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Review Of Automatic Detection And Grading Of Diabetic Maculopathy

Bijee Lakshman[1] and R.Radha[2]

[1]Department of Computer Science, Bhaktavatsalam Memorial College for Women, Korattur, Chennai, Tamilnadu, India.
bijeesanjay@hotmail.com
[2]Department of Computer Science, S.D.N.B.Vaishnav College for Women, Chrompet, Chennai, Tamilnadu, India.
radhasundar1993@gmail.com

ABSTRACT

Eye malady identified with diabetes that makes swelling and strange spillage of liquids and fats into the macula, where fine centering and focal vision happen. Due to the area of eye harm, disjoin diabetic maculopathy can bring about loss of focal vision and lack of sight. Hence, it is important to diagnize diabetic maculopathy at an early stage in a more efficient and automatic method. This paper gives complete review of various techniques used for automatic detection of Diabetic Maculopathy. The objective of this study to provide a complete overview of various methods and techniques used by many researchers to automate the detection of Diabetic Maculopathy.

KEYWORDS: DIABETIC MACULOPATHY, OPTIC DISC, MACULA.

1. INTRODUCTION

Diabetic Maculopathy (DM) is a condition that can result from Diabetic Retinopathy(DR) which causes damage to the macula. Macula is the region in the eye which provides us with our central vision. Ophthalmologists follow certain procedures in order to detect maculopathy. As the percentage of population in the world with DM increases day by day, it is necessary to have an automatic system to detect this pathology by any clinical staff so that work could be easy for the ophthalmologists, hence, many researchers have found various methods to automate the detection of DM.

The objective of this survey is to find an easy and a novel approach to automatically detect the pathology in the retina. Various research studies on automatic

detection of Diabetic Retinopathy and Maculopathy is discussed in this paper. It is found that in majority of the research papers, the following procedure is done initially. Fundus images of the retina is considered as the data and pre-processed to make the image clear and perfect in order to do further processing to identify various objects like optic disc , macula , fovea, blood vessels, exudates (if any). It is necessary to identify and locate the optic disc in the retina from the pre-processed image, so that, only with the location of optic disc (OD), it is possible to find other objects in the retina easily. Hence, the first process in the procedure is to identify and locate OD, then from the location of OD, it is possible to find macula which is the centre part of the retina, also located at a distance twice the diameter of OD. To achieve a clear and sharp boundary image of OD and macula, morphological operations are applied on the same. Hence, OD, macula and further objects like centre of macula(fovea) and exudates in the retina are extracted to detect DM. Feature extraction is done after detection of Maculopathy in order to find out the grading of the severity in DM. Grading are of three different types like mild, moderate and severe . Many researchers have done a detailed study in this topic and have found various interesting methods to automate the system of detecting diabetic maculopathy. The algorithm is given in Figure 1. Section 2, describes various methods used in detection of optic disc, macula, macula centre, exudates and further detection of diabetic maculopathy. Feature extraction of the retinal images done by various researchers are also discussed in this section. Section 3, describes various techniques followed to grade the pathology. Section 4, gives the performance analysis in a tabulated form of different approaches done by various researchers in the literature. In Section 5, discussion is done about Conclusion and Future Work.

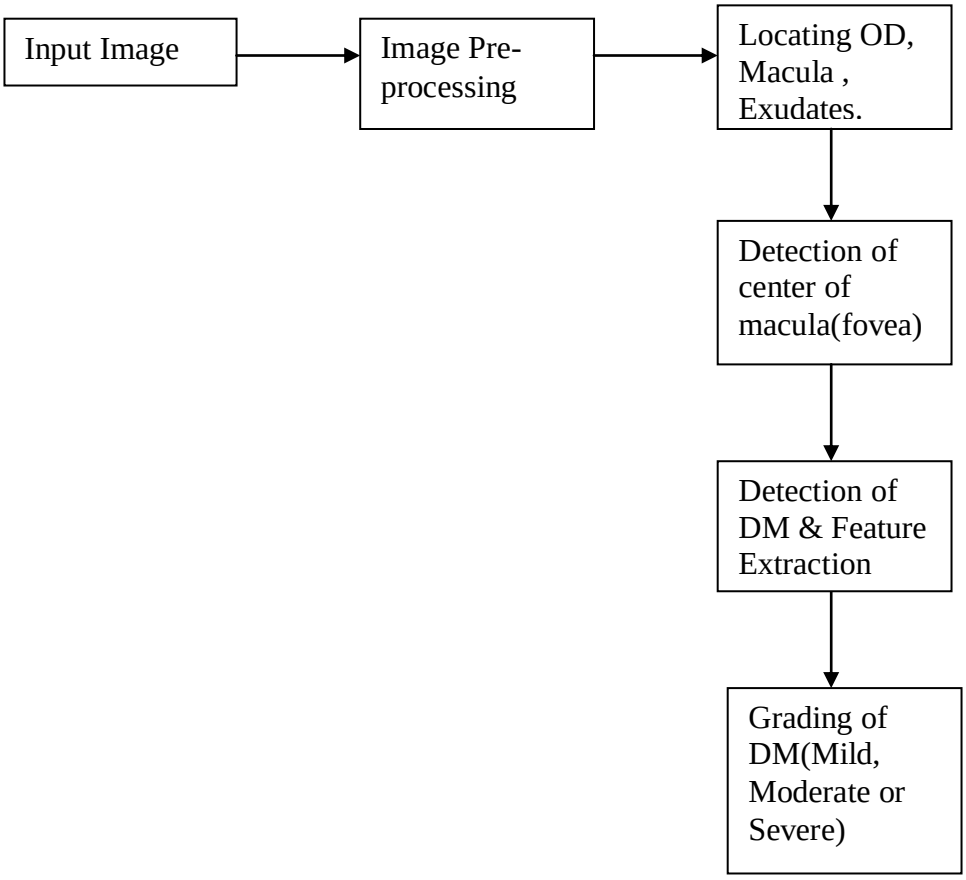

Figure 1: Steps for Detecting Diabetic Maculopathy

2. REVIEW OF VARIOUS METHODS USED FOR DETECTION OF OBJECTS IN RETINA AND AUTOMATIC DIAGONIZATION OF DIABETIC MACULOPATHY

The following researchers have used various methods for locating the optic disc, macula, macula center and exudates in it, therefore detecting the presence of diabetic maculopathy. After the detection of DM, the feature extraction is done by various other researchers in different techniques in order to grade by severity in maculopathy.

Ashok Kumar.T. et al ., demonstrated a method for the rapid detection and extraction of features like optic disc and macula for the diagnosis of ophthalmic pathologies from the fundus images of retina. Bit plane slicing and mathematical morphology was applied to the pre-processed imageto achieve the exact boundary of features like optic disc and macula. The database was taken from MESSIDOR with various visual qualities. The algorithm used here was found superior to the existing algorithms in terms of computational time and accuracy.

Alireza Osareh et al., proposed a method in automatic recognition of exudative maculopathy using Fuzzy C- Means Clustering and Neural Networks. Fuzzy C-Means Clustering was used in image colour normalization, enhancing the contrast between objects and the background, thereby segmenting the colour retinal images in to

homogeneous regions. Exudates and non-exudates patches were classified further using a fully connected multi layer neural network with a 10-N-1 architecture.In this approach, 92% sensitivity and 82% specificity were obtained.

Aliaa Abdel-Haleim Abdel-Razik Youssif et al. , presented a method to detect automatically the position of OD in digital retinal fundus images based on matching the expected directional pattern of the retinal blood vessels. A simple and standard 2-D Gaussian matched filter was used for segmenting the retinal blood vessels. Using local intensity, the segmented vessels are thinned and filtered to represent the OD center candidates. The difference between the proposed matched filter resized into four different sizes and the vessels' directions at the surrounding area of each of the OD-center candidates were measured. An estimate of the OD-center co-ordinates were found by the minimum difference. Images were used from the STARE project's dataset in which 98.77% accuracy was achieved and in the DRIVE's data base that was used, achieved 100% accuracy.

Arturo Aquino et al., proposed a method to detect the optic disc boundary in digital fundus images by using the morphological and edge detection techniques followed by the circular hough transform. It required a pixel within the ODas initial information, so a location methodology based on voting-type algorithm was also proposed. Images were used from MESSIDOR data base and 99% accuracy was obtained.

Rashid Jalal Qureshi et al., proposed an efficient combination of algorithms used for detecting optic disc. Algorithm used in this method was based on (a)pyramidal decomposition, (b)edge detection, (c)entropy filter (d) hough transformation (e) feature vector and uniform sample grid. The following methods used to detect the macula was based on (a) intensity (b) spatial relationship with the optic disc (c) temporal arcade (d) watershed and morphological operators (e) a novel approach by extracting the green plane from the colour fundus images and then generated the background image by applying an A × A median filter and subtract it from the green plane which resulted in a shade corrected image. Next, the image is binarized by considering all non-zero pixels as foreground pixels and others as background. An image labeling procedure is applied and largest component is selected as macula. Here, the ensemble classifier i.e. the combination of algorithms was found to be more accurate than any of its individual members. Images were taken from the web based database like diaretdb0, diaretdb1 and drive. Total average accuracy for the detection of macula was 96.87% and for optic disc was 98.06%.

Gopal Datt Joshi et al., presented an automatic OD parameterization technique based on segmented OD and cup regions obtained from monocular retinal images. A novel OD segmentation method was proposed which integrated the local image information around each point of interest in multi-dimensional feature space which provides robustness against variations that was found in and around the OD region. A novel cup segmentation method was also proposed based on anatomical evidence such as vessel bends at the cup boundary which are considered relevant by the glaucoma experts. The work presented here enabled more comprehensive evaluation of the OD and performing glaucoma detection using multiple disk parameters. The overall performance was found to be good.

Adam Hoover et al., described an automated method to locate the optic nerve in the images of the ocular fundus. Fuzzy convergence is used to determine the origination of the blood vessel network. Method is evaluated using 31 images of healthy retinas and 50 images of diseased retinas. 89% accuracy was achieved. This method was also compared against three simpler methods, demonstrating the performance improvement.

Kittipol Wisaeng et al., proposed a method for automatic detection of optic disc in digital retinal images by using morphological method and Otsu's algorithm which is done after colour normalization, contrast enhancement and noise removal – the key pre-processing steps. STARE project's dataset is used here and 91.35% accuracy was obtained in detecting the OD correctly.

Chanjira Sinthanayothin et al., described an automated localisation of the optic disc, fovea and retinal blood vessels from digital colour fundus images. 112 retinal images were pre-processed via adaptive, local, contrast enhancement. By the identification of the area with the highest variation in intensity of adjacent pixels, the optic discs were located. Multilayer perceptron neural network identifies the blood vessels, for which the inputs were derived from a principal component analysis(PCA) of the image and edge detection of the first component of PCA. By using the matching correlation, foveas were identified, together with its characteristics. The sensitivity and specificity of the recognition of each retinal main component was as follows: 99.1% and 99.1% for optic disc; 83.3% and 91.0% for blood vessels; 80.4% and 99.1% for the fovea.

Jaspreet Kaur et al., proposed a method in automatic localisation of optic disc and macula from fundus images. Localisation of optic disc was done by applying a threshold and then an estimation of optic disc center was done through iterative thresholding. Optic disc boundary was detected by using the geometric active contour model. Image segmentation was performed by starting with initial curve and evolving its shape by minimizing energy function represented by level set function. The iterative curve evolution was stopped at the image boundaries where the energy was minimum. It was found that implicit active contours provided better results with gray scale images than RGB images. A sensitivity of 90.67% was obtained.

M. Ponni Bala et al., proposed a new feature based automated technique for classification and detection of exudates in colour fundus images. Their method helps the professionals work to examine on every fundus images rather than only on abnormal image. The exudates were separated from the fundus images by thresholding and the removal of optic disk was done using morphological operation and connected component analysis. An automated Fuzzy Inference System (FIS) was used for classifying the retinal images as exudates and non-exudates. The sensitivity , specificity and accuracy are reported as 91.11%, 100% and 93.84% for fuzzy inference system classification.

B.Ramasubramaniam et al., found an automated method to detect and localize the presence of exudates and maculopathy from low-contrast digital images. Firstly, the image was segmented using colour K-means clustering algorithm. The segmented image along with optic disc is chosen. Features based on colour and texture are extracted in order to classify these segmented region. The selected feature vector were

then classified into exudates and non-exudates using Support Vector Machine (SVM) Classifier. Morphological operation is used to perform the detection of diabetic maculopathy. The success rate detecting the images with exudates was 96%.The experiment was done with images that were collected from Aravind Eye hospital, Madurai.

Annie Grace Vimala G.S. et al., proposed an automatic and efficient method to detect the exudates. The retinal images are pre-processed via. Contrast limited adaptive histogram equalization (CLAHE). The pre-processed colour retinal images are segmented using K-Means Clustering technique. The segmented images establish a dataset of regions. A set of features based on colour and texture are extracted to classify the segmented regions into exudates and non-exudates using the Gray Level Co-Occurance Matrix(GLCM). The selected features are classified into exudates and non-exudates using the Support vector Machine(SVM) classifiers. The success rate in detecting the exudates are 96%. Images were obtained from a nearby hospital and was compared with the publicly available STARE and DRIVE database.

Ahmed Wasif Reza et al., proposed a new algorithm for the extraction of bright objects like optic disc, exudates and cotton wool spots which are the main features. The algorithm was based on marker-controlled watershed segmentation. The proposed algorithm used average filtering and contrast adjustment for pre-processing steps. The concept of the markers was used to modify the gradient before the watershed transformation was applied. The images were used from the STARE and DRIVE dataset and a sensitivity value of 95% was achieved.

Asha Gowda Karegowda et al., have attempted to detect exudates using back propagation neural network(BPN). In order to prevent the optic disc from interfering with exudates detection, the optic disc was eliminated . Significant features were identified from the images after pre-processing using the methods - decision tree and GA-CFS (Genetic Algorithm-Correlation based Feature Selection)which were used as input to the BPN model to detect the exudates and non-exudates at the pixel level. The results proved that, BPN performance with features identified by decision tree and GA-CFS approach has outperformed the performance of BPN with all inputs. The images were taken from DIARETDB1 dataset which is publicly available. The best performance of the BPN classifier was found with Sensitivity of 96.97%, Specificity of 100% and classification accuracy of 98.45%.

Phillips R.P. et al., have developed a digital fundus imaging system and image processing programs which provides objective, quantitative measures of macular oedema, retinal exudates, and microaneurysms in diabetic retinopathy. The degree of macular oedema is quantified both in terms of area of fundus involved and severity of oedema by analysis of the temporal changes in intensity of fluorescence, using flourescein angiograms. These angiograms are also used for the detection and counting of microaneurysms, by a combination of shade correction, matched filtering and shape algorithms. A colour transparency projected through a red free filter is analysed using a combination of shade correction and thresholding techniques for detection and measurement of retinal exudates. The accuracy of the technique was estimated to be approximately 97%.

Keerthi Ram et al., proposed a clustering-based method to segment exudates

using multi-space clustering and color space features. The proposed method was a bottom-up approach which consists of the following steps: (a) suppressing the fundus mask (b) obtaining pixel values in multiple color spaces (3) constructing the feature spaces to perform clustering (4) clustering to obtain labels (5) combining the clustering outcomes, to get candidate regions (6) suppressing false candidates. Publicly available DIARETDB1 dataset was used for evaluation consisting of 89 images, of which 38 images contained hard exudates and 20 contained soft exudates. 71.96% of sensitivity and an acuuracy of 89.7% was obtained.

Adnan Rashid Chaudhry et al., have developed a method in automatic positioning based on top down approach, which started with the vascular tree segmentation and skeletonization. The detected vessels helped in localization and detection of optic disc. An approximate OD center was found by ellipse fitting to the boundary of OD. The vascular tree and the ellipse fitting helped in detection of the macula and its center the fovea in relation to the OD center.

Kavitha S. et al., presented an efficient approach for automatic detection of exudates and macula to measure the severity of diabetic retinopathy in fundus images. The exudates are detected by using a region based approach and fine segmentation of exudates was achieved using adaptive thresholding and split and merge technique. The macula region is detected using the tophat filtering technique. The severity of diabetic retinopathy was estimated by comparing the distance between macula and exudates.

Poshtyar et al., presented an approach to detect optic disc center and macula using spatial information of optic cup.Optic cup is the region in optic disc with the brightest pixel values. The proposed method was based on morphological, adaptive thresholding and arithmetic operations. This method was computationally efficient and fast. It performed well even when there were unhealthy and low quality retinal images.

Akara Sopharak et al., investigated and proposed a set of optimally adjusted morphological operators that was used for exudate detection on diabetic retinopathy patients' non-dialted pupil and low-contrast images. These automatically detected exudates were validated by comparing with expert ophthalmologists' hand-drawn round –truths. The results were successful and the sensitivity and specificity for exudates detection was 80% and 99.5% respectively.

Cemal Kose et al., proposed a simple statistical technique for the detection of the optic disc and macula for calculating the diameter of the OD and the distance between OD and macula. The results could be used in automatic diagnosis or monitoring systems developed for retinal diseases. A tool was provided for verifying the location of the OD and macula to increase reliability. This study also uses the weighted distance method to extend the healthy parts of a retinal image. 400 images were used for testing. A detection rate of 97% of the OD and macula, an accuracy of 95% of the diameter of the OD, and an accuracy of 97% of the positions of the OD and macula were obtained.

Akram M.U. et al., have developed an automated system for optic disc localization and detection. This method localizes the OD using average filter and thresholding, extracts the region of interest (ROI) containing OD to save time and

detects the OD boundary using hough transform. This method could be used in computerized analysis of retinal images , in automated screening for diabetic retinopathy. The technique was tested on publicly available DRIVE, STARE, DIARETDB0 & DIARETDB1 databases. An average accuracy of 96.7% for localization and an average area under receiver operating characteristic curve of 0.958 for optic disc detection was obtained.

Giraddi et al., have attempted to detect exudates by a combination of DBSCAN clusrtering algorithm and fuzzy classifiers. The DBSCAN algorithm produces many clusters that human cannot make out. In order to correctly identify the exudates , post processing is performed using fuzzy classifier to classify clusters as exudates or non-exudates. Exudates in training retinal images were marked by expert ophthalmologists. Various histogram based features were calculated for the regions marked. These features were used for training the fuzzy classifiers. Optic disc is localised by the circular hough transform. The publicly available dataset DIARETDB0 was used for evaluation. In addition to the above dataset, images from vasan eye care hospital were also used. This algorithm achieved image based classification accuracy above 90%.

Ferdic Mashak Ponnaiah G. et al., proposed a method to remove false hard exudates and improve retinopathy detection accuracy using genetic algorithm based automatic optic disc detection and removal method. The outputs of baseline hard exudates detection method presented in the database (DIABETDB1) for evaluating the improvement after the removal of false positives in the OD region. The improvement in performance in using more versatile metric weighted error rate was evaluated. After removing false positives at OD region by manual removal method and the proposed automatic removal method, the results of baseline method for evaluating the improvement in classification accuracy were compared.

Esmaili et al., presented a curvelet-based algorithm for detection of OD and exudates on low contrast images. This algorithm which was composed of three main stages did not require user initialization and was robust to the changes in the appearance of retinal fundus images. Firstly, bright candidate lesions in the image were extracted by employing DCVT and modification of coefficient of enhanced retinal image. For this purpose, the authors applied a new bright lesions enhancement of green plane of retinal image to obtain adequate illumination normalisation in the regions near the OD and to increase brightness of lesions in dark areas such as fovea. Following this step, the author introduced a new OD detection and boundary extraction method based on DCVT and level set method. Finally, bright lesions map (BLM) image was generated and to distinguish between exudates and OD (ie. A false detection for the final exudates detection), the extracted candidate pixels in BLM that were not in OD regions (detected in previous step) were considered as actual bright lesions. The sensitivity and specificity for exudates detection method were 98.4% and 90.1%, respectively, and the average accuracy of their OD boundary extraction method was 94.51%.

Aqeel et al., proposed a robust, combined method for blood tree segmentation on a 2D image. In this algorithm, pre-processing takes place, such as image filteration and color contrast enhancement, and after that the combined approach for image

segmentation and classification were executed using texture, thresholding and morphological operation. This method gave clearer and more accurate output for ophthalmologists and automated retinal image diagnosis.

Gerald Schaefer et al., proposed a neural network based approach to automatically detect exudates in retina images. A sliding windowing technique was used to extract parts of the image which were then passed to the neural net to classify whether the area is a part of exudates region or not. Principal Component Analysis and histogram specification were used to reduce training times and complexity of the network, and to improve the classification rate. A sensitivity of 94.78% and a specificity of 94.29% was obtained.

3. LITERATURE STUDY ON VARIOUS TECHNIQUES FOLLOWED TO GRADE THE SEVERITY LEVELS OF DIABETIC MACULOPATHY AND ITS RELATED PATHOLOGIES

K. Sai Deepak et al., proposed a two-state methodology for the detection and classification of diabetic Macular Edema (DME) severity from color fundus images. DME detection was carried out via a supervised learning approach using the normal fundus images. A feature extraction technique was introduced to capture the global characteristics of the fundus images and discriminate the normal from the DME images. Disease severity was assessed using a rotational asymmetry metric by examining the symmetry of macular region. The performance of the proposed methodology and features were evaluated against several publicly available datasets. The detection performance had a sensitivity of 100% with specificity between 74% and 90%. The severity classification accuracy was 81% for the moderate case and 100% for severe case. The datasets used were DIARETDB0, DIARETDB1, MESSIDOR,HEI-DMED.

Jayakumari C. et al., proposed a grading system for detecting hard and soft exudates. A novel technique of intelligent segmentation and classification of exudates for diabetic retinopathy, by applying energy minimization method using a recurrent neural network that is an Echo State Neural Network (ESNN) which, yielded highly satisfactory results when compared with that of an existing contextual clustering segmentation (CC) was explored in this study. The modular neural network was trained using a set of 30 images consisting of 5 normal images and 25 abnormal images. The trained system had been tested with 5 normal and 20 abnormal images and was found to acquire satisfactory results with 90% sensitivity. Images were obtained from a popular eye clinic, Chennai.

Carla Agurto et al., presented an automatic system to detect pathologies on the macula such as hard exudates, microaneurysms, and haemorrhages. A bottom-up implementation was made in this approach, which tries to capture each abnormal structure in the macula in order to detect DR lesions. This technique starts by eliminating the non-uniform illumination thereby enhancing the contrast of red lesions in the images. Possible DR lesions (hard exudates and red lesions) candidates on the macula were extracted by using amplitude-modulation frequency-modulation (AM-FM) features. AM-FM features extract texture information from different frequency scales, providing for an effective method for the detection of hard exudates and red

lesions. For each lesion candidate, they also extract shape, color and other texture features that were then combined with AM-FM features. Pathologies in the macula were detected from the candidate lesions using supervised classification with Partial Least Squares. Images were acquired from University of Texas Health Science Center, San Antonio. The sensitivity and specificity for detection of (a) hard exudates were 100% and 58% respectively, (b) red lesions were 74% and 90% respectively.

Akram M.U. et al., proposed a novel computerized method for the grading of diabetic maculopathy in fundus images. The proposed system comprised of pre-processing of retinal image followed by feature extractor module for the formulation of feature set. Support Vector Machine (SVM) classifier was then used to grade the diabetic maculopathy. The publicly available fundus image database MESSIDOR were used for the validation of the algorithm. The results of the proposed system was compared with other methods in the literature in terms of sensitivity and specificity which had given higher values when compared to others on the same database.

Mui Hong Ang et al., presented an intelligent system that was capable of differentiating between fundus eye images belonging to normal eyes and those belonging to eyes affected by either of the two types of maculopathy – nonclinically significant macular edema (nonCSME) and clinically significant macular edema (CSME). Characteristic features were extracted from the raw fundus images using morphological image processing techniques and fed to a feed-forward artificial neural network (ANN) in this method. 90 subjects belonging to normal, non CSME, and CSME categories were used for evaluating the proposed technique. Results showed that the p-values (obtained using the analysis of variance(ANOVA) test) of the selected features were less than 0.001, which indicated that the features were clinically significant and very discriminative. The ANN classifier resulted in a good accuracy of 96.67% and sensitivity and specificity of 96.67% and 100% respectively.

Siddalingaswamy P.C. et al., presented a computer based system for automatic detection and grading of diabetic maculopathy severity level without manual intervention. The optic disc was detected automatically and its location and diameter was used to detect fovea and to mark the macular region respectively. The hard exudates were detected using clustering and mathematical morphological techniques. Based on the location of exudates in marked macular region the severity level of maculopathy was classified into mild , moderate and severe. The method achieves a sensitivity of 95.6% and specificity of 96.15% with 148 retinal images for detecting maculopathy stages in fundus images as comparable to that of human expert.

Jagadish Nayak et al., have proposed a computer- based approach for the detection of diabetic retinopathy stage using fundus images. Image pre-processing, morphological processing techniques and texture analysis methods were applied on the fundus images to detect the features such as area of hard exudates, area of the blood vessels and the contrast. This model used total of 140 subjects consisting of two stages of diabetic retinopathy and normal. The extracted features are statistically significant with distinct mean. These features were then used as an input to the artificial neural network (ANN) for an automatic classification. The detection results were validated by comparing it with expert ophthalmologists. An accuracy of 93%, sensitivity of 90% and specificity of 100% was achieved.

Carnimeo et al., contributed for supporting diabetic symptoms detection in retinal images by synthesizing a cellular neuro-fuzzy network that was able to provide informations on vague pale regions of fundus images with subject diabetic damages. The contrast of the images was enhanced by means of a CNN-based fuzzy subnet, after highlighting pale regions in input images by intensity difference map evaluation. After an adaptive thersholding evaluation, contrast- enhanced images with biomodal histograms were globally segmented by a CNN-based subsystem, providing binary output images, in which suspect diabetic area were easily isolated. Performances were evaluated by means of the correct recognition rate, which provided percentage measures of exactness in the detection of suspect damaged areas.

Nayak.J. et al., presented a computer based intelligent system for the identification of clinically significant maculopathy, non-clinically significant maculopathy and normal fundus eye images. Features were extracted from these raw fundus images which were then fed to the classifier. This protocol was feed-forward architechture in an artificial neural network classifier for classification of different stages. Three different kinds of eye disease conditions were tested in 350 subjects. A sensitivity of more than 95% of these classifiers with a specificity of 100% was obtained.

Shoba Christila S. et al., have developed localization of the fovea automatically by getting information of the OD and the blood vessel structure and mathematical morphology method was used to localize the fovea region further accurately. The algorithm had two stages such as the first stage deals with the detection of the blood vessels of the retinal fundus image and then the proceeding stage utilizes the geometrical distance between OD and fovea region and the structure of the blood vessels to perfectly localize the fovea region. The extracted macula and fovea region may help further automatic detection and grading the severity level of DM. Datasets used were DRIVE and had a higher accuracy rate.

Purabi Sharma et al., proposed an automated system for grading the severity levels of DM which could assist the ophthalmologists in early detection and diagnosis of the disease. Presence of exudates in the macular region is an important indication of maculopathy. The macula is localised based on its distance and position with respect to the OD. The macular region is then divided into three concentric geometric windows. Based on the presence of exudates in a particular window, the severity level of maculopathy was identified. If exudates are present in the innermost region then it was classified as severe case. Presence of exudates in the outermost region was classified as mild case. The moderate case was the one with exudates present in the middle region. The proposed work has been tested on retinal images with different levels of maculopathy from different databases (DIARETDB0, MESSIDOR, DIARETDB1) and images obtained from a local eye hospital. A sensitivity of 96.2% in correctly grading the different stages of maculopathy.

Senthil Kumar C. et al., proposed an algorithm for the detection of retinal landmarks (optic nerve head, macula and vasculature) based on optic cup location and anatomical structural details from diabetic retinopathy images of both left and right eye. This algorithm used colour fundus images obtained from mydriatric camera. The algorithm proceeds through 4 main steps:

(i) Colour image pre-processing - to enhance and remove noise from the image.
(ii) Detection of optic nerve head – optic nerve head is located by increasing the area of interest around the optic cup. Since the optic cup was detected first, which was embedded in optic nerve head.
(iii) Detection of macula – it is located at a distance approximately twice the diameter of the optic nerve head just below the horizontal axis of the optic nerve head.
(iv) Detection of vasculature – it uses logical AND operation on two images, one being a threshold image and another being edge detected image.

Detected OD area is validated. The quantitative performance was evaluated by calculating sensitivity, specificity and predictive values.

Anam Tariq et al., proposed an automated system for the grading of diabetic maculopathy to assist the ophthalmologists in early detection of the disease. A three stage system consisting of macula detection, exudates extraction and grading of maculopathy. First stage uses optic disc and blood vessels to extract macula from retinal image. Exudates extraction stage extracts all possible exudates from retina using filter bank and support vector machines. Finally, the system grades the input image in different stages of maculopathy by using the macular co-ordinates and exudates feature set. The evaluation of the proposed system was performed by using publicly available standard retinal image databases.

Archana G. et al., presented an automated method for the detection of bight lesions(exudates) in the retinal images and its classification based on their severity and level of risk. The proposal starts by eliminating the non-uniform illumination thereby enhancing the brightness of the images. A novel method to detect the abnormality which classifies the images as normal or abnormal based on the features obtained from the image was detected. The abnormal images were further classified as mild, moderate or severe. The obtained results show effectiveness in both detection of exudates and the severity of classification of exudates in the field of assessment of diabetic retinopathy. Fifty images from Aravind Eye hospital were used for the research. The results showed high sensitivity, specificity and accuracy.

Umer Aftab et al., proposed a method for the identification of exudates in colored retinal images which help in building a computer aided diagnostic system for macular edema. The proposed system consisted of three stages i.e., candidate exudates detection, feature extraction and classification. Filter bank was used for candidate exudates detection, basic properties of exudates for feature extraction and Gaussian mixture model for classification was used. The databases used were STARE, DIARETDB0, DIARETDB1 and the sensitivity, specificity and accuracy was found to be 93.36%, 98.25% and 97.59% respectively.

4. PERFORMANCE ANALYSIS OF VARIOUS METHODS USED FOR DETECTION OF OBJECTS IN RETINA AND AUTOMATIC DIAGONIZATION & GRADING OF DIABETIC MACULOPATHY AND ITS PATHOLOGIES.

Table 1. Performance analysis of various methods in detection of optic disc, macula, exudates, diabetic maculopathy(DM) and grading of severity levels in DM and its pathologies.

Method	Purpose-Detection of	Sensitivity (%)	Specificity (%)	Accuracy (%)
Fuzzy C-Means clustering & neural networks	Exudative Maculopathy	92	82	-
2-D Gaussian matched filter	OD	-	-	100
Morphological, hough transform technology – voting type algorithm	OD boundary	-	-	99
Ensemble classifier [combination of algorithms]	OD & Macula	-	-	OD – 98.06 Macula – 96.8
Fuzzy Convergence	Optic nerve	-	-	89
Morphological method & Otsu's algorithm	OD	-	-	91.35
(a)Multilayer peceptron neural network (b) PCA matching correlation (c) Adaptive, local, contrast enhancement	(a)Blood vessels (b) fovea (c)OD	83.3 80.4 99	91.0 99.1 99.1	-
Iterative thresholding, geometric active contour model, level set function	OD & Macula	90.67		
Thresholding, morphological operation & connected component analysis, fuzzy inference system (for classification)	Classification & detection of exudates	91.11	100	93.84
K-Means clustering (for segmentation), SVM classifier & morphological operations	Exudates and DM	-	-	96
Marker-controlled watershed segmentation	OD, exudates & cotton wool spots	95	-	-

Back propagation network decision tree & genetic algorithm-correlation based feature selection	Exudates	96.77	100	98.45
Combination of shade correction, matched filtering & shape algorithms	Macular edema	-	-	97
Clustering based method	Exudates (Hard & Soft)	71.96	-	89.7
Morphological operations	Exudates	80	99.5	
Statistical Technique	OD & macula	-	-	97
Average filter & thresholding, hough transform	OD localization & detection	-	-	96.7
DBSCAN clustering algorithm & fuzzy classifiers, hough transform	OD	-	-	90
Curvelet based algorithm, DCvT & level set method	OD & exudates	98.4	90.1	OD – 94.51
Sliding windowing technique, PCA & histogram specification	Exudates	94.78	94.29	-
Supervised learning approach & Rotational asymmetry metric	Detection & classification of DME(Macular edema)	100	74 – 90	81 – moderate 100 - severe
AM-FM features, supervised classification with partial least squares	Pathologies in macula	Hard exudates - 100, red lesions – 74	Hard exudates – 58 , red lesions – 90	-
Feed forward ANN	Types of maculopathy	96.67	100	96.67
Clustering & mathematical morphological techniques	Detection & grading of DM severity levels	95.6	96.15	-
Morphological processing, texture analysis methods & ANN for classification	Diabetic retinopathy stages	90	100	93
Feed-forward architecture in ANN classifier	Maculopathy	Greater than 95	100	-
Windowing technique	Grading severity levels of DM	96.2	-	-

Filter bank, Gaussian mixture model for classification	Macular edema	93.36	98.25	97.59

5. CONCLUSION & FUTURE WORK

From the above analysis table, it is found that most of the researchers have used morphological operations and clustering based techniques to detect optic disc (OD), macula, exudates, diabetic maculopathy (DM) and have used neural network methods for grading the DM and its pathologies like macular edema. The highest sensitivity, specificity and accuracy obtained was from back propagation network, decision tree and genetic algorithm correlation based feature selection and for grading the severity levels in DM – filter bank, Gaussian mixture model was found to be more accurate.

This paper presents the literature review of the detection of objects in retina like optic disc, macula, and exudates and also detects diabetic maculopathy, other pathologies like macular edema and grading its severity levels. From these, more research could be done in grading the severity levels of diabetic maculopathy and other pathologies in macula.

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