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Fovea Detection and Disease Identification Using Integreated GF-SVM Method

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Abstract: Fundus image analysis it is very difficult to identify the fovea region and eye diseases. Some times its cause to achieve a success to meet the cost and importance. An automated fundus image analysis system is developed for the detection of optic disc, blood vessels, fovea, etc. And also the identification of different eye diseases. The detection and analysis are proceeds in three different stages. They are extract the candidate region (preprocessing), features extraction and classification. Here, the optic disc localisation stage and a pre-processing stage to reduce noise and blood vessel structures and finally classify the fovea region. Also identifying the disease using the neural network classifier. For GF-SVM mechanisms. The optic disc localisation results in a localised point that represents the centroid of optic disc region whereas optic disc segmentation results in a complete contour of optic disc. In the optic disc localization stage, a feature vector approach that employs four salient characteristics of the optic disc is implemented. Fovea is one of the important feature of a fundus image. Fovea detection helps doctors and non-trained persons to identify Diabetic Retinopathy (DR), Age Related Macular Degeneration (AMD), Retinopathy of Pre-maturity (ROP) and some other diseases of the patients. Diabetic retinopathy is a cause of sight loss sometimes it will reach an advanced stage and cannot be cure. However, retinal image is essential and crucial for the ophthalmologists to diagnosis the disease. In the RGB image the green channel exhibits the best contrast between the vessels and background. With the help of advanced adaptive histogram equalization, thresholding method and smoothening method can detect the fovea region. Gabor filter and support vector machine are also used for classifying the features and its similar parts. The automatic screening will help for the doctors to quickly identify the condition of patients. Here, implemented a new efficient method to localize the fovea in retinal fundus image. Also, it is the new integrated efficient method to detect both disease and an eye region. In this proposed research aim for automatic screening of fovea for detection of many diseases quickly at a time. By automatically identifying the normal images, the workload and its costs will be reduced by increasing the effectiveness of the screening programs. The data base collected from Lotus Eye Hospital, Coimbatore. According to data, we can detect the sensitivity, specificity, accuracy, etc.

Key words: Fundus images, automatic screening, advanced adaptive histogram equalization, gabor filter, support vector machine, fovea, diabetic retinopathy

INTRODUCTION

Diabetic Retinopathy (DR) is nominated as the most common cause of blindness for the past 50 years. The epidemiological studies carried out in industrialized countries classify DR amongst the four main causes of sight problems over the whole population (Akram *et al*., 2013). Early detection and treatment of DR is very crucial as it is a progressive disease and its severity is determined by the number and the types of lesions present in the fundus image. A healthy retina contains blood vessels, optic disc and macula as its main components and any changes in these components are signs of any eye disease. Diabetes is very common disease and patient needs regular screening for early detection of DR. The ophthalmologists have to examine a large number of images in order to perform mass screening. The cost of manual examination is prohibiting the implementation of screening on a large scale. The automated systems for detection of MAs described in this section normally use different features and accurate classifier to improve the accuracy but still there is a space for improvement due to the existence of blood vessels. In our proposed system, we extract the vascular pattern first in order to improve the accuracy as MAs and blood vessels have almost similar intensity values which can

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lead to false MA regions. So, in a combination of reliable feature set and classifier, we also keep in mind the fact that MAs have very close relation with blood vessels and the removal of vessel pixels has further improve the accuracy of MAs detection. It is describes a system for detection of MAs by extracting candidate regions. It generates a features set for each region depending upon their shape, gray level, color and statistical based properties. The true MA regions are selected and classified using a hybrid classifier which is a weighted combination of GF and SVM. The main contribution of the study is that it improves the accuracies of all three stages using accurate vascular segmentation, sound feature set and hybrid classifier for accuratedetection of MAs. The proposed method introduces the elimination of blood vessel pixels prior to MAs detection and enhances the feature space before applying the classifier (Akram *et al*., 2013).

Diabetic retinopathy is major cause for visual loss and visual impaired vision worldwide. A proper detection and treatment of this disease in needed in time. Microaneurysms detection is difficult process because they appeared as a first sign of diabetic retinopathy disease. In past few years, many approaches raised for the identification and detection of this diseases using some features extraction techniques, mathematical algorithms and artificial neural network classifiers which lacks in some drawbacks in preprocessing, extraction of appropriate features, blood vessels extraction and in choosing classification techniques. This study is developed to perfectly detect the candidate regions by using Gabor filter bank and separation of blood vessels from the retina image. Then for each candidate region different feature vectors are extracted. These features are given to multi class classifier for training and testing. Performance of this proposed research is evaluated with performance metrics such as accuracy, sensitivity, specificity and execution time and proved as a successful method for automatic early detection of diabetic retinopathy (Gowthaman, 2014).

Diabetic retinopathy: Eye is a very essential and critical organ of the human body which only gives vision. It is a complex organ next to human brain. There are huge eye diseases spreading nowadays due to improper care. Among those diseases Diabetic Retinopathy (DR) is severe and wide spreading diseases. It has been identified as one of the cause for blindness or vision impairment. The initial detection of this disease can be done manually. But, it is very tough and waste of time and not sure about the accurate detection. This urged to develop automated techniques which are probably accurate and more number of images can be processed together. For this huge techniques are proposed by many authors for early detection of DR in image processing. The retinal image of the patients affected by this disease is captured initially. Those images are subjected first for preprocessing because they may be in low resolution and noisy. Then from preprocessed image the features are extracted for the identification. Feature extraction is an important technique in which appropriate and effective features must be extracted which only helps for perfect identification. From those features, they are finally given for the identification and classification technique (Gowthaman, 2014). Apart from this an enhancement is added to it. That includes identifying a disease called diabetic retinopathy. Diabetic retinopathy is primarily a lesion of the retinal capillaries. Later this extends to the larger vessels known as veins, arterioles and arteries (Paintamilselvi, 2012).

Problem formulation: It is very difficult to detect fovea region because which have thin and complex structure, area of appearance is very small. Sometimes Computer Aided Diagnosis (CAD) Technique used for detecting diabetic retinopathy is leading in less accuracy result. There is a chance of reduction in image clarity. Major problem is time consuming. Prediction of blindness is difficult. Very difficult to identify eye diseases and abnormalities like:

- Diabetic retinopathy
- Age related Macular Degeneration (AMD)
- Retinopathy of Pre-maturity (ROP)
- Exudates
- Microaneurosym
- Glaucoma

Literature review: The extraction of optic disc mainly based on the Principal Component Analysis (PCA) and stochastic watershed transformation. The stages of disease can be find by using extended minimum and maximum transform. The input for the segmentation is obtained by PCA. The purpose of using PCA is to reduce the dimension of the image and to achieve the greyscale image. Stochastic Watershed transformation is applied in grey-scale images. It is a powerful segmentation tool in that the minima of the image represent the objects of interest and the maxima represent the separation boundaries between objects (Esther and Sophia, 2014).

In the fundus image analysis, fovea detection plays a vital role in screening Diabetic retinopathy. Blood vessels that originate from the optic disc may leak fluid which leads to microaneurysms and deposit in the fovea region. Detecting the fovea center helps in identifying the presence of microaneurysms, exudates and hemorrhages which causes diabetic retinopathy. Exhaustive survey of literature shows that Wellner's adaptive thresholding method has not been applied to retinal images to detect Diabetic retinopathy. In this study, Wellner's adaptive thresholding method is used to locate the center of fovea for early detection of Diabetic retinopathy. This method uses local threshold values that separate the foreground from the background region which helps in identifying the fovea region more clearly than other method. Both the healthy and pathological images were analysed for the detection of fovea center (Nandhini and Malathi, 2014).

A method is presented for automated segmentation of vessels in two-dimensional color images of the retina. This method can be used in computer analyses of retinal images, e.g., in automated screening for diabetic retinopathy. The system is based on extraction of image ridges which coincide approximately with vessel centerlines. The ridges are used to compose primitives in the form of line elements. With the line elements an image is partitioned into patches by assigning each image pixel to the closest line element. Every line element constitutes a local coordinate frame for its corresponding patch. For every pixel, feature vectors are computed that make use of properties of the patches and the line elements. The feature vectors are classified using a NN-classifier and sequential forward feature selection. The algorithm was tested on a database consisting of 40 manually labeled images (Staal *et al*., 2004).

Image and video compression exploits the redundancy of data to create a smaller representation. Lossy compression can be considered to be a type of transform coding where the raw data is transformed to a domain. Such a transform coding stores most of image energy into very few coefficients. In this study, we propose a compression algorithm based on Set Partitioning in Hierarchical Trees (SPIHT) that exploits the Human Visual System (HVS) and its fovea. In order to increase the image quality of the reconstructed image, Regions Of Interest (ROI) are defined around a given point of gaze. The use of a fovea combined with ROI for image compression can help to improve the quality of the perception of the image and preserve different levels of detail around the ROI (Hernandez *et al*., 2013).

MATERIALS AND METHODS

Automatic detection of fovea: Automatic Detection of Diabetic Retinopathy (ADDR) is a fully automated system for detection of Diabetic Retinopathy (DR). Fovea is the most essential part of the retina for human vision. If the delicate cones of our fovea are destroyed the person may become blind. The size of fovea zone in fundus eye image determines whether it may lead to various diseases which may turn out to blindness. Fovea is characterized by the center of the macula. In fundus retinal image the macula is the darkest part approximated by a circle. Geometrically fovea is at a distance 2.5 times the diameter of the Optic Disk (OD) from its center (Raj and Devi, 2013). Fovea size is relatively small compared to the rest of retina, but the fovea is the only area of the retina where 20/20 vision is attainable and very important for seeing fine detail and color. Usually, this fovea zone is approximated to a circle of radius 200 micron. The fundus images are most commonly used by ophthalmologists to monitor the progression of disease. They are captured using devices called ophthalmoscopes. Normally these images are manually graded by specially trained clinicians in a time consuming and resource intensive process (Varalakshmi and Janardhan, 2014). Here used some morphological operators and geometrical features to localize the fovea region successfully. Proposed scheme is simple but efficient in extracting the fovea region. Experiment shows that the outcome the scheme is comparable with others when applied on standard data set. Moreover, it performs well on our own data set consisting of images with variation. Thus, the proposed scheme is robust also. The extracted macula and fovea region may help in further diagnosis of related diseases (Samanta *et al*., 2011). Figure 1 shows the basic system level block diagram. Here seems region extraction, feature vector and their classifications.

Systems over view: The analysis of diabetic retinopathy is divided into two different classes, i.e., screening of diabetic retinopathy and monitoring of diabetic retinopathy. Here, the automatic screening system is for diagnosing the diabetic retinopathy. For that here uses a fundus camera image as an input and find all lesions (abnormalities) existing in the image, whereas in monitoring, the system detects the changes between the two images of the same eye taken in different time moments (Akram *et al*., 2013). Here presents a method for the screening of diabetic retinopathy and it identifies the first sign of diabetic retinopathy else called as microaneurysms using digital retinal images. Figure 2 shows a complete typical block diagram of the proposed system. Overall, divide the proposed system into three different stages, i.e. candidate region extraction, feature vector formation and classification. The candidate region extraction phase enhances the regions containing red lesions and extracts all possible candidate regions for MAs. It also removes all possible blood vessel pixels to minimize spurious regions. In stage 2, feature vectors are

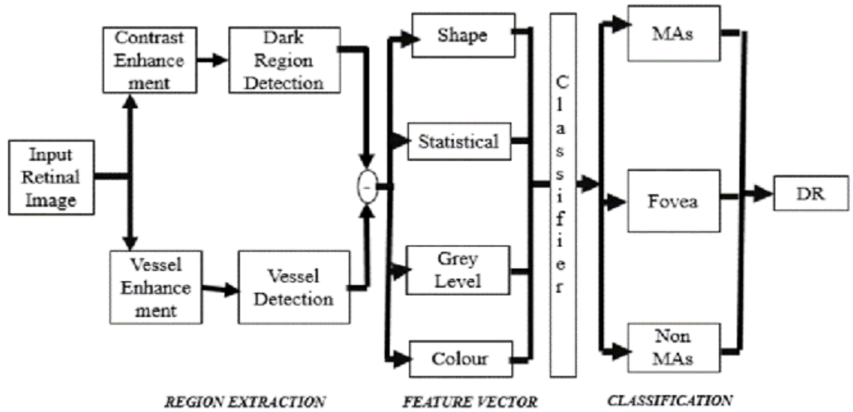

Fig. 1: Basic system level blocks

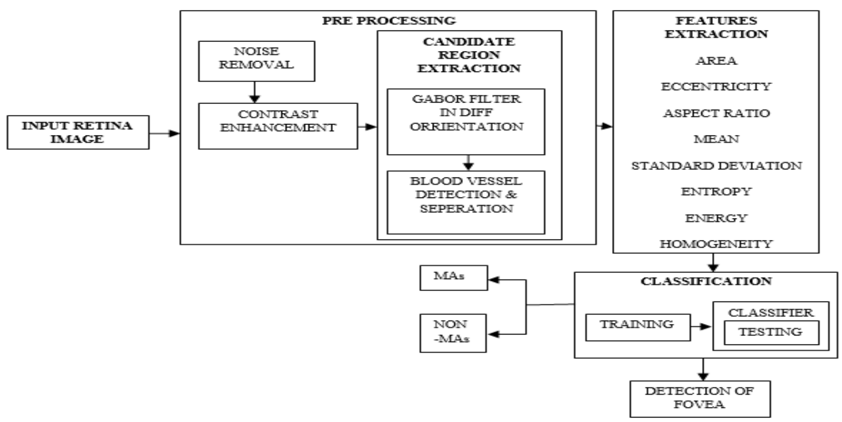

Fig. 2: Overall block diagram for fovea detection

calculated for each extracted region using some distinct properties (Akram *et al*., 2013). Finally, the classifier separates out the MA and non-MA regions here also detect the fovea region. Thus predict the quantity and time taken for the image analysis of diabetic retinopathy.

Pre-processing: Preprocessing is a vital and initial process in any kind of image processing system. The process makes the image to be ready for the further feature extraction like shape, area, geometry and statistics, etc. and for classification according with the features. The captured retinal images are at low light and there is maximum chance of noise to affect images (Gowthaman, 2014). In this preprocessing, the images are de noised and enhanced. At first they are given for noise removal technique. In medical image processing noise removal is crucial step because this may give the chance to affect the result widely. There are various noise removal techniques available in image processing (Gowthaman, 2014). Further go for the contrast enhancement method. For that using the dark region detection. Here using the Gaussian filter for the noise removal and image smoothening process. Figure 2 shows the overall block diagram.

Candidate region extraction (feature extraction): Candidate region (lesion) is a small circular object which is look like dark red dot and patches in retinal image. We can see them with our naked eye it can be able to identify but they varies based on its texture, contrast and blood vessels in the image makes difficult to identify its clearly. In this phase, they are extracted by Gabor filter and blood vessels are segmented to extract it without any difficulty (Gowthaman, 2014). The Gabor filters are one of the strongest and accurate way to detect vessel pattern and its extraction make the entire process easier. The contrast enhanced image is given for Gabor filter banks for enhancement of lesions. Gabor filters are famous due to their fine frequency tuning and orientations electiveness. They are appropriate for texture representation and discrimination (Esther and Sophia, 2014). Gabor filter is represented by a Gaussian kernel function which can model a wide range of shapes depending upon the values of its parameters (Gowthaman, 2014).

Blood vessels segmentation blood of the retinal images allows early diagnosis of disease. We propose to use a median filtering scheme to carry out demising of the image and thereby to find the fovea of the retina. Examination of blood vessels allows detection of eye diseases like glaucoma and diabetic retinopathy. For instance, popular convolution approaches suffer from variable retinal background and low contrast between vessels and surrounding pixels. Obtaining the center and surroundings of the optic disk, the diameter of the disk can be easily calculated. To localize the fovea region, we start with the image, containing only the blood vessels.

Features are essential for any classification or analysis in image processing. There are several types of features which can be extracted from the images each gives its identical information's about the image. Here, MAs region supposed with properties such as shape, color and size which appears as a dark red colored circle shape. To identify MA and non-MA region feature vectors are formed for each candidate regions (Gowthaman, 2014).

Classification: The classification is the final process which classifies the result. There are various classifiers used in literature which divides into two classes majorly called as dichotomies and some classifies into multi classes. Here, SVM classifier is taken to compare the efficiency of proposed research (Gowthaman, 2014). Based on the dark region and bright region we can classify the fovea, blood vessels and optic disc. Classification are also containing the training and testing method. According to training the lesions are classified based on area, shape, mean, standard deviation, energy, entropy, etc.

SVM classifier: Support Vector Machine (SVM) is a useful method for classification of high dimensional problems which suits for only 2 class classification. For multi class classification (K) the classifier has to be trained typically placed in parallel and each one of them is trained to separate one class from the K-1 others. This way of decomposing a general classification problem into dichotomies is known as a one-per-class decomposition and is independent of the learning method used to train the classifiers. This process is little difficult and lacks in time consumption (Gowthaman, 2014). Here in this multi class SVM classification, the candidate region features which are extracted for the dataset previously are divided into two segments for training segment and testing segment (Gowthaman, 2014).

Algorithms:

- Step 1: Giving RGB image (specimen) to the GDU
- Step 2: Smoothening the given specimen image as per our requirements
- Step 3: Obtaining green channel image from given specimen RGB
- Step 4: By using Adaptive histogram equalization method enhancing the specimen
- Step 5: Blood vessel segmentation has been take place here
- Step 6: Find optic disc from the difference between dark and brighter regions
- Step 7: Detect the fovea region
- Step 8: Detect Lesions
- Step 9: Detect DR

RESULTS AND DISCUSSION

For analysis of fovea region and Diabetic Retinopathy, the method is easily understood and used even by ophthalmologists and non-ophthalmologists. Here described a new efficient method to localize the fovea in retinal fundus image. Here used median filter, Adaptive Histogram Equalization, thresholding method, tracking method and machine trained classifier to localize the fovea region successfully. Proposed scheme is simple but efficient in extracting the fovea region. The entire research done by with the help of MATLAB. Experiment shows that the outcome the scheme is comparable with others when applied on standard data set (images). This is clear in our simulation output shown in Fig. 3. Moreover, it performs well on our own data set (images) consisting of images with variation. Thus, the proposed scheme is robust also.

The extracted optic disc and fovea region may help in further diagnosis of related diseases like Diabetic Retinopathy, Age related Macular Degeneration (AMD), Retinopathy of Pre-maturity (ROP) and some other diseases of the patients.

Figure 3 as input which is selecting from the data base. Whether it is normal or not the image be propagated through the compiler. The data base is collected from Lotus Eye Hospital. Figure 3 shows the smooth image. Which is in convenient pixel value. Because each and every compiler performs the images with different methods. So for the necessary things it needed, it convert the pixel sizes. Figure 3 shows the green channel image. The images are obtained from a fundus camera. Extract the red, green and blue colour panel. Because the green channel has the most ability to detect the blood cells.

Figure 4 shows the contrast enhancement method. For the contrast enhancement we are using the adaptive contrasting method. It is the process of adjusting digital images so that the results are more suitable for display or further analysis. Figure 4 shows the Gabor Filter Extraction Method. Detect the region from 0 to 180 angle in clock and anti-clock direction. Blooded particle get detected. Figure 4 shows the segmented red lesions containing spurious region.

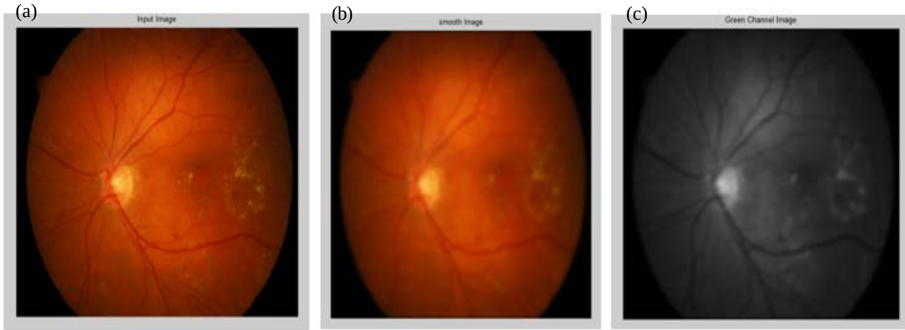

Fig. 3: a) Input image; b) smooth image and c) green channel image

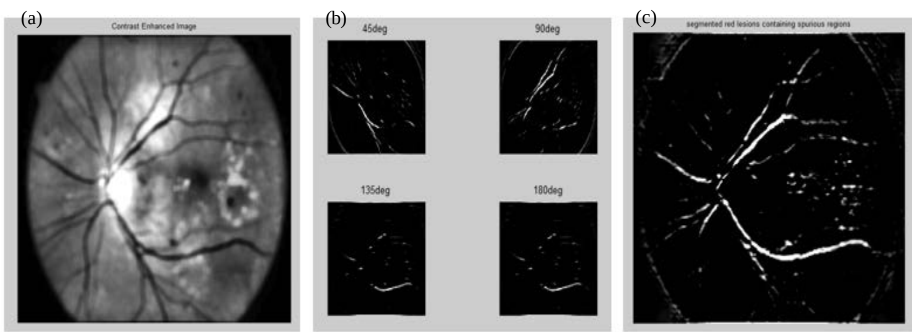

Fig. 4: a) CE image; b) GF extraction and c) segmented region

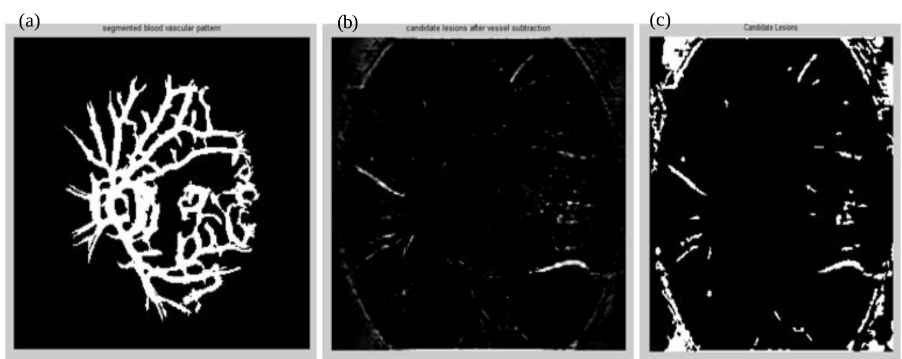

Fig. 5: a) Vascular pattern; b) Lesions after subtraction and c) candidate lesion

Figure 5 shows the vascular pattern. Blood vessels are important structure in retinal images. It contains enough information for the localization of some anchor points and it maps the whole retina. Figure 5 shows the candidate lesions after vessel subtraction. Blood vessel segmentation is crucial process. Figure 5 shows the candidate lesions after the removal of blood vessels. By performing the above four operations bloods vessels are accurately detected and blood vascular patterns are segmented from Gabor filtered image.

Figure 6 shows the Adaptive Histogram Equalized Image. Figure 6 shows the classified image. For classification using the SVM classifier. Figure 6 shows the detected image. Support Vector Machine (SVM) is a useful method for classification of high dimensional problems which suits for only 2 class classification.

Figure 7 shows the optic disc. This is the highest concentration of blood vessels. So that it is very easy to detect the optic disc. Figure 7 shows the mentioned optic disc in the image. Figure 7 shows the exact fovea region by the advanced adaptive histogram equalization method (advanced integration method). Here using the disease diagnosis and fovea detection simultaneously.

Comparison Table 1 shows the sensitivity, specificity, accuracy, etc. of the proposed system. According to the table drawn a chart for the comparison

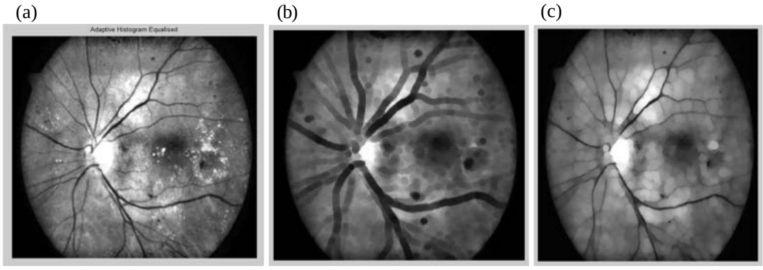

Fig. 6: a) AHE image; b) classified image and c) detected image

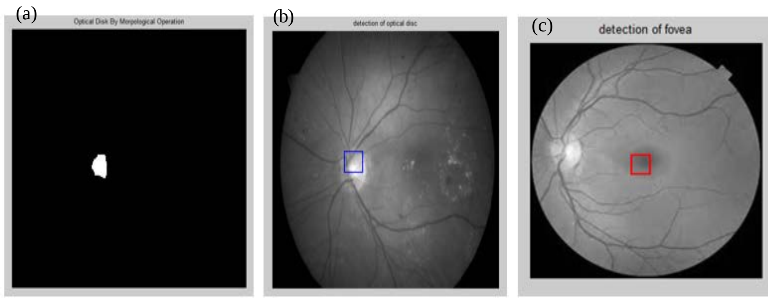

Fig. 7: a) OD by MO method; b) optic disc and c) Fovea

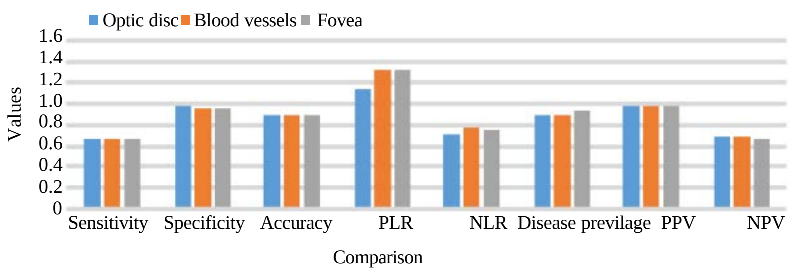

Fig. 8: Comparison between OD, blood vessels, fovea

Table 1: Comparison for proposed system

Measures	Proposed method Optic disc	Blood vessels	Fovea
Sensitivity	0.6650	0.6620	0.6722
Specificity	0.9756	0.9508	0.9608
Accuracy	0.9000	0.8900	0.8906
PLR	1.1500	1.3200	1.3400
NLR	0.7100	0.7600	0.7500
Disease previlage	0.8999	0.9010	0.9300
PPV	0.9840	0.9789	0.9798
NPV	0.6767	0.6798	0.6640

table. So, we can easily identify these methods. In Table 1 the proposed modified region growing algorithm is compared with the existing region growing techniques in terms of accuracy sensitivity and specificity measures. From table the accuracy of the proposed method is (0.9022) but the existing technique region growing technique has offer only (0.8995) of accuracy. Similarly, the sensitivity and specificity of the proposed method is (0.8902) and (0.8909) but existing technique gives (0.663) of sensitivity and (0.655) of specificity respectively. Hence, from table it has been prove that our proposed method has segmented the optic disc more accurately than the existing technique (Fig. 8).

Table 2: Comparison between existing and proposed methods

Measures	Proposed method	Existing fuzzy c-means	Existing k-means
Accuracy	0.9022	0.65890	0.4032
Sensitivity	0.8902	0.66300	0.3879
Specificity	0.8908	0.65500	0.4167
FPR	0.0750	0.34400	0.5832
PPV	0.9300	0.66015	0.4009
NPV	0.9098	0.65700	0.4050

Comparison Table 2 shows the comparisons between proposed method and other existing methods. There was a comparison chart also made for table. In Table 2 the proposed modified fuzzy c-means algorithm is compared with the existing FCM and k-means algorithm in terms of accuracy, sensitivity and specificity measures. From table it has been shown that the proposed modified fuzzy

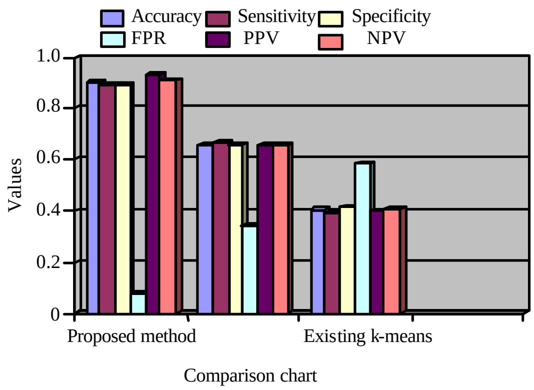

Fig. 9: Comparison chart accordance with data

means algorithm has given of (0.8995) accuracy but the existing FCM and k-means has given only (0.6589) and (0.4032) of accuracy, respectively. Similarly, the sensitivity and the specificity of our proposed method are (0.8902) and (0.8908) they are higher than the existing FCM and k-means techniques. The comparison graph has been given below (Fig. 9).

CONCLUSION

Diabetic Retinopathy is major cause for visual loss and visual impaired vision worldwide. A proper detection and treatment of this disease in needed in time. Microaneurysms detection is difficult process because they appeared as a first sign of diabetic retinopathy disease. In past few years, many approaches raised for the identification and detection of this diseases using some features extraction techniques, mathematical algorithms and artificial neural network classifiers which lacks in some drawbacks in preprocessing, extraction of appropriate features, blood vessels extraction and in choosing classification techniques.

Here developed to perfectly detect the candidate regions by using Gabor filter bank and separation of blood vessels from the retina image. Then for each candidate region different feature vectors are extracted. These features are given to multi class classifier for training and testing. Performance of this proposed research is evaluated with performance metrics such as accuracy, sensitivity, specificity and execution time and proved as a successful method for automatic early detection of diabetic retinopathy. Analyses the method to detect the fovea region of the eye. Two major algorithms are considered in analyzing it. First algorithm involves the isolation of blood vessels and removing the blood vessels. Next algorithm deals with the localisation of fovea. This method is simple and efficient in extracting the fovea. In the proposed approach of blood vessel detection, morphological operations and geometrical functions are used to arrive the output.

In the second algorithm of fovea localisation, sliding window technique is utilized to find the gray mixed black fovea. The proposed approach is further enhanced to detect the diabetic retinopathy disease through feature extraction and principal component analysis method. It performs well on individuals own data set consisting of images with variation. This method is robust also. This proposed methodology can be utilized in hospitals to detect diseases occurring on the eyes by doctors easily. Future scope of this project is to detect many eye diseases thus making mankind to be benefitted in large extent to be free from eye diseases leading to blindness with higher efficiency. From the results and its slotted out puts, clearly identify whole concepts about the whole research. It is described a new efficient method to localize the fovea in retinal fundus image. Used median filter, advanced adaptive histogram equalization, thresholding method, tracking method and machine trained classifier to localize the fovea region successfully. Proposed scheme is simple but efficient in extracting the fovea region.

Our proposed research has provided (0.9022) of optic disks segmentation accuracy on average of clustering effectiveness using modified region growing algorithm and modified fuzzy c-means, respectively. For proving that our proposed method is only better, we have compared our proposed method with the existing region growing method and which resulted in higher values accuracy than the existing one. Hence, we can say that our proposed research outperforms other existing methods and provides effective optic segmentation and clustering results for the retinal images and thus efficiently detect the fovea region and disease analysis.

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