Comparative Study and Detection of Diabetic Retinopathy in Retinal Images Using Computational Approach

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Abstract

Retinal image segmentation and classification is a challenge task in diagnosing and treating for Diabetic Retinopathy (DR) over the past decade. Usually, retinal image is used to assess the diabetic diseases, as it offers complementary information for acquiring the retinal image sequences. This long outstanding problem to classify the DR significantly requires more time for a physician. Therefore, developed an automated computational approach for physicians with less time and speed up the diagnosing procedure. The proposed work based on machine learning techniques for achieving blood vessel classification using the optic disc segmented features of retinal image. The segments are generated through the image processing mechanism, which ensure the effectiveness of optimal segment selection that yields to detect the optic disc and blood vessel more accurately. In, this proposed work detailed comparative study for image processing and machine learning techniques in DR are analyzed. Finally, the effectiveness of the proposed work is carried out by using this various machine learning algorithm and attained the better performance value. The proposed work achieves the best results values for blood vessel classification in DR and computed the performance metrics in terms of accuracy, sensitivity and specificity respectively.

Key word – Blood Vessel, optic disc, Diabetic Diseases, Classification, Severity level.

1. Introduction

Diabetic Retinopathy (DR) is an eye disease that is considered as the long-standing diabetes problem. If DR is detected early, the progression of this diseases can be restricted by providing medical treatment. Ophthalmoscopy is one of the detection methods that can be used to identify the disease at a preliminary stage. But ophthalmoscopy requires the skilled professionals and more time to analysis the disease results. For such situations, an alternate and economic method is to perform retinal image. The automatic abnormalities detection of DR can help ophthalmologists in the diagnosis of the disease, with the subsequent time and cost saving. The majority of patients who suffered from DR diseases have no symptom attained until the late stages. Therefore, early screening and invention are important. The main stages of DR are Non-Proliferative Diabetic Retinopathy(NPDR) and Proliferative Diabetic Retinopathy (PDR) that depend upon the presence of clinical features such as Micro aneurysms (MAs), Hemorrhages (HAs), Exudates and Neovascularisation. The Importance of Screening to detect DR disease can lead to successful treatments in preventing vision loss.

According to World Health Organization report the occurrence of diabetes diseases in the world is expected to rise from 2.8% in 2000 to 4.4% of the world population by 2030. Diabetes will be the seventh dead causing disease in 2030. In India 98 million people may have diabetes in 2030. Currently 2.2 billion people in the world are affected by vision impairment or blindness. Diabetes is associated with a developing risk of COVID-19. The existence of diseases is identified by collecting information from retinal images and analyzed through the comparative analysis report which ensures the effectiveness of the proposed method. The motivation of the proposed work is the number of diabetic patients affected by retinal diseases increasing nowadays; so it is the need to generate a computational automated methodology for diagnosing retinal diseases.

To solve the above issues, an effective and the robust method detection is developed to detect the diseases using the fundus retinal image data. To design the diabetic retinopathy detection method for accurately identifying the location of optic disc, exudates, hemorrhages based on the information collected from the retinal image. To provide an effective mechanism in finding the diseases affected cells along with the nearby structure of the eye.

To study the behavior of the eye disease in detail, it is important to know the structure of the human eye. The Figure 1 Represent the cross-section of a human eye and its major parts. The Figure 2 represents the Anatomical Features of Fundus Retinal Image. Figure 3 Represents the Distinct morphological features in fundus retinal image (a) Optic Disc Localization, (b) Macula Localization, (c) Blood Vessel Identification, (d) Hemorrhage Identification, (e) Exudates Identification. Table 1 represents the Clinical highlights and finding of Diabetic Retinopathy.

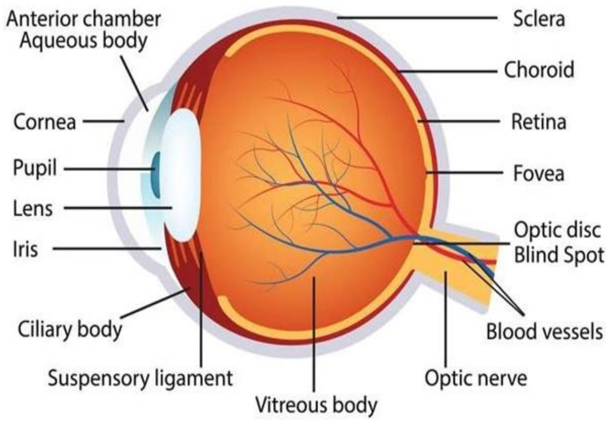


Figure 1. Represents the cross-section of a human eye and its major parts.

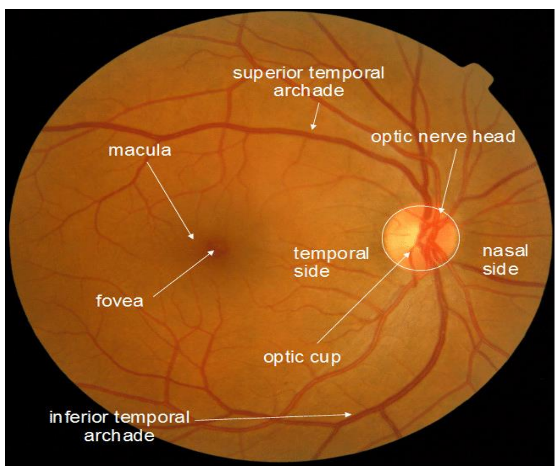


Figure 2. Anatomical Features of Fundus Retinal Image

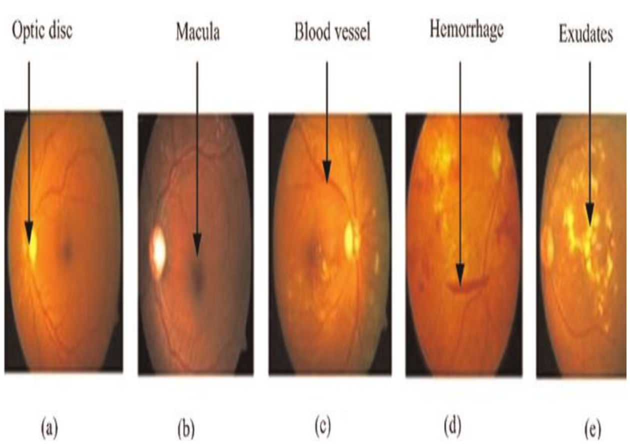


Figure 3 Represents the Distinct morphological features in fundus retinal image (a) Optic Disc Localization, (b) Macula Localization, (c) Blood Vessel Identification, (d) Hemorrhage Identification, (e) Exudates Identification

Table 1. Clinical highlights and finding of Diabetic Retinopathy

Diabetic Retinopathy Types	Clinical Observations
Normal	No abnormal feature
Mild NPDR	Presence of microaneurysm
Moderate NPDR	Maximum presence of microaneurysm, exudates, hemorrhages
Severe NPDR	Abnormalities
Proliferative diabetic retinopathy	Abnormalities with blood vessel

2. Related Works

This section discusses about the recent literature survey. Table 2 represents the Related Work of Optic Disc. The Table 3 illustrate Literature Review - computational techniques applied to extract the Retinal vessel from retinal image database.

Table 2 Related Work of Optic Disc

Author and Year	Techniques Applied	No of Samples	Database	Accuracy
Bharkad, S et al (2017) [1]	Finite Impulse Response Filer	369	DRIVE, DIRATEDB0, DIRATEDB1	98.95
Alshayeji, M. et al (2017) [2]	Edge Detection Method	303	STARE, DRIVE	95.91
Sarathi, M.P et al (2016) [3]	Region Growing Method	1384	DRIVE, LOCAL DATASETS	91
Singh, A et al (2016) [4]	Wavelet Feature Techniques	63	LOCAL DATASETS	94.7
Abed, S.E et al (2016) [5]	Swarm Intelligence Techniques	318	STARE, DRIVE	98.45

Table 3 - Literature Review - computational techniques applied to extract the Retinal vessel from retinal image database

S.No	Author Name & Year	Image Segmentation Methods	Classification Techniques	Sample Size Taken	Database	Accuracy yields
1	Kaur, J et al., (2017) [6]	Un-sharp masking techniques used to brightness the image quality	Geometrical features Method	**785**	STARE, DRIVE, HRF	95.45%
2	Neto, L.C et al., (2017) [7]	Gaussian filter on a green channel applied for noise removal, morphological top-hat applied for enhancing the vessel pixels	Local Coarse segmentation method	**60**	STARE, DRIVE	87%
3	Zhang, L et al., (2015) [8]	vessel feature extraction by Gabor filter	Segmentation method	**40**	DRIVE	95.05%
4	Tan, J.H et al., (2017) [9]	LUV model, luminance channel, L, based on RGB conversion, contrast enhancement applied for vessel pixel.	Convolution Neural Network	**40**	DRIVE	94.54
5	Pandey, D et al., (2017) [10]	Global threshold mechanism applied for ROI extraction	Template Matching	**60**	STARE, DRIVE	96%
6	Farokhian, F et al., (2017) [11]	For smoothing, Morphological operations and suppressed the background	k-means & Mathematical morphology	**40**	DRIVE	93%

3. Proposed System Architecture

Figure 4. demonstrate the Overall Architecture of Proposed Work. Table 4 narrates the Image Acquisition Process of proposed research work.

Figure 4. Overall Architecture of Proposed Work

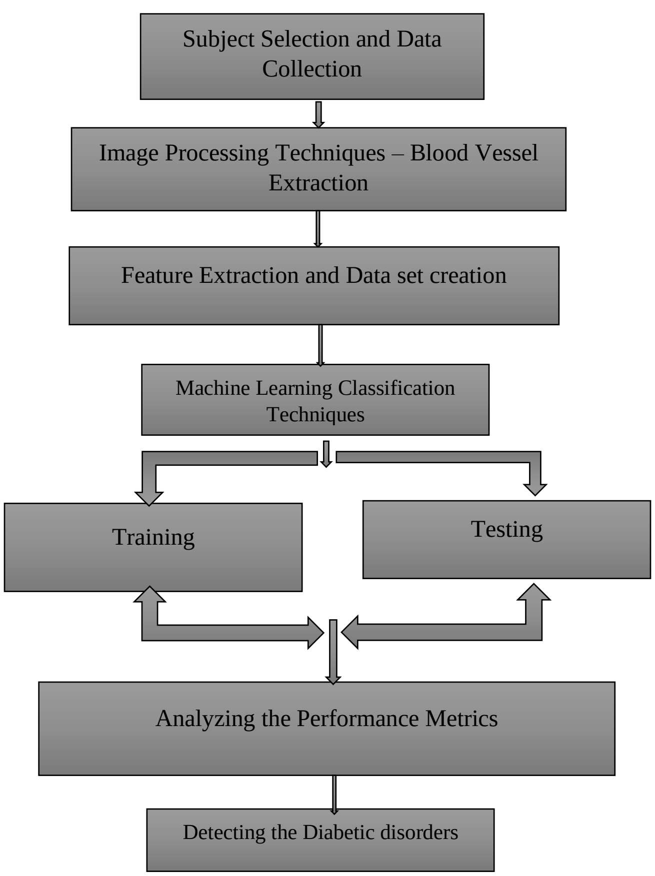


Table 4 Image Acquisition Process

Total Image	120 images
Retinal Image Data Collected	Pima Indian Diabetes Dataset
Patient Age	30 to 80 years
Image colour channels	Red, Blue and Green
Intensity value of each image channel	0 to 255 ranges
File Format	TIFF
Resolution	2896×1944 pixels
Implemented Tool	MATLAB

The input retinal image is carried out by pre-processing stage, where the image is pre-processed based on the filtering and thresholding mechanism. Hence, the input retinal image is pre-processed in terms of filtering and ROI extraction process. The resulted pre-processed retinal image modalities are passed to the segmentation stage, where the segments are formulated by separating the several regions. The generated optimal segments contain optic disc region, non-diabetic region, exudates and hemorrhages region, while the diabetic region is used for further processing. However, the features, Linear and Non-Linear Energy, different categories of Entropy such as Sum Entropy, Difference Entropy, Singular Value Decomposition Entropy, Fuzzy Entropy, Distribution Entropy, Permutation Entropy, Sample Entropy, Shannon Entropy, Approximate Entropy, Weighted Permutation Entropy and Curve Length are extracted from the diabetic disease region. The original retinal image as well as the generated feature vector is passed to the classification stage, where the diabetic retinopathy disease classification based on the several level strategy is performed using machine learning algorithm such as neural network, random forest and support vector machine. Figure 3. Illustrate the segmented output of Blood Vessel. Figure 4. Illustrate the segmented output of Optic Disc.

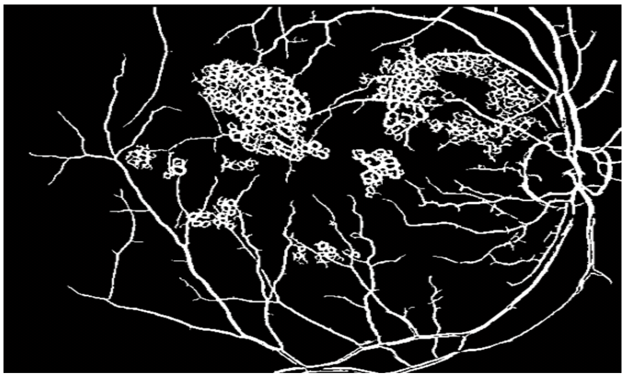


Figure 3. The segmented output of Blood Vessel

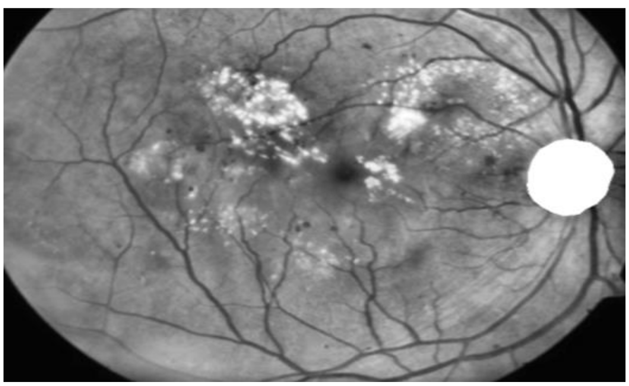
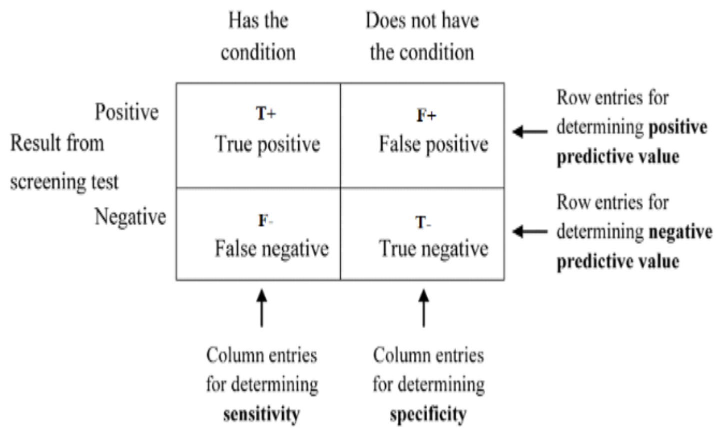


Figure 4. The segmented output of Optic Disc

4. Results & Discussion

MATLAB is used to implement this research work. Initially, datasets divide into train sets (80%) and test sets (20%). Finally, the classification is carried out by the machine learning algorithms. Three machine learning classification techniques used to implement this research work such as neural network, random forest and support vector machine. This will determine performance metrics for the classification of retinal image datasets in Diabetic diseases. Here the Neural Network trained by Levenberg–Marquardt techniques which yields the better accuracy when compare to the other training algorithm. Initially the features extracted from fundus image are fed into the input layer, the optimal weight adjusted by this algorithm and finally produce the best accuracy classification results. For the evaluation of performance, the metrics that were used such as sensitivity, specificity and accuracy are measured. Figure 5. Illustrate the Regression State of SVM. Figure 6. Illustrate the Regression State of RF. Figure 7. Illustrate the Regression State of NN. Table 5. Illustrate the Performance values of Machine Learning Techniques. Figure 8. Represents the Performance metrics evaluation of diabetic retinopathy classification.



$$\text{Sensitivity} = \frac{[T+]}{[T+]+[F-]} \times 100 \qquad (1)$$

$$\text{Specificity} = \frac{[T-]}{[F+]+[T-]} \times 100 \qquad (2)$$

$$\text{Accuracy} = \frac{[T+]}{[T+]+[F+]} \times 100 \qquad (3)$$

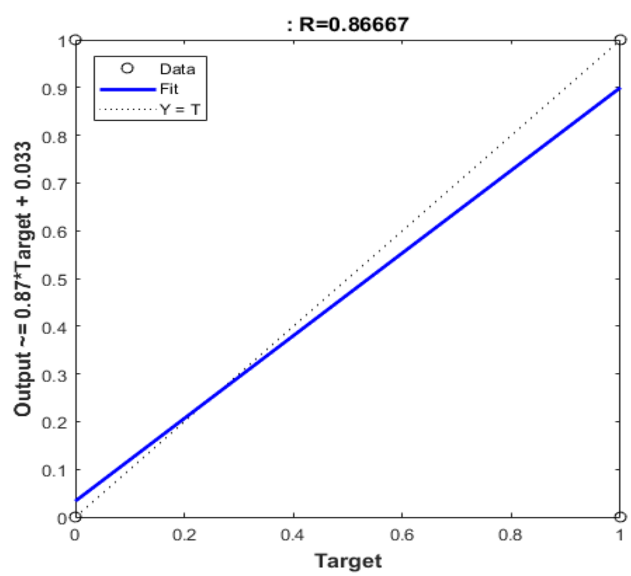


Figure 5. Regression State of SVM

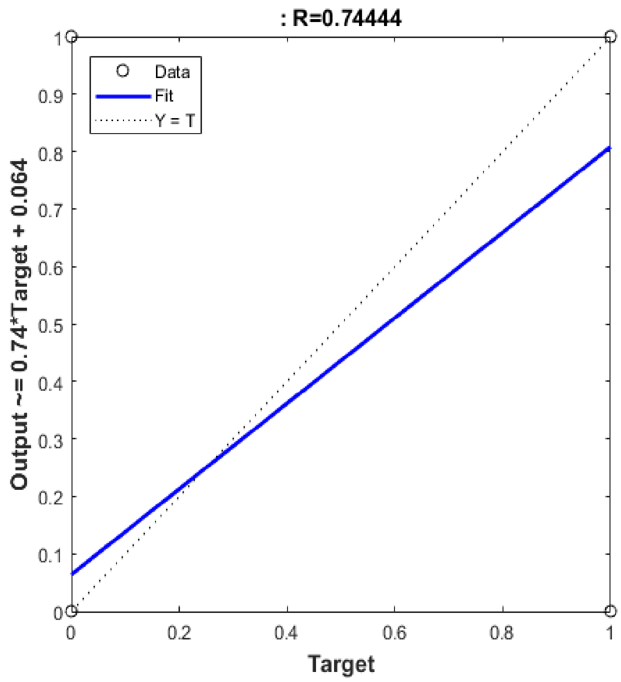


Figure 6. Regression State of RF

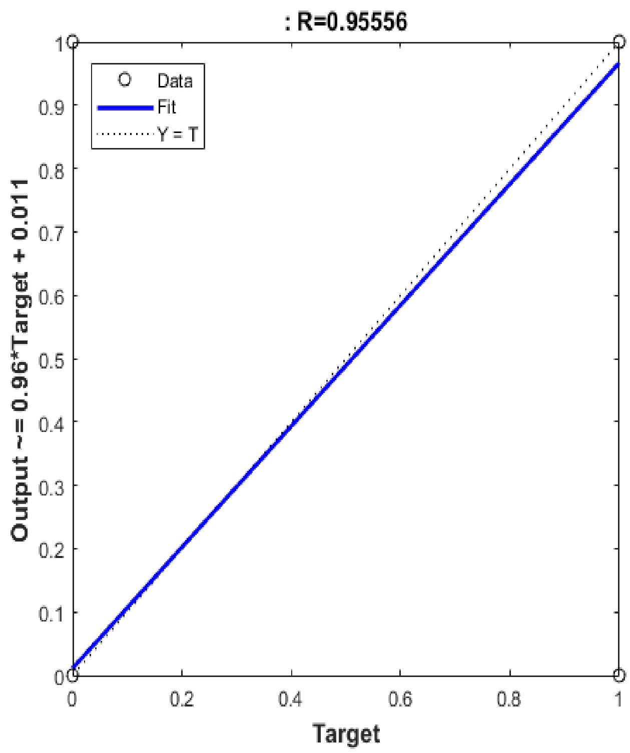


Figure 7. Regression State of NN

Table 5. Performance values of Machine Learning Techniques

Performance Metrics Evaluation of Diabetic Retinopathy Classification			
Metrics	SVM Techniques	RF Algorithm	NN Algorithm
Sensitivity	77%	60%	90%
Specificity	88%	80%	69%
Accuracy	86.6%	74.4%	95.5%

Figure 8. Performance metrics evaluation of diabetic retinopathy classification

5. Conclusion

The proposed research work measured the diabetic retinopathy metrics. The performance analysis of machine learning techniques is compared and justified. The best accuracy rate yields from Neural Network machine learning method of 95.5%. This computational approach automatically categories the diabetic retinopathy abnormalities. This is considered as an important aspect because the assessment of diabetic patients is to know the quality of therapy given to them which has a direct effect on the quality of life for these diabetic patients. As the result, the current research report is useful for physicians to assess the diabetic retinopathy in diagnostic testing. In our future work, we will integrate more than two datasets and use deep learning algorithms for classification purposes.

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