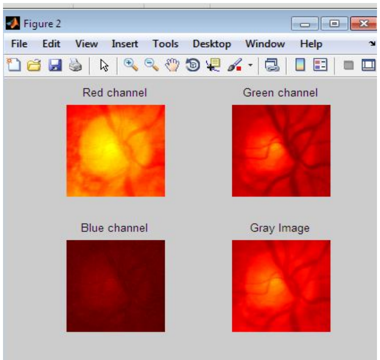
Figure 3 the computational flow of proposed system

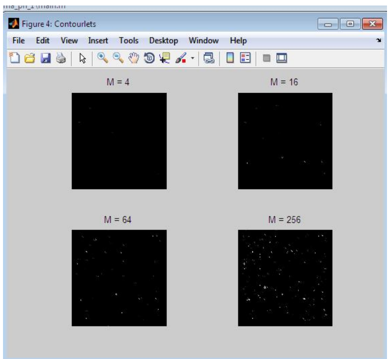
After ROI extraction in the RGB color model, the extracted region is converted into HSV color space due to its perceptual color relationships nature. HSV color space depicts the colors regarding hue, saturation, and value or intensity. Thus, it can separate the image intensity from color information. Also, it defines the colors in the same way, how the human eye does. The other color spaces such as Lab and CMY are used by other researchers for segmentation. As the proposed system uses LBP for optic disc segmentation, the HSV color space is suitable as it has the value or intensity information. Figure.3 shows the different color spaces for a sample ROI fundus image.

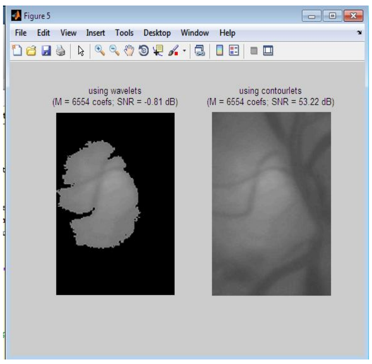
IV. RESULT AND DISCUSSIONS

Glaucoma is characterized by regular damage of Retinal Nerve Fibre (RNF). Fractal and power spectral features are used to analyze RNF and LSTM-RNN classifier yielded classification accuracy is very efficient. To assess the performance of the proposed glaucoma detection system, totally 50 fundus images: 25 images for normal case and 25 images for glaucomatous cases are used. It is obtained by auto focus fundus camera with a resolution of 1504x1000 pixels in the RGB mode. The simulation of the proposed first phase glaucoma detection system is done in MATLAB R2013b and tested on Intel architecture under the windows operating system.









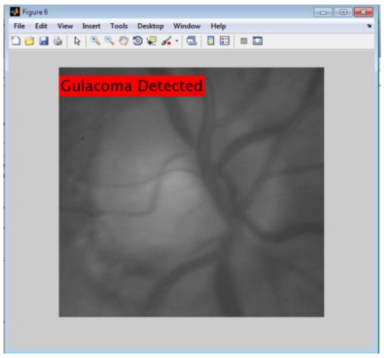


Figure 4 a) Input image b) RGB channel image c) Contourlet transform d) contourlet segment image e) Glaucoma detected image

It is already stated that the green component of the given fundus image provides best contrast than other two components which can be clearly seen in Figure 5.3 (c). Hence, Green channel is only considered for ROI extraction. To reduce the memory and time requirements, ROI is extracted. After extraction in the Green channel, the same region is cropped from the original RGB fundus image which is shown in Figure 4 (a). The extracted ROI image is transformed into HSV color space as it is very closer to human vision. The transformation equations are already discussed in chapter 4. In Figure 5.4, the first row shows the cropped original fundus images; the second row shows their corresponding hue component, the third and the final row show saturation and value component respectively.

It can be clearly seen that the OD region is visible in the Value channel rather than other two components; Hue and Saturation. Hence, the proposed OD segmentation approach uses Value channel for the next process. LBP pattern is extracted from the value channel and shown in Figure 4.(b) In Figure 4. (c) The first row shows the LBP image; the second row shows the threshold image, the third and the final row show the post processed image and bounding box image using connected component analysis respectively. Proposed second phase glaucoma detection system hardware implementation is done in python3.6 and tested on Intel architecture under the Linux based operating system.

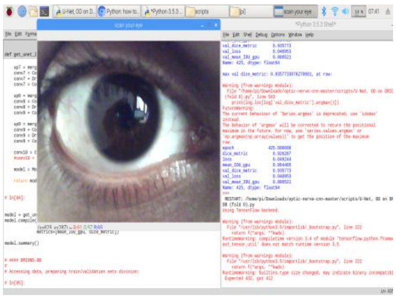


Figure 5 a) Hardware implementation for Glaucoma detection b) input image

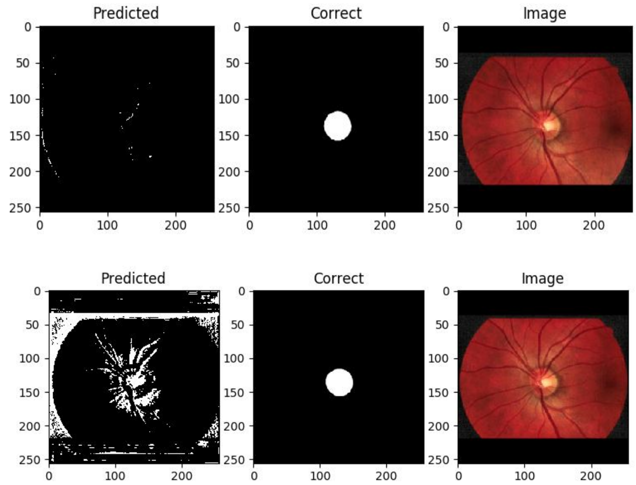


Figure 6 proposed hardware implementation results

Figure 4 (d) shows the OD boundary on value channel and also superimposed on original RGB image using elliptical fitting approach. The proposed OD segmentation using LSTM and RNN is applied on all normal and abnormal fundus images. Based on the OD segmentation result, the area of the OD region is computed by counting all true pixels inside the OD boundary. Figure 4 (e) shows the area of the OD region for both normal and glaucomatous images. This value is used for CDR calculation later. From the result and statistical analysis figure 5 state that proposed LSTM+RNN based system produce better result for 92.5% comparatively RBF (91.25 %), moriet (89%), and Mexican hat (85%). The proposed system can be integrated with the existing ophthalmologic tests and clinical assessments in addition to other risk factors according to a determined clinical procedure and can be used in local health camps for effective screening. Figure 6 describe the phase hardware implementation result. Both simulation and hardware implementation results of proposed system and its algorithm results are more effective over previous algorithms

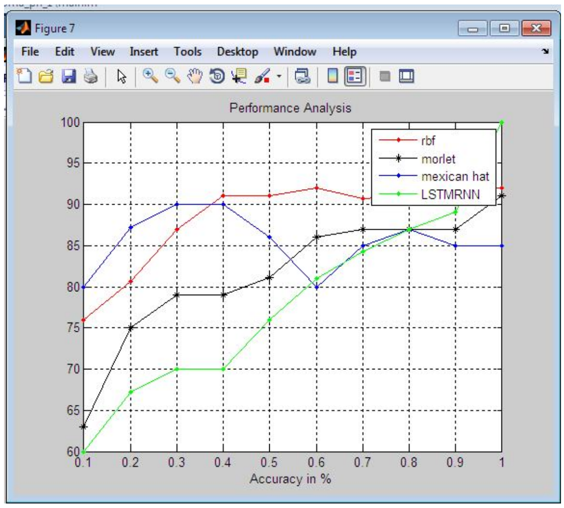


Figure 7 Performance analysis of Glaucoma detection

V. CONCLUSION

An automatic diagnosis system is developed to detect glaucoma and diabetic retinopathy at an early stage using digital fundus images. In this work, attempts are made to address the issues associated with the detection of two ocular diseases. A novel approach employing color clustering in L*a*b* color space is used to segment the cup information from the images. Optic cup segmented using LSTM-RNN technique achieved a high F score and the cup boundary was detected well in all the quadrants except in those regions where there are a strong blood vessel convergence.Features for classification method and different kernels for classification and found that LSTM-RNN the highest accuracies. It can be concluded that the contourlet and corr-entropy features are useful for glaucoma diagnosis. In this methodology need to test for huge database and also can be extended to diagnose glaucoma at an early stage. Automated diagnosis using digital image analysis offers huge potential benefits to examine a large number of images with time and cost savings, offers more objective measurements than current observer driven techniques and reduces the workload required from manual trained graders.

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