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Diabetic Retinopathy Detection using Image Processing: A Survey

[1] **Anupama Pattanashetty**, [2] **Dr. Suvarna Nandyal**

[1] Research Scholar, Department of Computer Science and Engineering
PDA College of Engineering, Kalaburgi

[2] HOD, Department of Computer Science and Engineering
PDA College of Engineering, Kalaburgi.

Abstract - Image Processing is having is significance for disease detection on medical images. These disease recognition and classification approaches are specific to human organ and image type. One of such disease class includes detection of retinal disease such as glaucoma detection or diabetic detection. This paper shows an audit of most recent work on the utilization of image processing techniques for DR highlight identification. This present paper deals with the exhaustive review of literature based on different algorithms for the detection of diabetic retinopathy.

Keywords – *Glaucoma, Fundus Image, Diabetic Retinopathy, Hemorrhages, Blood Vessels, Exudes, Microaneurysms.*

1. Introduction

To perform the medical image processing and disease detection, a series of image processing operations are required to improve quality of acquired image and to perform the detection. These processing stages are given here under:

Enhancement: Medical images are often deteriorated by noise due to interference and other phenomena that affect the imaging processes. Image enhancement is the improvement of image quality to increase the perception of information in images for medical specialists.

Noise Suppression: Suitable noise suppressing algorithm is selected based on what type of noise presented in the image. Impulse noise (having distribution of extreme values, only isolated pixels are affected) should be removed by Mean or Median filter. Narrowband noise (a few strong frequency components form the noise) is suppressed by removing false frequency coefficients from the discrete two-dimensional spectrum and reconstructing the image from the new spectral information.

Sharpening: Enhancing the sharpness by accentuating edges may contribute to raise more visible details in an image. Laplacian, Sobel, Robert Cross are some algorithms used to extract edges and thus increase the sharpness of the image.

Contrast Enhancement: The appearance of an image depends significantly on the image contrast. There are three contrast enhancement methods: Linear contrast adjustments, nonlinear contrast adjustments (the brightness mapping is described by linear or nonlinear functions) and histogram equalization (changing pixel intensities so that the histogram is optimized with respect to even distribution).

Image Segmentation: The goal of image segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels .Actually, partitions are different objects in image which have the same texture or color. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. The goal of image segmentation is to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Segmentation could be used for object recognition, occlusion boundary estimation within motion or stereo systems, image compression, image editing, or image database look-up. The concept of Watersheds is well known in topography. It is a morphological based method of image segmentation. Segmentation using the watershed transforms works well if you can identify, or "mark," foreground objects and background locations.

1.1 Retinal Disease Prediction

Retinal Disease detection locates and segments Retinal Disease regions from cluttered images, either obtained from video or still image. It has numerous applications in areas like surveillance and security control systems, content based image retrieval, video conferencing and intelligent human computer interface. Most of the current Retinal Disease recognition systems presume that retinal disease is readily available for processing. However, we do not typically get images with just Retinal Disease. We need a system that will segment Retinal Disease in cluttered images. With a portable system, we can sometimes ask the user to pose for the Retinal Disease identification task. In addition to creating a more cooperative target, we can interact with the system in order to improve and monitor its detection. With a portable system, detection seems easier. The task of retinal disease detection is seemingly trivial for the human brain, yet it still remains a challenging and difficult problem to enable a computer /mobile phone/PDA to do Retinal Disease detection. This is because the human Retinal Disease changes with respect to internal factors like Retinal Disease expression, beard, mustache glasses etc and it is also affected by external factors like scale, lightening conditions, and contrast between Retinal Disease, background and orientation of Retinal Disease.

Retinal Disease detection remains an open problem. Many researchers have proposed different methods addressing the problem of Retinal Disease detection. In a recent survey Retinal Disease detection technique is classified into feature based and image based. The feature based techniques use edge information, skin color, motion and symmetry measures, feature analysis, snakes, deformable templates and point distribution. Image based techniques include neural networks, linear subspace method like Eigen Retinal Disease, fisher Retinal Disease etc. The problem of Retinal Disease detection in still images is more challenging and difficult when compared to the problem of Retinal Disease detection in video since emotion information can lead to probable regions where Retinal Disease could be located.

1.2 Medical Image Processing

Medical image processing and analysis is a technique and science to detect degenerated tissue. The main advantage of medical imaging is to make diagnosis as possible as noninvasive way in the treatment planning and clinically diagnosis. There are various types of medical imaging technologies based on noninvasive approach like Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and X-Ray etc.MRI is best suitable high quality medical imaging technology rather than others to collect perfect internal information of the body organ for clinical diagnosis. Medical imaging is a field in which researches develop tools to acquire, manipulate and achieve digital images that are used to provide better care for the patients. In medical science the problem as well as the data stream is three-dimensional and the effort to solve the problem is mostly combination of both human and machine.

Medical tasks can often be split into three areas:

- Data operations like filtering, noise removal, and contrast and feature enhancement
- Detection of medical conditions and events
- Qualitative analysis of the lesion or detected events.

1.3 Diabetic Retinopathy

Diabetic retinopathy also known as diabetic eye disease and damage occurs to the retina due to diabetes. It can eventually lead to blindness. It is an ocular manifestation of diabetes, a systemic disease, which affects up to 80 percent of all patients who have had diabetes for 20 years or more. Despite these intimidating statistics, research indicates that at least 90% of these new cases could be reduced if there were proper and vigilant treatment and monitoring of the eyes. The longer a person has diabetes, the higher his or her chances of developing diabetic retinopathy. Each year in the United States, diabetic retinopathy accounts for 12% of all new cases of blindness. It is also the leading cause of blindness for people aged 20 to 64 years.

Diabetic eye problems are classified into two types:
Non-proliferative diabetic retinopathy (NPDR): is the earliest stage of diabetic retinopathy. With this condition, damaged blood vessels in the retina begin to leak extra fluid and small amounts of blood into the eye. Sometimes, deposits of cholesterol or other fats from the blood may leak into the retina.

Proliferative diabetic retinopathy (PDR): mainly occurs when many of the blood vessels in the retina close, preventing enough blood flow. In an attempt to supply blood to the area where the original vessels closed, the retina responds by growing new blood vessels. This is called neovascularization. However, these new blood vessels are abnormal and do not supply the retina with proper blood flow. The new vessels are also often accompanied by scar tissue that may cause the retina to wrinkle or detach.

2. Current Challenges, Trends, and Issues

As in "[1]", paper describes the accessibility of the human eye, its transparency and the absorption properties of its internal tissues have fostered a rapid evolution of applications for lasers in ophthalmology. Lasers achieve their effects in the eye through photo thermal, photo disruptive or photochemical mechanisms. Author provided an overview of the present status of clinical and research applications for lasers in ophthalmology.

As in "[2]", Author present spectral reflectance curves obtained with a prism-grating-prism (PGP) spectrographic camera from structures producing hemoglobin signatures, including the retinal artery and vein, the pigmented retina and the optic disk, as well as from the macular area which is free of this signature. Oxygen-dependent changes in the hemoglobin signature are determined from vessels and tissue surround.

As in "[3]", this paper describes the methods to detect features of fundus images such as optic disk, fovea, and exudates and blood vessels. To determine the optic Disk and its centre we find the brightest part of the fundus and apply Hough transform. The detection of fovea is done by using its spatial relationship with optic disk. Exudates are found using their high grey level variation and their contours are determined by means of morphological reconstruction techniques. The blood vessels are highlighted using bottom hat transform and morphological dilation after edge detection. All the enhanced features are then combined in the fundus image for the detection of abnormalities in the eye.
As in "[4]", Author describes the retinal fundus photograph is widely used in the diagnosis and treatment of various eye diseases such as diabetic retinopathy and glaucoma. The proposed method consists of two steps: in the first step, a circular region of interest is found by first isolating the brightest area in the image by means of morphological processing, and in the second step, the Hough transform is used to detect the main circular feature.

As in "[5]",Author proposes a work on segmentation of blood vessels in retinal images using 2-D Gabor Wavelet to enhance the image then unsharp filter is used to sharpen the vascular edges and then used a canny edge detector is used to get the vessel segmentation mask. Then the technique is tested on DRIVE data base with an accuracy of 94.69% with standard deviation of 0.0053.

As in "[6]", in this work Glaucoma diagnosis is done by doctors. For detecting Glaucoma grading always gives different conclusion between one doctor to another. For helping doctors diagnose Glaucoma grading, this research made software with edge detections method, so it could give edge pattern of Retinal and Glaucoma itself. Edge detection of Glaucoma in this research is the first step for Glaucoma grading research. This research found the best edge detection method for Glaucoma detecting between Robert, Prewitt, and Sobel method. From these three methods, Sobel method is suitable with case of Glaucoma's detecting. Sobel method had smaller deviation standard value than two others edge detection method.

As in "[7]", Author describes Methods for 2-D fundus imaging and techniques for 3-D optical coherence tomography (OCT) imaging are reviewed. Special attention is given to quantitative techniques for analysis of fundus photographs with a focus on clinically relevant assessment of retinal vasculature, identification of retinal lesions, assessment of optic nerve head (ONH) shape, building retinal atlases, and to automated methods for population screening for retinal diseases.

As in "[8]", Author worked on 150 images with a new filtering approach in the wavelet domain for image pre-processing, and uses Sobel edge detection, Texture Analysis, Intensity and Template matching to detect Optic Disc.

As in "[9]", Proposed technique ACO hybrid with Fuzzy and Hybrid Self Organizing Hybrid with Fuzzy describe segmentation consists of two steps. In the first step, the MRI Retinal image is Segmented using HSOM Hybrid with Fuzzy and the second step ACO Hybrid with Fuzzy method to extract the suspicious region Both techniques are compared and performance evaluation is evaluated.

As in "[10]", the proposed System deals with the image obtained from stratus Anterior Segment Optical Coherence Tomography. Pre-processing is done to the

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AS-OCT image which includes color conversion, resizing the image, removal of noise from the original images by using mean filter before it is given as input for classification. Then Thresholding technique is used to segment the ROI after that Fuzzy min-max neural network algorithm will be implemented on the retinal fundus images. The algorithm was tested on the 15 normal and 24 abnormal images and achieved an accuracy of 97%.

As in “[11]”, Author adopted a technique which extracted ROI from retinal images. Optic disc segmentation is performed on the extracted ROI in order to detect the disc boundary using optimal color channel. The disc boundary obtained from the above step may not denote the exact shape of the disc as boundary can be affected by a large number of blood vessels at the entrance of the disc. Hence, optic disc boundary smoothing is performed using ellipse fitting for capturing near perfect shape of the disc. Optic cup segmentation is also performed. After the cup boundary has been detected, ellipse fitting is again employed to eliminate some of the cup boundary’s sudden changes in curvature. Ellipse fitting becomes especially useful when portions of the blood vessels in the neuro-retinal rim are included within the detected boundary. The CDR is consequentially obtained based on the height of detected cup and disc. If the cup to disc ratio exceeds 0.3 then it indicates the abnormal condition that is the presence of glaucoma.

As in “[12]”. Here a proposed work segment the required Disc-Cup area then morphological operations are applied on the gray scale image for extracting features from an image and finally two layer feed forward neural network is trained with 20 images to recognize different stages of the disease. The proposed algorithm is tested on 40 images among 26 patients with glaucoma and 12 are normal. The algorithm is successful in classifying 34 images accurately and failed to classify the 4 images.

As in “[13]”, proposed system deals with Extreme Learning Approach [ELM] approach and probabilistic neural network for blood vessel detection in retinal images and recognizes retina to be normal and abnormal. Feature extraction is done by Discrete Wavelet Transform which allows noise filtering and blood vessel enhancement in the single step. The proposed approach is based on pixel classification using 7-D vector to find the approximate position of abnormality present in the retinal blood vessels.

As in “[14]”,Author described a work on optic disk and cup segmentation for glaucoma screening based on super pixel classification using multimodalities such as in the first step, segmentation is initially done using clustering algorithms to classify each super pixel as disc or non-disc then 2-D Gabor filter to detect the accurate boundary due to its directional selectiveness capacity of detecting oriented features and fine tuning to specific frequencies and in the second step cup segmentation is done by thresholding using binary image and finally The Cup to Disc Ratio (CDR) of retinal fundus camera image is the primary identifier to confirm glaucoma for a given patient.

As in “[15]”, Author demonstrates the extraction of optic disc by using variable level set method based ellipse optimization algorithm for more accurate detection of optic disc. When compared with the results of other systems, this approach gives a better segmentation of disc which results to more accurate glaucoma diagnosis. The good performance of this new approach leads to a large scale databases. This offers an efficient tool for enhancing diagnostic abilities and can add to the sensitivity of the existing technique to improve the performance. To improve the results a number of testing images and training can be increased.

As in “[16]”, the paper deals with classification of three classes such as non-glaucoma, glaucoma suspect & glaucoma cases through $CDR_{v,}$ if CDR_{v} is increased gradually it also means that size of the optic cup becomes larger according to ophthalmologist’s suggestion when CDR_{V} is higher than 0.6 is considered as glaucoma. When CDR_{V} is between 0.4 & 0.6 it is in the suspect range of glaucoma. They have considered 100 images for training among 50 are non glaucoma and 50 are affected by glaucoma disease and to detect the disease first resize the image to 256X256 and then applied a color conversion from GB to gray scale for contrast enhancement then removed a noise using Gaussian filters to smoothen the image and applied a histogram equalization technique to improve the image contrast & intensity of pixels in the input images next feature extraction is done using PCA i.e subtracted mean is the average across each dimension this reduces a data set whose mean is zero and calculated the covariance matrix to measure how much two random variables change together and then calculated a Eigen vectors and Eigen values of the matrix which gives the useful information about the data and then form the feature vector .then finally used a SVM classifier for the classification with an accuracy of 98%.

As in “[17]”, Author aims to segment and locate the blood vessels, Optic disc and cup using Selfish Gene algorithm to achieve high efficiency, throughput and accuracy for identifying glaucoma. The blood vessels are segmented by using prewitt edge detection. The optic disc and cup is segmented using gradient algorithm to improve intensity and then size, area and shape features are extracted. After that CDR is calculated if it exceeds threshold level then that person affected by glaucoma then the level of disease is identified.

As in"[18]",Author combined a Gabor filter and Generalized linear model for extraction of Retinal blood vessels with this clarity in extraction can be improved. The proposed work can be tested on DRIVE AND STARE database. To classify the image as normal and abnormal, the methods include combinations of algorithms like Gabor filters, histogram equalization, edge detection, neural networks and morphological operations.

As in "[19]", proposed work deals with segmentation and mathematical filters based statistical approach to identify retinal disease. The statistical model is used to extract the features using segmentation model to separate the disc and cup features from retinal image and the analytical results obtained from the work in terms of detection ratio.

3. Conclusion and Future Scope

This research survey paper depicts many works related to automated diabetic retinopathy (DR) detection, retinal veins are harmed because of liquid spillage from these vessels. Diverse injuries, i.e., Exudes, hemorrhages, microaneurysms, and textures are utilized to recognize the phase of DR. It is found that early determination of DR can lessen the possibility of vision misfortune up to half, Through the extensive literature review carried out it has been observed that though various methods for detection of DR have been carried out there is still a need and scope to develop a Computer Aided System which can not only help diagnose DR but would also help in checking the progression of the disease so that its growth can be restricted if not prevented. Lot of recent research is being carried for detection of DR and Glaucoma using fundus images, but still detection of progression of DR in patient remains to be researched. In future, we need to develop Hybrid techniques for more accurate, robust as well as affordable automated techniques for DR detection at low cast. Once DR is correctly diagnosed then they can take proper medicine or undergo surgery in a timely manner to avoid total blindness.

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Author Profile:

Mrs. Anupama Pattanashetty is currently a Research Scholar in Computer Science and Engineering Department at PDACE Kalaburgi. She has completed B.E from TCE Gadag and M.Tech from VTU RC Kalaburgi.

Dr Suvarna S Nandyal born in Gulbarga, Karnataka, India in 1972. She received the B.E in Computer Science & engineering from Gulbarga University in 1993. M.Tech (Computer Science & Engineering) from VTU Belgaum in 2006. She has published number of papers in international journals and conferences. Her research interests include Image processing, Machine learning, Design & development of Mobile based Application, Computer Network, Multimedia Communication.