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A Survey on Detection of Diabetic Retinopathy

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***Abstract*—Visual perception is very important for human life. Although several medical conditions can cause retinal disease, the most common cause is diabetes. Diabetic Retinopathy (DR) can be identified using retinal fundus images. Detection and classification of deformation in Diabetic retinopathy is a challenging task since it is symptomless. Several algorithms were analyzed for the identification of abnormality. The analysis of different models in detecting the abnormalities from the image is done which includes various preprocessing techniques to standardize the image and post-processing techniques are applied for morphological adjustments, segmentation algorithms for segmenting the Lesion of Interest(LOI) namely white lesions and red lesions, further feature extraction methods extracts the features like Micro Aneurysms, Hemorrhages, Exudates and Cotton Wool Spots and so on finally, classification methods were utilized which concludes the presence or absence of DR symptoms along with the severity based on the count of the features extracted in the given retinal image. This survey study aims to develop a novel algorithm to identify and detect types of above mentioned diseases and find out the severity of those diseases also examine with 100% accuracy.**

KEYWORDS: ***Diabetic Retinopathy; Micro Aneurysms; Hemorrhages; Exudates; Cotton Wool Spots; Lesion of Interest.***

I. INTRODUCTION

The Bio-medical imaging is a large field which plays a vital role in research. The bio-medical imaging is an advanced type of microscopy which also supports medical science research for diagnosis.

The eyes are the most essential organs of our body. The health of the human eye is as important as any other body organ but care taken for the health of eyes are often ignored. There are various kinds of eye disease which affects the vision of human eye. Although several medical conditions can cause eye disease, the most common is diabetes which begins by high sugar levels (glucose stays in blood does not reach cells). Diabetes [1] (2016) increases the risk of developing any type of eye disease since it is symptomless. Hence, it is necessary to detect as well as diagnose the disease at the earliest stage. When the disease grows, the patient's vision become worse which lead to diabetic retinopathy. So some awareness has to be made for eye care services in the management of diabetes for decreasing the burden of preventable blindness. A schematized screening system for Diabetic Retinopathy can be developed to achieve 100% accuracy.

Diabetes can damage the blood vessels. The damaged blood vessels obstruct the supply of oxygen to the retina which leads to retinal damage. It can cause blindness if left undiagnosed and untreated at an early stage.

There are two stages of Diabetic retinopathy: Non Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). The early stage is NPDR which progresses in three stages namely mild, moderate and severe. Initially there occurs small balloon like swelling in the retina's minute blood vessels called 'Micro Aneurysms' (MAs), which seep fluid into the retina. They may also burst and cause tiny blood spots called 'Hemorrhages' (HMs) on the retina. As it progresses, the fluid and protein leak from the damaged blood vessels called 'Exudates' (EXs) occurs, which cause retina to swell. The NPDR stages are determined based on count of deformation features.

The advanced stage is PDR which is a extreme form of the disease where many more blood vessels are blocked resulting in "ischaemia" (restriction in

blood supply to tissues) also forms new blood vessels. At this stage, lack of oxygen in retina leads to grow new fragile blood vessels in the retina and into the vitreous where the gel-like fluid fills the back of the eye. The PDR stage includes the deformations features such as cotton wool spots (CWS), Intraretinal microvascular abnormalities (IRMA), Neovascularisation (NV), Retinal detachment (RD), Vitreous Hemorrhages (VH) and Sub-hyaloid Hemorrhage (SHH).

A. Global statistics of Diabetic Retinopathy in India

Eye care is emphasized very less in healthcare frameworks for communicable diseases and non-communicable diseases. The global statistics observed by World Health Organization (WHO) [2] estimated that 285.3 million people are visually impaired, out of which 39.8 million are blind and 246 million have low vision. The reasons of blindness may include glaucoma (12.3percent), age-related macular degeneration (8.7percent), diabetic retinopathy (4.8percent), childhood blindness (3.9percent) and trachoma (3.6percent).

B. Standardized test for Detecting Diabetic Retinopathy

HbA1c is glycated hemoglobin measured by standardized test using high performance liquid chromatography. If higher the HbA1c value then greater the risk of diabetes-related complications. The optimal HbA1c cutoff for detecting any diabetic retinopathy is 49mmol/mol (6.6%) for mild and is 52mmol/mol ((6.9%) for moderate or severe [3] (2014).

C. Impact factors due to Diabetic Retinopathy

The Social Impact factors of DR are social life, hobbies, social networks, work productivity, financial security and loss of income. The Emotional Impact factors of DR encompass all emotional reactions to actual or threatened vision loss, such as fear, worry, guilt, loss of confidence, anger, stress, depression and anxiety.
The evidence proves that diabetic retinopathy and associated vision loss have several devastating effects, which also includes disruption of family functioning and drop of work prospects [4] (2011). DR-related vision loss can be reduced by changing the constant repetitive visual functioning.

Hence considering importance of diabetic retinopathy and its severity the integrated and hybrid methods have been developed for the detection and classification.

II. LITERATURE REVIEW

Jose Tomas Arenas Cavalli et al., (2015) [5] proposed a web based application which is completely independent of user's computer operating system called as an 'automated DR screening'. The two types of abnormalities namely bright lesions and red lesions are achieved as a result. The lesion segmentation segregates the pixels corresponding to the lesions which falls in mismatch of other unwanted areas so those unwanted areas need to be located before the detection of exact deformation. The 2D Gabor wavelet transform, Bayesian classifier and KNN regression are used for locating those areas. Then fuzzy c-means clustering, neural network classifier, and morphological operators are used to detect bright lesions and red lesions. The complete system performance reached 91.89% sensitivity and 65.24% specificity.

Sharath kumar P N et al.,(2016) [6] proposed a method implementing the screening system of diabetic retinopathy in four stage process. The retinal images are standardized using cubic interpolation, local contrast enhancement and background subtraction. The optic disk and blood vessel regions are located using optic disk protocol and HSV space. To recognize signs of Diabetic retinopathy HSV space, Gamma correction, histogram, binary thresholding, shade correction, top-hat transform, contrast limited adaptive histogram equalization are used. Finally water-fall model is used to classify the retina as DR or Non-DR. The proposed method gave sensitivity of 80% and specificity of 50%.

Kemal AKYOL et al., (2017) [7] presented a methodology and technique to detect the location of structural disorders accurately in the early stage. The Methodology includes image pre-processing for image enhancement .The region of interest is marked using Oriented and rotated binary robust independent basic feature algorithm (BRIEF) and Speeded up Robust Features (SURF). Gabor Attributes (GA) and Discrete Fourier Transform Attributes (DFTA) are extracted as features from the region of interest further feature reduction is done using Spectral Regression Discriminant

Analysis(SRDA) to get the significant features. At last classification of Diabetic Retinopathy stages are done using Logistic regression (LR) and Random Forest (RF) classifiers. The proposed system achieved 85.33% sensitivity, 94.66% specificity and 90% accuracy.

Shirin hajeb mohammad alipour et al.,(2012) [8] attempted a work on diabetic grading system. The image is preprocessed using contrast limited adaptive histogram equalization algorithm. Digital curvelet transform (DCUT) is applied for detecting optic disk. Exudates (Ex) are detected by thresholding. Again Digital curvelet transform is used for blood vessel detection. Finally foveal avascular zone is segmented by detecting and connecting end points of extracted vessels these points. Micro Aneurysms are detected by subtracting the extracted blood vessels (BV) from input image. As a result features like FAZ, MA, EXs, BV, OD are detected and classified as grade1, grade2, grade3 diabetic retinopathy using Support Vector Machine (SVM) algorithm. This grading system results 100% sensitivity and specificity.

U R Acharya et al., (2009) [9] presented a work using morphological image processing techniques to detect features of diabetic retinopathy. Adaptive Histogram Equalization, morphological opening (disc-shaped), median filtering and binarization was performed to standardize the image. To detect exudates the green channel extraction, morphological closing (disc-shaped, octagon-shaped), median filtering and binarization are done. To detect Micro Aneurysms the green channel extraction, canny edge detection, subtraction operations are done. To extract the hemorrhages the blood vessels image g subtracted from blood vessels with hemorrhages along with inversion and enhancement using Adaptive Histogram Equalization, morphological dilation and erosion (ball-shaped). Based on extraction, the Diabetic retinopathy stages are classified as mild NPDR, moderate NPDR, severe NPDR and PDR using Support Vector Machine (SVM) classifier. The system achieved average accuracy of 85%, sensitivity of 82%, and specificity of 86%.

Pavan kumar Mishra et al., (2014) [10] implemented an automated diagnostic system to detect features of diabetic retinopathy. The blood vessels are detected by the green channel extraction and masking of the image using gabor filter. The optic disk is detected by enhancing the image using Adaptive Histogram Equalization and morphological closing operation. Then otsu algorithm segments optic disk area alone. The exudates are localized using the mean intensities of the candidate region and subtracting it from the optic disk segmented image. Finally KNN classifier predicts the severity condition based on feature values. The accuracy was very high which implies greater accuracy of DR detection.

R.Radha et al., (2013) [11] proposed a method for the retinal analysis to recognize normal and abnormal retina through detection of exudates. The Retinal blood vessels are detected with preprocessing techniques such as bitwise plane separation, Discrete cosine transform (DCT), dilation and erosion. The Exudates are segmented using k-means algorithm on also morphological operations are carried for smoothening. The Discrete Wavelet Transform is applied for feature extraction from the image. These extracted features are trained in the probabilistic neural network to classify the retina as normal and abnormal. The results showed 98% accuracy in detection.

DhiravidaChelvi.E et al., (2015) [12] presented a paper to determine the stages of the Diabetic retinopathy based on the SIFT (Scale-invariant feature transform) features points. The input image is preprocessed by applying gray scale conversion, salt and pepper noise, median filter and pixel level enhancement. The SIFT feature points and histogram value are calculated for input image and template images by matching both the images. The numbers of connected components are calculated using morphological operations. The comparison of these output score decided whether it is affected by NPDR or PDR and also determines the stages as mild, moderate, severe. In the proposed approach the performance accuracy obtained is 93%.

Annie Grace Vimala GS et al., (2017) [13] presented a study which focuses to develop a computer Aided diagnostic system (CAD). The image is preprocessed by normalizing the intensity values from 0 to 1 scale for all the images. Then binarization using an empirical threshold value (T=0.78). The binarized image undergoes noise removal using morphological operations. Further the morphological features such as area, eccentricity, extent, orientation, convex area of the polygon and solidity were extracted. The RBF-

kernel based Support Vector Machine classifier was used to diagnose diabetic retinopathy. The Support Vector Machine (SVM) classifier output was compared against the ground truth results. The performance of the proposed computer aided detection system demonstrates the higher rates of sensitivity (92%), specificity (91%) and accuracy (92%).

Priya.R et al., (2011) [14] proposed automated approach to classify diabetic retinopathy stages. Initially, Retinal image is preprocessed using Gray scale conversion, Adaptive Histogram Equalization, Discrete Wavelet Transform, and Matched Filter Response. Then it is clustered using Fuzzy C-means. The features such as area, mean, standard deviation are extracted from the clustered image. The extracted features of the images are trained in SVM model which classifies the images into Normal, Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). Obtained result shows that the sensitivity of the system is 99.45%, specificity is 100% and accuracy is 98.92%.

III. CONCLUSION

The extracted different features of retinal fundus image of existing methods are analyzed and categorized that are presented with brief description along with its performance measures. To discriminate the retinal images as normal and abnormal, it has to be standardized using preprocessing techniques further it is clustered to segment the lesion of interest (LOI) and based on the optimal threshold value the LOI is classified as NPDR and PDR. The previous works comprises detection of different features with different techniques which results in high computational and time complexity. Therefore a novel automated approach can be developed with integrated techniques to reduce the time and computational complexity. Developing of a screening system which provides a decision about the existence of the disease with integrated techniques can also reduce the screening requirements by up to 100%.

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