Eye Disease Detection Using Computer Vision

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***Abstract*—**Glaucoma and Diabetic Retinopathy(DR) are among the leading causes of blindness. Belated handling of Cataract can impact the vision causing blindness. Often the scarcity of experts can lead to delayed diagnosis, resulting in untreatable conditions. But detection of these diseases at earliest stage and treatment can aid patient in avoiding vision loss. An automatic disease detection system can help this by providing accurate and early diagnosis. In proposed system, diagnosis will be obtained using image processing and mining techniques on fundus image. Feature extraction using DCT. K-NN classification algorithm will be used to classify the image in a specific class (Normal,Glaucoma,DR or Cataract).

Keywords-*Glaucoma, DR, Cataract, Image Processing, DCT, Mining, K-NN*

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I. INTRODUCTION

Image processing and analysis is a vast area of application, one of which is in the field of medicine. Humans can be affected with a variety of diseases and as such, there is the necessity of finding means of early detection, especially in the case of delicate organs like eyes. Glaucoma, Diabetic Retinopathy and Cataract are some such eye diseases, whose early detection may result in the possibility of cure, whereas if undetected over a large period of time in later stages, will result in blindness.

Glaucoma can be identified by observing the degeneration of optic nerve fibre. Damage to this nerve and a diminished field of vision are significant symptoms. DR can become chronic and gets worse with time. Due to pressure in blood vessel, blood and other fluids will be observed in eye, giving the appearance of abnormal retina. It is a disease which may be caused as a side effect of Diabetes, which may result in damaged blood vessels.

Cataract is a clouding of the lens of the eye and occurs frequently in older age groups. An ophthalmologist needs a slit camera lens in the diagnosis of cataract, which may not be possible in rural areas. This results in belated handling of the disease, which has severe repercussions, and may ultimately lead to blindness.

Since such diseases present symptoms which are not very significant at earlier stages, and detection at later stages presents very little scope for treatment, it is necessary to design a solution for patient useage. Generally eye care is provided on a sustainable basis by screening the population for eye disease in the community and then referring only patients who would benefit from further diagnostics and treatment to the very scarce specialist care. Thus, a solution for this situation is an automated system for eye checkup to diagnose diseases in their initial stages, which provides more accurate and less time consuming diagnosis.The diagnosis can be done by observing the shape and other characteristics of the different parts of the retinal image.

II. LITERATURE SURVEY

Retinal images provide vital information about health of sensory vision.Many attempts have been made in the past to extract useful information from those images in order to detect the presence of disease condition. Few of those are summarized here:

Automated Diagnosis of Glaucoma Using Texture and Higher Order Spectra Features(2011)

Glaucoma is caused due to an increase in intraocular pressure. This occurs if there is malfunction in drainage structure of the eye. To identify this disease in its early stages, U. Rajendra Acharya, Sumeet Dua, Xian Du, Vinitha Sree S, and Chua Kuang Chua[1] focused on the following features: higher order spectra(HOS) parameters and texture descriptors. These features are extracted and given to various classifiers for classification: SVM, sequential minimal optimization (SMO), random forest, and naive Bayesian (NB) classifier.

Advantages:

1. Fivefold cross validation performed for checking accuracy of classification
2. Classification with more than 91% accuracy achieved
3. Technique can be easily incorporated into existing medical infrastructures as it uses commonly used fundus imaging equipment

Disadvantages:

1. Method applicable only for glaucoma identification

Glaucoma classification using Regional Wavelet Features of the ONH and its surroundings(2015)

Paper published by Muhammad Salman Haleem, Liangxiu Han, Jano van Hemert and Alan Fleming[2] tries to classify images as normal and glaucoma by identifying Regional Wavelet Features of the Optic Nerve Head(ONH) and different regions around it. These regions are usually used for diagnosis of glaucoma via visual observation in clinics.

Advantages:

1. RWF is more accurate than global feature classification(texture, grayscale and wavelet energy of the Optic Nerve Head)
2. Classification accuracy is 93%

Disadvantages:

1. Useful mainly for the identification of Glaucoma only

Cross-examination for Angle-Closure Glaucoma Feature Detection(2015)

Determining use of redundant features for complex disease diagnosis plays a vital role. Swamidoss Issac Niwas, Weisi Lin, Chee Keong Kwoh, C.-C. Jay Kuo, Chelvin C. Sng, Maria Cecilia Aquino and Paul T. K. Chew[3] proposes angle-closure glaucoma mechanism. For feature selection both supervised (Minimum Redundancy Maximum Relevance (MRMR)) and unsupervised (Laplacian Score (L-score)) methods have been cross- examined. For classifying various classes of ACG mechanism an Adaboost machine learning classifier is used .

Advantages

1. Helps to do a comparative analysis .

Disadvantages

1. Analysis is mostly based on small data set.

Automatic localization and contour detection of optical disc(2015)

Retinal diseases like Diabetic Retinopathy require identification of optic disc. Paper published by Manish Kr. Aggarwal and Vijay Khare[4] proposed a system using KL divergence matching in order to localize optic disc, followed by segmentation of main blood vessel.

Advantages:

1. Can locate a point in OD with 100% accuracy from DRIVE database images and 90% accuracy from STARE database images
2. Takes less computation time with histogram approach

Disadvantages:

1. Not useful in poorly contrasted images

Retinal fundus diseases diagnosis using image mining(2015)

This paper[5] helps in detection of glaucoma and diabetic retinopathy which causes vision loss. The system takes training images to classify them as normal, glaucoma or DR. Discrete Cosine Transform is used for feature extraction .For disease classification KNN algorithm is used .

Advantages

1. Use to determine images as normal, glaucoma and diabetic retinopathy
2. Gives better accuracy and efficiency as compared to other methods.

SURF descriptor and pattern recognition techniques in automatic identification of pathological retinas (2015)

Rodrigo Veras , Romuere Silva , Fla´vio Arau´jo , Fa´tima Medeiros[6] applied the Speed Up Robust Feature ,developed algorithm that finds points of interest to form visual dictionaries. To assemble these interest points k-means clustering algorithm is used . To predict whether an image is healthy or consists any type of pathology this paper uses multiple classifiers.

Advantages

1. Able to detect characteristic points of each image .

2. The method proposed is robust.
3. The accuracy rate was 97.25

Disadvantages

1. Poor performance as the algorithm is not able to detect small artifacts.
2. There is loss of information during the creation of the visual dictionary.

Automatic Segmentation and Area Calculation of Optic Disc in Ophthalmic Images (2015)

The most useful parameter indicating presence of Glaucoma condition is appearance of optical disc. But presence of blood vessels makes it hard to correctly identify and segment optical disc region.In the paper published by Pooja Sachdeva and Kiran Jot Singh [7], an automatic segmentation method is proposed for detecting optic disc and calculating optic disc area.On the basis of these features,early detection of Glaucoma is possible.

Advantages:

Adaptive mask is used for segmentation of disc. Thus this method is applicable to multiple sizes and resolutions of images.

Disadvantages:

1. Better result can be obtained using fuzzy logic for segmentation.
2. For real-life applications, hardware implementation is needed.

A computer-aided healthcare system for cataract classification and grading based on fundus image analysis (2015)

Liye Guo , Ji-Jiang Yang , Lihui Peng , Jianqiang Li , Qingfeng Liang[8] proposed a method which analyzes retinal fundus images and based on features extracted detects cataract condition, if present.Based on severity,cataract is graded as mild ,moderate or severe.The feature extraction is performed using 2 methods : Wavelet transform and sketch based methods together with direct cosine transform.

Advantages :

1. Along with cataract and non-cataract classification,method gives grading for condition according to severity.
2. Features which cannot be identified in space domain are easy to recognize in frequency domain.

Disadvantages:

1. Only able to identify cataract disease.

Detection of optic disc and cup from color retinal images for automated diagnosis of glaucoma(2016)

Megha Lotankar, Kevin Noronha and Jayasudha Koti [9] proposed a system in which Color Fundus Image (CFI) is used to analyse retinal nerve damage to detect glaucoma. From digital CFI optic disc, cup and neuroretinal rim are extracted through segmentation. For segmentation of OD Geodesic active contour model is used and for detecting cup color information of the pallor region in M channel of CMY color space is used .It uses features like vertical Cup to Disc Ratio (CDR), Horizontal to Vertical CDR (H-V CDR), Cup to Disc Area Ratio(CDAR), and Rim to Disc Area Ratio (RDAR). Classifiers like SVM (Support Vector Machine), NB (Naive Bayes) and kNN(k-Nearest Neighbour) are used for classification.

Advantages:

1. Cost effective as compared to OCT (Optical Coherence Tomography) and HRT (Heidelberg Retina Tomography).
2. OD and OC segmentation technique used is effective for lower quality images.
3. k-NN gives classification accuracy of 99.22%.

Disadvantages:

1. Geodesic active contour model greatly depends on contour initialization

Detection of Glaucoma using image processing techniques: A review(2016)

This is a review paper in which different techniques are studied to detect glaucoma using retinal images. Authors B. Naveen Kumar, R.P. Chauhan and Nidhi Dahiya[10] have compared these methods based on pre-processing techniques, classifier used and success rate in tabular form. Optimal method to detect glaucoma at early stages can be determined by studying this paper.

Determination for Glaucoma disease based on red area percentage(2016)

A novel method to detect glaucoma is proposed by Mohammad Aloudat and Miad Faezipour,[11] which analyses Red Area Percentage (RAP) level of the extracted portion of the sclera.For iris segmentation Circular Hough Transform technique (CHT) is used.

Advantages:

1. Vessels and redness of sclera are noticeable in glaucoma candidates.
2. Real time face detection is used

Disadvantages:

1. Sclera extraction is difficult as it has the same features as that of skin.

Optic disc localization using local vessel based features and support vector machine(2016)

Anum Abdul Salam, M. Usman Akram,Sarmad Abbas and Syed M. Anwar[12] proposed a system to diagnose retinal diseases like glaucoma and diabetic retinopathy by analysing optic disc. Optic disc analysis consists of Optic disc localization and optic disc segmentation. Features like Vessel density and Vessel orientation are extracted and classified using SVM.

Advantages:

1. Optic disk localization gives accurate results even in the presence of many bright lesions and noise in the fundus image.
2. Algorithm provides accuracy of 98% in optic disc localization and detection.

Disadvantages:

1. In optic disc segmentation, the bright lesions might be misclassified as optic disc.

Feature extraction from the fundus images for the diagnosis of Diabetic Retinopathy(2016)

To assist early stage of a Diabetic Retinopathy detection of lesions in a fundus image is necessary.this paper uses MAHM algorithm. ManojKumar S B, Manjunath R, Dr. H S Sheshadri [13] proposes new parameter for optic disk detection which detects the major vessels and later use the intersection of these to find the approximate region for optic disk. In the further step this region is localized by applying color properties. This system uses color fundus images as input .

Advantages

1. Provides an efficient framework for Diabetic Retinopathy .
2. Various features such as hemorrhages, microaneurysms, hard exudates and soft exudates can be detected.

Disadvantages

1. Can only detect Diabetic Retinopathy

Automatic Detection of Blood Vessel in Retinal Images(2016)

Correct detection of blood vessels is essential for identification of many retinal diseases like DR,hypertension.In paper [14], a method for automatic detection of blood vessels was proposed which uses Hessian matrix for vessel detection.The vascular structure is identified by using eigenvalues of Hessian matrix after convolving image with Gaussian kernel.

Advantages:

1. Applicable to both healthy as well as abnormal retinal images.

Disadvantages:

1. Vessel segmentation has been done without the elimination of Optic disc.

Mobile cataract detection using optimal combination of statistical texture Analysis(2016)

Paper published by Yunendah Nur Fuadah, Agung W. Setiawan, Tati L.R. Mengko, and Budiman[15] proposes one of the few known systems for early detection of cataract without having an ophthalmologist with a slit lamp camera on hand. It uses android smartphone and K-Nearest Neighbor (KNN) classifier in order to statistical texture analysis.

Advantages:

1. Cataract can be identified with up to 97% accuracy
2. Patient need only have smartphone to identify disease
3. Identifies cataract in various stages: immature, mature, hypermature

Disadvantages:

1. System used only for cataract identification

III. PROPOSED SYSTEM

The literature survey highlighted the need for a system which can detect the diseases resulting in vision loss if not detected early like Glaucoma. The proposed system focuses on three major diseases:

Cataract

Glaucoma

Diabetic Retinopathy

which are mainly responsible for vision loss if not diagnosed earlier. The process involves a combination of image processing and data mining concepts where features are extracted and then mining is applied to detect the exact disease of the retina. A database of retinal images will be considered and the purpose will be to classify the images as Normal, Glaucoma, DR or Cataract.

IV. SYSTEM ARCHITECTURE

Our proposed system in response to this analysis involves the following phases:

A. Preprocessing

Preprocessing is performed to obtain noise free and enhanced image, which can be used to detect features.The major tasks included in preprocessing are :

- Resizing of images : To remove non uniformity in medical images.
- Conversion from RGB images to YCbCr images
- Filtration : To remove noise.
- Edge detection :To detect blood vessels in retinal images.
- Binarization
- Segmentation
- Skeletonization

B. Feature Extraction:DCT (Discrete Cosine Transform)

The details which are hard to recognize in space domain are more prominent in frequency domain.DCT transforms image to frequency domain.

Following features of eye helps in prediction of class :

Blood vessels,Optic disc, exudates ,hemorrhages and Microneurysms.

The DCT coefficient is further used for classification purposes.

C. Classification

Classification rules are defined on the basis of features extracted for each of the four categories and images are identified as Normal, Glaucoma, DR or Cataract using kNN classifier.

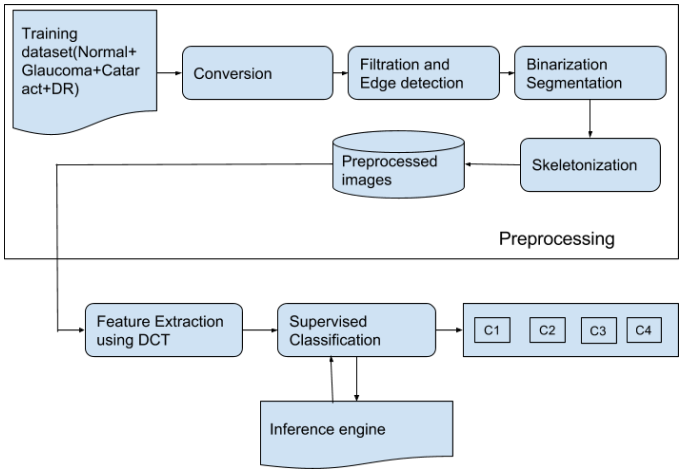

Figure 1. System Architecture

CONCLUSION

In this project, an image mining model for different diseases such as glaucoma, cataract and diabetic retinopathy is proposed. A combination of image processing and data mining concepts are used where features are extracted from the given training dataset and then mining is applied to identify the exact eye disease. This system integrates a single approach for all three diseases. We have proposed different algorithms for each phase (i.e preprocessing, feature extraction and classification) depending on the system requirements and given input database of fundus images.

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