International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 9 | ISSN : 2456-3307

Computer Aided Diagnostic Techniques in Automated Detection of Eye Related Diseases - A Comparative Study

Dr. S. Mohan Kumar [*1], Ms. Anisha Rebinth [2]

[*1] Professor, Department of Information Science and Engineering, New Horizon College of Engineering, Bangalore.
drsmohankumar@gmail.com [1]
[2]Research Scholar -Visvesvaraya Technological University, Research Centre, Dept. of Information Science and Engineering, New Horizon College of Engineering, Bangalore.
E-Mail: anisha.rebinth@gmail.com[2]

ABSTRACT

World Health Organization (WHO) in a new study has recognized eye related defects to be one of the primary health challenges faced by the existing society. Common retinal abnormalities include Glaucoma, Diabetic retinopathy and Macular degeneration. Retinal eye defects have significantly increased in the last decade across developing and developed countries. These defects if not diagnosed and treated at the appropriate time, would result in complete loss of vision. Diabetic retinopathy is predominantly common among diabetic patients. In Macular Degeneration, the central part of the retina is widely affected. In this case, the retinal cells deteriorate and images are not established correctly. The CAD system for eye diseases falls under the Supervised Learning techniques. This technique refers to methods that enable creation of a correlation with different features and labelled outcomes. Few of these include KNN, Naïve Bayes, Adaboost Classifiers, tree-based Classifier, ELM classifier, SVM and LIBSVM classifier etc. The main objective of this paper is to summarize the various CAD techniques adopted for early detection of eye diseases.

Keywords : Retinal abnormalities, Glaucoma, Diabetic retinopathy, Fundus images, Feature detection, Segmentation, Optic disc, Optic cup, KNN, Naïve -bayes, SVM.

I. INTRODUCTION

WHO has highlighted in a recent study that 285 million people with visual impairments either in the form of blindness or visual impairment. This amounts to 10% of the total world population. This stresses the need for cost effective, faster techniques to identify such deficiencies and address them at an early phase. [4] Retinal abnormalities are currently common critical issues faced by people across different strata of the society. Common retinal abnormalities include Glaucoma, Diabetic retinopathy and Macular degeneration. These defects if not diagnosed and treated at the appropriate time, would result in complete loss of vision. Many of the most recent treatments for these ailments include reduction in progression of the defect rather than a complete cure of the abnormality. In many cases, it is noticed that these defects go unnoticed as they are symptom free and substantial loss of vision occurs even before the actual diagnosis.

Retina is a critical part of the eye enabling conversion of light to neural signals to enable the brain for visual recognition. Retina requires sufficient and constant supply of blood through network of tiny blood vessels for proper functioning

[8]. Diabetic retinopathy is predominantly common among diabetic patients. As the blood sugar level increases, the blood vessels in the retina are damaged. The blood vessels swell, leak or close eventually stopping the flow of blood to the retina.

Macular Degeneration is the deterioration of the central portion of the retina. In this case, the retinal cells deteriorate and images are not received correctly. Glaucoma is a chronic visual impairment which leads to loss in vision. It is generally characterized by degeneration of optic nerves. The general perception is that glaucoma is caused by increased pressure in the eye. The elevated pressure is caused by the impaired drainage of fluid (aqueous humor) in the eye. The normal eye pressure is between 14mm Hg and 20mm Hg.[12]

Most of these defects are gradual and hence identification of defects at an early stage becomes a significant challenge. While vision damage cannot be cured, the progression of these abnormalities can be slowed down with medication. With the growth of population and reduction in doctor to patient ratio, it is necessary to develop cost effective automated methodologies that enable faster / earlier diagnosis. Recent advancements in the field of Image Processing and Data Science have helped automated diagnosis of many eye related defects.

Image processing is the transformation of an image, which is a 2-dimemtional signal, f(x,y) (where x and y represent the amplitude and intensity of the image) through data processing. For processing, the image is converted to digital form using sampling and quantization. The different steps in image processing are, image acquisition, enhancement, segmentation, feature extraction and pattern recognition. An extension of the application of image processing in the field of medical sciences is called medical image processing. This involves use of image processing techniques to create visual representations of the interior of a body for clinical analysis.[19] The use of medical image processing to assist doctors in diagnosis of diseases is called Computer Aided Diagnosis.

The main objective of this paper is to summarize the various CAD techniques adopted for early detection of eye diseases. Different feature selections that have been used and classification techniques for identification of the retinal disorders are discussed.

II. METHODOLOGY

The CAD System for Glaucoma diagnosis:

The general methodology followed in the computer aided diagnosis of glaucoma follows traditional machine learning techniques following a predefined standard set of steps [23]. A summary of the steps involved are as follows

a) Preprocessing: Fundus images are of high resolution and normally captured under various varied lighting conditions and hence requires enhancement and standardization preceding feature extraction. Fundus images captured are by a high-resolution fundus camera and these images consume significant time and hardware resource requirements. Pre-processing is done to the fundus images using methods like CLAHE in order to remove the non-uniformity.

b) Segmentation: The segmentation of the region-of-interest (ROI) from the fundus images will be performed prior to feature ex- traction. The segmentation of the ROI process involves localizing the OD and then extracting features from the segmented OD. RNFL and PPA are detected and measured using filtering methods (Gabor), textual analysis and transformation (polar). This is generally semi-automated in the overall process of detection.

c) Feature extraction: This process involves using images of the fundus to identify distinguishable features. Cup to Disc is the fraction of optical cup to optical disc dimensions. In this step identification of the optic disc and characterization is performed. From the original image the identified region is extracted for segmentation. The optic disc detection involve localization followed by segmentation

d) The discrete wavelet transforms (DWT), empirical wavelet transforms (EWT) and variational mode decomposition (VMD) are used during feature extraction. Both DWT and EWT utilize low and high pass filters to decompose the images into coefficients. Then, these coefficients are subjected to further analysis. The VMD decomposes the images into different amplitude- and frequency-modulated coefficients. These transformation techniques decompose the images to obtain coefficients that are useful in differentiating the two classes of optic discs (normal and glaucoma). On the other hand, the GIST descriptor which is a form of image descriptor that describes the visual features of the fundus images based upon various orientations and scales of the images, is also used for glaucoma detection.

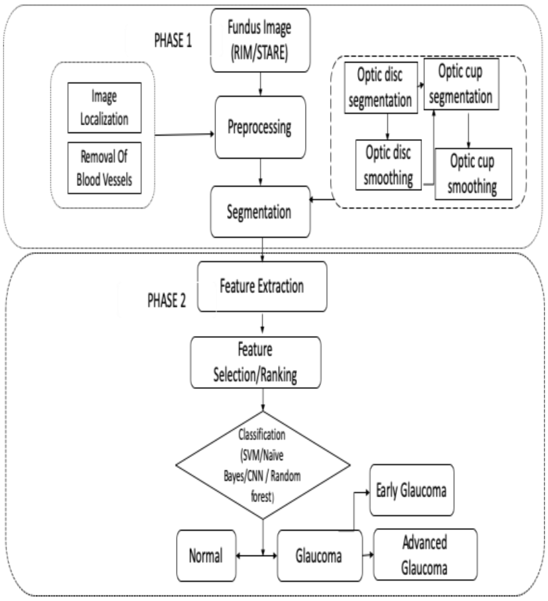

Figure 1. Proposed CAD System

III. LITERATURE REVIEW

Most of the research around CAD for eye diseases are based on tree / linear / probability based. The application and the accuracy of the different approaches are discussed below

Priya et. al [12], used dataset from Dr. Sudhakar, Nagpur. The dataset comprises of 50 images taken from an age group ranging from 20 - 70 Years. Preprocessing was done using histogram equalization and radon transformation. Radon transform is used for feature detection. Two features namely, Higher Order Spectra and texture descriptors are extracted using Radon transform. Different classifiers were used for the classification of the images. The classifiers used were random forest and Naïve Bayes classifiers. The classifier was chosen based on the effectiveness in capturing discriminative properties. Lack of normalization can skew the classification results. Z-Score normalization and min-max normalization were used to normalize the features. The classification accuracy obtained was ~91%.

Jyothika et. al [8]., in the classification approach, have preprocessed using anisotropic diffusion filter for noise removal, OTSU thresholding, canny edge map and image inpainting for extraction of retinal blood vessels. Optic cup and Optic disc boundary detection by K-Means clustering, Multi-thresholding, Active contour method and Fuzzy C-Means clustering were used. Finally, ellipse fitting is used for smoothing of the boundaries. Classification is done using SVM and Back propagation networks. Model accuracy was evaluated on a dataset of 20 images from Vitreo Retina Unit, AIIMS, Delhi

Iyyappan et. al [6]. uses 2D discrete wavelet transform (DWT) for feature extraction and classification using neural networks. The images for the training and validation were captured using fundus camera. Discrete wavelet transforms (DWT) based feature extraction is done using Daubechies (db3), symlets (sym3) and biorthogonal (bio3.3) which are basically three wavelet fillers. Wavelet decomposition is done by capturing both spatial and frequency information of the signals. Image is passed through high pass filter and low pass filter. Classification is done using probabilistic neural network (PNN).

In Darsana et. al. [7], feature extraction is performed using color model analysis, morphological processing, filtering and thresholding. Mask generation and feature segmentation is based on array centroid method used for rim to disc calculation ratio. In this paper classification is done using SVM.Here during preprocessing, the best channel based on hue, saturation and value is selected for optic cup and disc segmentation and vessel extraction. Blood vessels are removed using morphological closing in value channel image. Median filtering is done to remove noise and preserve the edges. After filtering, thresholding is done using manually selected threshold value. Segmentation of optic cup and optic disc and rim is done. Top hat filtering is done using square structuring element. Array centroid method for segmentation has centroid calculation, array initialization, mask image generation and mask feature image multiplication. CDR is computed and classification is done using SVM. The dataset used comprises of 30 images are classified as low, moderate and high-risk Glaucoma.

Sri Abirami[3] et. al. proposes a fuzzy min-max neutral network based on Data (DCFMN). DCFMN has two classes of neurons, classifying neurons and overlapping neurons. In preprocessing color conversion, resizing and pruning is done. Segmentation is done using thresholding techniques. Angle detection is done by DCFMN for previously segmented images. DCFMN architecture has three layers. These layers comprise of input, middle and output layer. Classification is done using fuzzy min-max neural network algorithm.

Laszlo et al [9], proposes a novel classification method in which in the first step which is preprocessing in which illumination correction, removal of blood vessel and the normalization of the papilla is done. In the next stage which is the feature extraction, the pixel intensity values, FFT coefficients and the B-Spine coefficients are considered. The classification is carried out by a two-stage classifier in which in the first stage, compression of PCA compressed feature type classification is performed separately and in the second stage, concatenation is applied to a two-dimensional common feature space.

Muthu Ramakrishnan et. al[13], proposes a methodology for the diagnosis of macular degeneration. The methodology is organized as image acquisition, preprocessing, feature extraction, ranking and selection. Contrast enhancement is done by CLAHE (Contrast Limited Adaptive Histogram Equalization) dimension. Features like Fractal dimension (FD), Graber wavelet entropies and HOS features are extracted from preprocessed fundus images. AMD classification is done by SVM, DT, DNN, KNN and Naïve Bayes classifier. ARIA and STARE datasets are used. AMD progression detected by presence of drusen pigmentary irregularities and new vessel proliferation.

Bo Wu et. al.[1], proposes a novel method to diagnose diabetic retinopathy. The four major steps are preprocessing, candidate extraction, feature extraction and classification. 27 Local and profile features referred to as characteristic features are extracted for classification using KNN classifier. In diabetic retinopathy, detection of microaneurysms which are important lesions that are small and round in shape near tiny blood vessels in fundus images. In preprocessing, illumination equalization is done using CLAHE to reduce noise and enhancement. Smoothing is done using Gaussian filter which is followed by candidate extraction. Using peak detection, the presence of peak is detected as identified as the center of the profile and the surrounding region is marked as the growing region.

Amin [2] paper deals with automatic classification in exudate and non-exudate region in retinal image. Preprocessing of candidate lesion extraction, feature extraction and classification is done. The Gabor filter is used in grayscale image for lesion enhancement. Segmentation is done based on math modal morphology. The feature set selection is done be combing mathematical and geometrical features. KNN and tree-based classifier are used for classification.

Harry Pratt & et al [14], uses convolutional neural network for diagnosis of diabetic retinopathy. Data augmentation with convolutional neural network architecture is used to identify intricate features like micro aneurysms, exudates and hemorrhages on the retina. Then automatic diagnosis is done without user input. The Kaggle data set was used for this purpose with an accuracy of 75% and sensitivity of 95%.

Maheshwari & et al [10], discusses automated diagnosis using digital fundus images based on empirical wavelet transform. EWT is used to decompose images and corentrophy features obtained from decomposed EWT component. The features are extracted and ranked using T-Value feature selection algorithm. The classification of glaucoma is done using least square SVM.

Bock et al [22], has devised a database driven system for the computerized detection of eye diseases called Cat Eye where processing, analysis and classification of retinal images is done. Homophobic surface fitting is used for the correction of non-uniform illumination. A process called morphological in painting for the removal of blood vessels in the eye. In this method features like 28 Gabor features, coefficients of Fast Fourier Transform and the pixel intensity values are extracted using four methods. Histogram play a role in providing a summary of the distribution of intensity. The classification process is done by a two stage SVM classifier.

IV. CLASSIFICATION ACCURACY

The feature extraction procedures and classification algorithms discussed above have been used across different retinal abnormalities. The following table summarizes the accuracy attained as reported by the different authors.

Author	Application	Classifiers and Accuracy	Application
Muthu Rama Krishnan Mookiah	2014	SVM-90.19%	Macular Degeneration.
Mardin Christian	2003	Tree Classifier-77%	Glaucoma
Carson Lam & et al.	2017	Random Forest Classifier-77%	Diabetic Retinopathy
Muthu Ramakrishnan	2013	SVM-91.67%	Glaucoma
Rajendra Acharya & et al.	2011	Random Forest Classifier-91%.	Glaucoma
Jyotika Pruthi & et al	2013	BackProbagation-97.3%	Glaucoma
Abirami & et al	2013	Linear Classifier Neural Network97%	Glaucoma
Anusorn & et al	2013	Tree based Classifier-89%	Glaucoma
K. Narasimhan	2011	SVM-95%	Glaucoma
Priya Khumbare	2014	Random Forest -91%	Glaucoma
Darsana S & et al	2014	SVM-95.7%	Glaucoma
Iyyanarrappan & et al		SVM-95%	Glaucoma
Bock & et al	2007	Neural Networks-86%	Glaucoma
Wong Li Yun & et al	2017	Neural Networks-90%	Diabetic Retinopathy
Hatanaka & et al.	2010	Tree Based Classifier-80%	Glaucoma
L'Aszl & et al	2009	SVM-86%	Glaucoma
Harry Pratt et.at.	2016	SVM - 75%	Diabetic Retinopathy

V. OBSERVATIONS

It has been observed from the following research papers that lots of methods using different features and classifiers have been used in automated diagnosis of retinal diseases and with the training sets and testing sets from databases like ORIGA, DIARETDB1, DRIVE, STARE the researchers have been able to obtain a detection accuracy of around 97% for a limited set of data.

VI. CONCLUSION

In the last decade significant amount of research had gone through in detection of eye related diseases using computational methods. Many of the methods attempted includes classification by classifiers like SVM, Random Forest, Guassian method etc. in conjunction with different feature selection methods. These methods have reached an entitlement in terms of detection accuracy. The next level of improvement can be attempted through methods like convolutional neural network.

VII. REFERENCES

[1] Wu, B., Zhu, W., Shi, F., Zhu, S., & Chen, X. (2017). "Automatic detection of microaneurysms in retinal fundus images", Computerized Medical Imaging and Graphics, vol.55, pp.106-112.

[2] Amin, J., Sharif, M., Yasmin, M., Ali, H., & Fernandes, S. L. (2017). "A method for the detection and classification of diabetic retinopathy using structural predictors of bright lesions", Journal of Computational Science", vol.19, pp.153-164.

[3] S. Sri Abirami, S.J Grace Shoba: "Glaucoma Images Classification Using Fuzzy Min-Max Neural Network Based on Data-Core", International Journal of Science and Modern Engineering (IJISME) ISSN: 2319-6386, Volume-1, Issue-7, 2013, pp 9-15

[4] Guo, L., Yang, J. J., Peng, L., Li, J., & Liang, Q. (2015). "A computer-aided healthcare system for

cataract classification and grading based on fundus image analysis", Computers in Industry, vol. 69, pp. 72-80.

[5] Singh, A., Dutta, M. K., ParthaSarathi, M., Uher, V., & Burget, R. (2016). "Image processing based automatic diagnosis of glaucoma using wavelet features of segmented optic disc from fundus image", Computer methods and programs in biomedicine, vol.124, pp.108-120.

[6] A. Iyyanarappan, G. Tamilpavai "Glaucomatous Image Classification Using Wavelet Based Energy Features and PNN" International Journal of Technology Enhancements and Emerging Engineering Research, Vol 2-4, 2014, pp85-89

[7] Darsana S1, Rahul M Nair," A Novel Approach towards Automatic Glaucoma Assessment" International Journal of Scientific Research Engineering & Technology (IJSRET), Volume 3-2, 2014, pp 281-288

[8] Jyotika Pruthi, Dr. Saurabh Mukherjee: "Computer Based Early Diagnosis of Glaucoma in Biomedical Data Using Image Processing and Automated Early Nerve Fiber Layer Defects Detection using Feature Extraction in Retinal Colored Stereo Fundus Images", International Journal of Scientific & Engineering Research, Volume 4, Issue 4, April-2013, pp1822-1828

[9] Laszlo G. Ny´ul: "Retinal image analysis for automated glaucoma risk evaluation". MIPPR 2009: Medical Imaging, Parallel Processing of Images, and Optimization Techniques. Proc. of SPIE Vol. 7497,2009.

[10] Maheshwari, S., Pachori, R. B., & Acharya, U. R. (2017). "Automated diagnosis of glaucoma using empirical wavelet transform and correntropy features extracted from fundus images", IEEE journal of biomedical and health informatics, vol. 21, no. 3, pp. 803-813.

[11] Chakravarty, A., & Sivaswamy, J. (2016)." Glaucoma classification with a fusion of segmentation and image-based features", IEEE 13th International Symposium on Biomedical Imaging, pp. 689-692.

[12] Priya kumbhare, Manisha Turkr and Rashmi kularkar "Computer Aided Automatic Glaucoma Diagnosis," International Journal of Electrical, Electronics and Data Communication, ISSN: 2320-2084 Volume-2, Issue-2,2014, pp 28-32

[13] Muthu Rama Krishnan Mookiah, U. Rajendra Acharya, Joel En Wei Koh & Augustinus Laude," Automated Diagnosis of Age-Related Macular Degeneration using Grayscale Features from Digital Fundus Images", Computers in Biology and Medicine 53(C), 2014, pp 55-64.

[14] Harry Pratt, Frans Coenen, Deborah M. Broadbent, Simon.P. Harding, Yalin Zheng, "Convolutional Neural Networks for Diabetic Retinopathy", (2016), Elsevier, Procedia Computer Science, Vol 90 pp 200-205.

[15] Fengshou Yin, Jiang Liu, Damong Wing Kee Wong & Xinting Gao, "ACHIKO-I Retinal Fundus Image Database and Its Evaluation on Cup-to Disc Ratio Measurement" (2013), IEEE Xplore.

[16] Kazuhiro Kobayashi & Qiu Chen, "Content – Based Image retrieval Using Features in Spatial and Frequency Domains" (2015), International Conference on Soft Computing, Intelligence Systems and Information Technology. Vol 516 pp 269-277.

[17] Bingquan Huo & Fegling Yin, "Research on Novel Image Classification Algorithm based on Multi-Feature Extraction and Modified SVM Classifier", (2015), International Journal of Smart Home, Vol 9 pp 103-112.

[18] Manish Kr Aggarwal & Vijay Khare," Automatic Localization and Contour Detection of Optic Disc" (2015), IEEE Xplore, International Conference on Signal Processing and Communication, pp 406-409.

[19] Dr S Mohan Kumar & Kumaran," Study on skin Lesion Classifications system and Dermoscopic Feature Analysis for Melanoma", International journal of Creative Research Thoughts, Volume 6, Pp 1863-1873.

[20] Dr. Mohan Kumar S, Dr. Balakrishnan," Classification of Breast Microcalcification- CAD

System and Performance Evaluation Using SSNE", International Journal of Advanced Research in Computer Science and Software Engineering, Vol 5, Pp 820-830.

[21] Rodgrigo Veras, Romuere Silva, Flavio Araujo & Fatima Mereiros," SURF Descriptor and Pattern Recognition Techniques in Automatic Identification of Pathological Retinas", (2015), Brazilian Conference On Intelligent Systems, pp 316-321.

[22] R¨udiger Bock, J¨org Meier, Georg Michelson, L´aszl´o G. Ny´ul, and Joachim Hornegger, "Classifying Glaucoma with Image-Based Features from Fundus Photographs", DAGM Springer-Verlag Berlin Heidelberg 2007, LNCS 4713, 2007, pp. 355–364, 2007

[23] Anisha Rebinth & Dr.S. Mohan Kumar, "Automated Detection of Retinal DefectsUsing Image Mining-A Review", European Journal of Biomedical and Pharmaceutical Sciences, Vol 5, pp 189-194, Jan 2018.

[24] Anisha Rebinth & Dr S. Mohan Kumar, "Automated Segmentation of Retinal Images-A Review", Journal of Advanced Research in Dynamical and Control Systems, Vol 10,05 Special Issue,2018, pp 1881-1885, May 2018.