

# Diabetic Retinopathy Detection Using Matlab

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**Abstract:** Diabetic Retinopathy (DR) has been considered to be the most menacing eye related disease which causes blindness or vision loss in a long run. This disease, usually spread to people who are affected by diabetes. Thus detecting this disease at first place is mandatory. Diagnosing to be done from medical images has been gaining importance in medical science. However, identifying abnormalities in retinal images are difficult and challenging in medical field. Thus efficient computing methods has to be employed to facilitate the detection of DR from Retinal images. Digital image processing is one such method where it has influence in medical field. In this paper, a DR detection technique, involving digital image processing, has been developed by utilizing retinal image, where fundus image has been obtained from patient's retina. Here, a MATLAB based system has been utilized for analysing the fundus image that are captured via Peek retina attached on smartphone camera lens. This proposed work aims at segmenting the fundus image into Exudates, Micro aneurysm, Optical Disk and haemorrhage and examine whether the retinal condition is in Proliferative / Non-Proliferative DR stage. To achieve this, additionally, morphological methods such as erosion and dilation have been utilized which enables the MATLAB base system to learn the pixel positioning pattern of the fundus images in order to detect the factors associated with DR. Various performance measures has been utilized in validating the proposed technique. From those performance analysis, we could observe 98% accuracy in detecting PDR and NPDR within 39 seconds (half minute). Though the attainment of accuracy is relatively high, there are further possibilities in improving the detection rate of the system.

**Index Terms:** Diabetic Retinopathy (DR), Retinal Images, Fundus Image, Image Processing, MATLAB, PDR / NPDR stage, Deep Learning Based AI method.

## 1. INTRODUCTION

Whole world always concerns much and gives the maximum efforts to the screening procedures contributing to the curable yet dangerous eye ailment like Diabetic Retinopathy. Anyway, many difficulties arose globally whenever trying to implement these kind of procedures for the purpose of identifying and curing those ailments with much precision and accuracy. As a result of these difficulties faced by several countries, numerous of visually diseased persons came across eye ailment in accordance with lack of appropriate cautionary procedures and prior identification of it. Diabetic retinopathy or the diabetic eye is considered as a condition caused due to extreme level of diabetes mellitus. The existence and severity of this neurovascular complication have been linked greatly with the glycemic control level and duration of type I and II diabetes[1]. This damaged retinal blood vessel condition now a days leads to new blindness cases in the adults. The earlier DR symptoms are floaters, difficulty in observing colors and complete vision loss. Non proliferative diabetic retinopathy and Proliferative diabetic retinopathy (advanced) are the two kinds of DR. The early diagnosis and detection is a great challenge followed by the unavailability of disease infrastructure. Various global screening plans is developed to decrease the proliferation of optic disorders for the detection and treatment of DR on individual basis. With the several procedures or

precautionary solutions being already available, segmentation of eye-retina region was found to be much contributing towards the earlier diagnosis of the symptoms that the diabetic retinopathy patient faces these days. Following this, OCTA-Optical coherence tomography angiography with progression resolved attributes was proposed [2] for better identification of the retinal region vasculature in identifying hazardous symptoms. Likewise, similar method utilizing OCT-Optical Coherence Tomography [3] produced by B-scans to find and treat the ailments found in the eye-retina. They had considered low pics with lesser resolution for the sake of their study. They deployed many interesting and contributing methodologies for retina ailment identification. Certain issues are presented in existing approaches. They are as follows,

- Increased time consumption
- Lack of reliability
- Inconsistent accuracy

In this proposed system, a DR detection technique has been developed, where the fundus image has been obtained from patient's retina. Here, a MATLAB based system has been utilized for analyzing the fundus image that are captured via Peek retina attached on smartphone camera lens. This proposed work aims at segmenting the fundus image into Exudates, Micro aneurysm, Optical Disk and hemorrhage and examine whether the retinal condition is in Proliferative / Non-Proliferative DR stage. The primary objectives of the proposed system has been listed below,

- To obtain an improved quality of input image via scaling in preprocessing stage.
- To improve the accuracy of detecting MAs, exudates, hemorrhages, and optical disc through effective image segmentation approach.

The remaining paper is arranged as follows: in section 2, related works of DR is presented. In section 3, Research methodology is presented. In remaining sections, performance, statistical, comparative analysis are presented. At last, conclusion is presented.

## 2 RELATED WORKS

There are several methods that have been involved in

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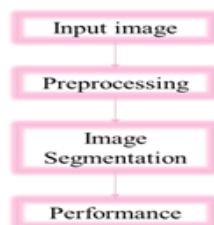
detecting DR. However, in this research paper, few methodologies like learning-based, feature-based, classification-based, etc. approaches have been discussed. In recent days, deep learning has been gaining importance in various technical applications especially semantic based understanding and image recognition. [Gargeya and Leng \[4\]](#) developed a robust automated identification approach based on deep learning had been developed for detecting the DR. This methodology utilized the fundus image and further classified them as healthy (no DR) and non-healthy. In this research work, the solutions were completely automated and processed 1000s of diversified fundus images. This had been done in order to provide accurate DR detection and effectively minimize the dependency for the resource based manual analysis over various clinical settings for further care. [Morales, et al. \[5\]](#) developed a digital tool that is utilized for detecting DR in retinal image using a technique called Gabor transform. As the symptoms of DR are asymptotic, it is very difficult in detecting it in early stage. Though the retinography is frequently taken, it has been in poor quality. Thus, a digital tool had been implemented which in turn facilitate the ophthalmologist to provide better diagnosis from DR. This tool used an algorithm based on Gabor transform in MATLAB and provided higher quality of retinography. [\[6\]](#) proposed a technique for segmenting retinal blood vessel using image processing and data mining methodologies. It stated that, the retinal diseases could be identified in retinal vasculature of those retinal images. As manual segmentation is a very tedious process and time consuming, employing computational approaches provide better solution. In this research, image cropping, transformation, filtering, etc. had been done in preprocessing. After feature extraction, k-means clustering approach had been executed in order to group the vessel clusters from non-vessels. The final segmented image is formed by joining the results from clustering and ensemble classification. [\[7\]](#) represented a novel automated detection system to detect DR and Diabetic Maculopathy in retinal fundus images by utilizing fuzzy based image processing techniques. This proposed system comprised of 4 parts namely acquisition, preprocessing, feature extraction, and classification. Additionally, a macular region localization technique had been implemented for detecting Maculopathy. An online novel dataset collection had been represented which has expertise diagnosing process, and its collection. Also, a comparative analysis had been presented where the proposed dataset had been compared with existing retinal fundi image databases for DR purposes. [Canche, et al. \[8\]](#) proposed an automation system for detecting hard exudates in DR images with the standard confidence level which in turn could help the specialists in screening and diagnosing this disease. As these hard exudates are very common in occurrence, it is very essential to detect it in very early stage. This paper also provided an extensive analysis in feature based selection methods. [Ratanapakorn, et al. \[9\]](#) proposed an image processing software for diagnosing the DR in fundus retinal images. Here the feature extraction and severity classification were performed by utilizing the MATLAB R2015a. Along with that, a GUI had been developed using MATLAB GUI toolbox. Here, a collection of 400 fundus images (where 379 – DR images, 21 – normal retinal images) had been used for interpretation. Thought the overall accuracy is 98%, the accuracy of classifying PDR / NPDR is 66.58%. This paper concluded that, it might be a helpful tool in distant rural area

where ophthalmologists are not available. [Sisodia, et al. \[10\]](#) performed pre-processing of raw fundus images using green channel extraction, image enhancement, histogram equalization, and other resizing techniques. As processing of retinal images using machine learning algorithm were very tedious, this paper came up with robust pre-processing and feature selection approach. Here, fourteen features were extracted for the purpose of quantitative based analysis. The dataset utilized for performing experiments were Kaggle DR Dataset and the results were examined by means of mean and standard deviation. It had been observed that exudate area is one of the primary features with best rank (mean difference 1029.7). [Kim, et al. \[11\]](#) developed a technique SD-OCTA (Spectral-Domain - Optical Coherence Tomography Angiography), in order to quantify the changes that are happened in micro vascular density and morphology in DR. In addition to SD-OCTA, an intensity based optical micro-angiography algorithm had been utilized. The indices of the morphology of the images and the micro-vascular density had been calculated using a semi-automated software program. The quantification used here are categorized as vessel density and skeleton density. On considering the vessel density, its morphology was in turn measured as Vessel Diameter Index (VDI) and Fractal dimensions (FD). [Deperlioğlu and Köse \[12\]](#) proposed a diagnosis mechanism using image processing and Convolutional Neural Network (CNN) to detect DR. For enhancing the fundus image, a method that had HSV, histogram equalization and V transform algorithms had been utilized. A Gaussian low-pass filter had been applied finally to the fundus image. In this paper, CNN had been utilized as a classification approach. 20 various experiments had been done to assess the performance of the proposed work at every stage. [Karami and Rabbani \[13\]](#) presented a Dictionary based learning technique for automated detection of DR in retinal fundus images. This proposed method is completely based on best atomic based learned dictionaries by K-SVD algorithm. But the K-SVD should possess the ability to discriminate the diabetic form normal classes. Here, sparse representation is utilized for classification approach, where the test image is belonged to the class of minimum numbered best atoms. [Kumar and Kumar \[14\]](#) presented a detection scheme by extracting the area and the number of Micro-aneurysms (MA) from retinal images. As detecting the MAs are tedious, variety of methods had been proposed for detecting diagnosing it. Initially, green channel extraction, morphological process, histogram equalization had been used as pre-processing techniques. In order to detect Mas, PCA, Contrast Limited Adaptive Histogram Equalization (CLAHE), average filtering had been utilized. DR has been classified by using Linear SVM. [Palavalasa and Sambaturu \[15\]](#) suggested that screening of DR effectively must requires automation methods. Thus a novel method had been proposed by this research where hard exudates are detected with maximum accuracy with respect to the level of lesion. Here, at initial stage, the possible candidate exudates had been detected using background subtraction technique. At the last stage, the false exudate had been removed using de-correlation based stretch methods. The algorithm is tested using DiaretDB database, which has al ground truth images. There are certain therapies namely sutureless pars-plana vitrectomy and intravitreal medical therapy are employed in ophthalmic area. Such treatments require capturing of fundus images using fundus camera. [Chorage and Khot \[16\]](#) proposed a detection

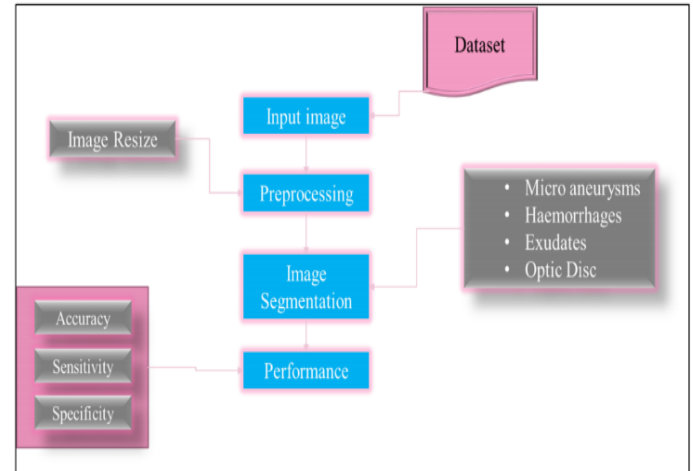
system where it detects both DR and cataract by using vessel extraction methods from the retinal fundus images. The detection had been done by using classifiers namely Feature based vector machine (FVM), SVM, etc. [Karim, et al. \[17\]](#) proposed a MATLAB based Neural Network Pattern Recognition Tool (NPRTOOL) for detecting MAs. This identification technique utilized digital image processing of the rear end image of an eye. Initially, preprocessing had been done where color to space conversion, median filtering, zero padding, image segmentation were used. After that, feature extraction had been employed where only preprocessed MA images were sent for determining the pixel value. Once the pixel values were obtained, the NPRTOOL should be executed where it classified the image as absence / presence of MAs. [Sarwinda, et al. \[18\]](#) proposed a texture based feature analysis to diagnose DR. This research work also investigated about the texture based capabilities from retinal images in order to differentiate between DR, Age-related Macular Degeneration (AMD), and normal. In this research, 4 experiments namely DR-AMD, DR-Normal, Multiclass, AMD-Normal were constructed for databases 1) STARE and 2) DIARETDB0. Here, features were selected using Kernel based PCA and they were evaluated using SVM KNN, Naïve Bayes. Overall the conventional methods has some issues, related to accuracy, time consumption, reliability, remain unanswered. In this proposed research, we are presenting the preprocessed retinal images followed by image segmentation in order to provide accurate detection of exudates, hemorrhages, optic disc, and MAs.

### 3 SECTIONS

Here the primary block diagram of the research methodology has been depicted in fig. 1. It comprises of 4 modules namely 1) Fundus input image, 2) Image Preprocessing, 3) Image based Segmentation, and 4) Evaluation of Performance. At initial module, the input undergoes acquisition process where the various vision based tasks processes the image. Secondly, pre-processing has to be done in order to attain perfect resolution of the input image. This can be obtained by resizing the inputted image. Thirdly, a novel automated unsupervised blood vessel segmentation based methodology has been utilized to enhance the features of the image. Final module comprises of evaluating the proposed method by using various performance measures. Each and every modules have been explained in further sections.



**Fig. 1.** Block diagram for proposed system



**Fig. 2.** Schematic Representation of proposed system

#### 3.1 System Description

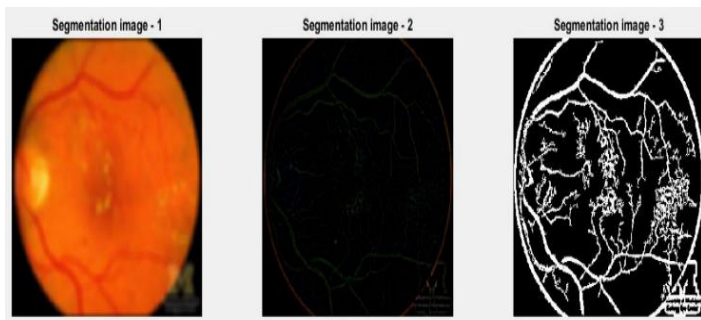
Here, the diagrammatic representation of the proposed technique has been represented in fig. 2. The four modules are described as below,

##### Input Fundus Image

In this research work, two image databases have been utilized namely STARE – STructured Analysis of the Retina [19] and DRIVE – Digital Retinal Image for Vessel Extraction [20]. Here, the former database comprises the quantity of over 20 retinal fundus images, out of that 10 of the images are having pathological cases. A digital camera named TopCon TRV-50 is used for capturing the image at the field view of 35°. The captured images should be with 700 x 605 pixel dimensions with 24 bits. The images in STARE are segmented manually where the pixels are named as non-vessel or vessel by two observers. The second observer has labelled the thin vessels, whereas the images labelled by first observer are considered to be the ground truth data and further taken for performance evaluation. This database doesn't have ROI masks.

The DRIVE database comprises of 40 retinal images where seven of them are different. A digital camera named Canon CR5 3CCD non mydriatic is used for capturing the images at the field view of 45°. The pixel dimensions would be 768 x 584 pixels along with 24 bits. Here, the images have been categorized as training and testing parts. Each of the part has 20 images where these images have the respective ROI region masks. The primary stage of every image processing is getting input, which can be termed as image acquisition stage. It is the process of digitizing and storing the required image. Once the image is obtained, then subsequent image processing steps would be commenced. Initially, the image from the source database file has been retrieved using two functions namely `uigetfile()` and `imread()`. The original colored retinal sample image is represented in fig. 3. However, if the attained fundi image is not up to the acceptable level, the images should be avoided.

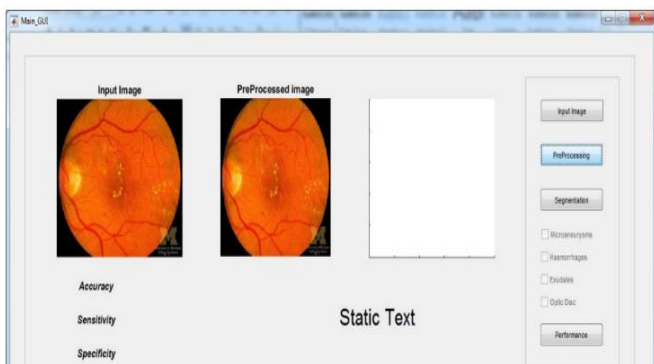




**Fig. 3.** Original colored Retinal image

### Image Preprocessing

Due to the wide scalable nature of the data sets and large number of image sources, these images are often considered as the artifacts which are not diagnostically applicable. In order to maintain the difficulties of these image variations and to standardize the image, image preprocessing step has to be followed. Initially, the images' pixel values should be scaled to the value in the range of 0 to 1. Then these scaled images are down-sized to a standardized resolution of 512 x 512 pixel dimensions. This can be done by cropping the inner circle of the retina and placing it into a square. As scaling resizes the digital image, it is considered to be the remarkable process in image processing technology. Upon considering the vector based graphical images, the basic image should be resized using the geometrical alterations, without compromising the quality of the image. When considering Raster graphical image, a robust fresh image should be generated with lower or higher quantity of pixels. If the number of pixels are scaled down, then the image might lose its quality. Thus the scaling of image is important in maintaining the image quality. It will enable the image segmentation by segmenting the retinal disorders of the given set of images. The screenshot of the software implementation of captured preprocessed image is depicted in fig. 4.



**Fig. 4.** Screenshot of captured preprocessed image

Image SegmentationHere, the proposed methodology implements an automated-unsupervised vessel segmentation for the retinal fundi images. The multi-dimensional based feature vector has been developed by utilizing green-channel

intensity.



**Fig. 5.** Vessel segmentation through green channel extraction [21]

The so called enhanced intensity features are developed by using morphological operations. In order to extract the green channel from the retinal image, several methods like erosion and dilation are utilized. Figure 5 represents the green channel extraction of blood vessels. In morphological operations dilation and erosion are used, where a collection of reference retinal images have been provided to the detection system. When considering the training phase, the system usually detects the retinal image collections in order to learn a specific image segment pattern. For example, the detection of exudates requires a collection of reference images which contains remarkable quantity of exudates. After the completion of training, the detection system then compare the sample image with neural network algorithm from the training set and it will detect the region of interest (ROI) of exudates in sample retinal images. Finally, the segmented images are detected to get whether they are MAs, Optic Discs, Exudates, and Hemorrhages. Figure 6 represents segmented retinal images. The morphological operations are explained below,

### Dilation:

This process will add the pixels to the object's boundaries in an image. The output pixel value is considered to be the highest value of all the given pixels in the neighborhood. This operation makes the objects to be more visible and can fill in small holes of the objects.

### Erosion:

This operation will removes the pixels on the object boundaries. Usually, the pixels that are added or eliminated from the objects of an image depends in shape and size of the structured element. In both the operations, the state of the provided pixel of any output image is evaluated by applying the respective rule of the corresponding pixel along with the neighbors in the input image.

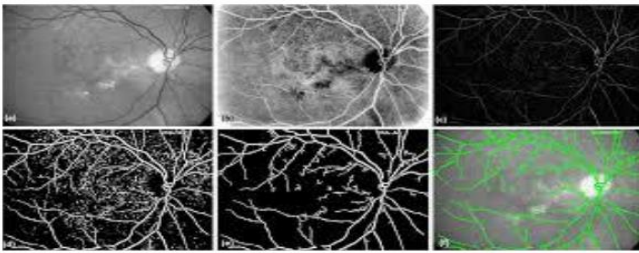


Fig. 6. Segmented Retinal images

#### 4 PERFORMANCE ANALYSIS

The performance of the proposed method has been evaluated using various performance measures namely accuracy, sensitivity, specificity. These measures can be expressed mathematically as follows,

$$\text{Sensitivity} = TP / TP + FN \quad (1)$$

$$\text{Specificity} = TN / TN + FP \quad (2)$$

$$\text{Accuracy} = TP + TN / TP + TN + FP + FN \quad (3)$$

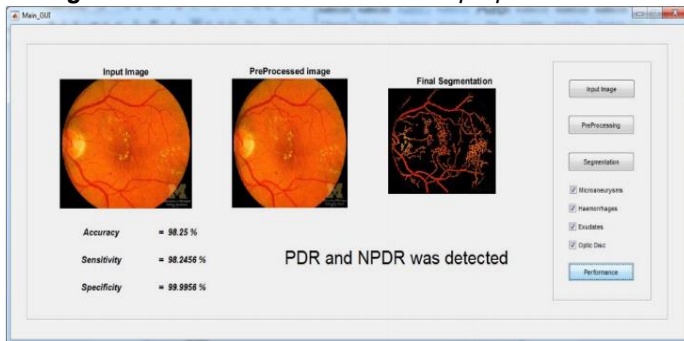
The performance evaluation of the proposed methodology has been recorded and represented in table 1.

**TABLE 1**  
PERFORMANCE MEASURES AND ESTIMATED VALUES OF PROPOSED SYSTEM

Performance Measures	Values (%)
Accuracy	98.25%
Sensitivity	98.2456%
Specificity	99.9956%

Figure 7 depicts the final segmented detected region along with performance evaluation.

Figure 7: Performance evaluation of proposed method



#### 5 STATISTICAL ANALYSIS

The statistical analysis has been done on approximation of detection accuracy of MAs, Exudates, Hemorrhage, and Optical Disk.

Accuracy Detection of MAs:

**TABLE 2**  
APPROXIMATION OF DETECTION ACCURACY OF MAs

Statistical Measures	Values
Included Test Number	50
Max	9
Min	3
Mean	7
Median	7
Mode	8
STD	1.6

From the table 2, the close approximation accuracy value of detecting MAs is 7, i.e. 71% accuracy. Here the standard deviation is high (1.6), which in turn signifies that it will have higher fluctuation depending on provided image.

Accuracy Detection of Exudates:

**TABLE 3**  
APPROXIMATION OF DETECTION ACCURACY OF EXUDATES

Statistical Measures	Values
Included Test Number	50
Max	10
Min	6
Mean	7.9
Median	8
Mode	8
STD	1.2

From the table 3, the close approximation accuracy value of detecting Exudates is 7.9, i.e. close to 80% accuracy. Here the standard deviation is high (1.2), which in turn signifies that it will have higher fluctuation between 70-80%.

Accuracy Detection of Hemorrhages:

**TABLE 4**  
APPROXIMATION OF DETECTION ACCURACY OF HEMORRHAGES

Statistical Measures	Values
Included Test Number	50
Max	9
Min	4
Mean	7.1
Median	7
Mode	8
STD	1.4

From the table 4, the close approximation accuracy value of detecting Hemorrhages is 7.1, i.e. 70% accuracy. Here the standard deviation is high (1.4), which in turn signifies that it will have higher fluctuation between provided image.

Accuracy Detection of Optical Disc:

**Table 5: Approximation of Detection accuracy of Optical Disc.**

Statistical Measures	Values
Included Test Number	10
Max	10
Min	5
Mean	7.8
Median	8
Mode	8
STD	1.3

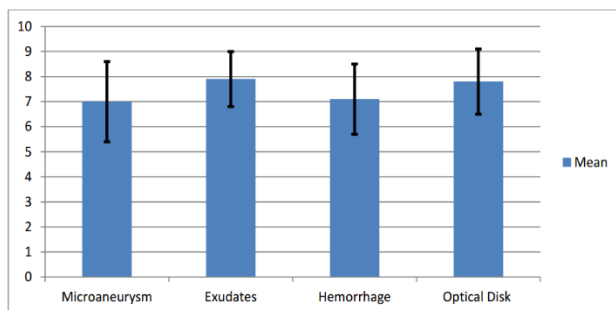
From the table 5, the close approximation accuracy value of detecting Optical Disc is 7.8, i.e. close to 80% accuracy. Here the standard deviation is low (1.3), which in turn signifies that it will have fluctuation between 70 – 80%. IJSTR style is to not citations in individual brackets, followed by a comma, e.g. “[1], [5]” (as opposed to the more common “[1, 5]” form.) Citation ranges should be formatted as follows: [1], [2], [3], [4] (as opposed to [1]-[4], which is not IJSTR style). When citing a section in a book, please give the relevant page numbers [2]. In sentences, refer simply to the reference number, as in [3]. Do not use “Ref. [3]” or “reference [3]” At the beginning of a sentence use the author names instead of “Reference [3],” e.g., “Smith and Smith [3] show ... .” Please note that references will be formatted by IJSTR production staff in the same order provided by the author.

## 6 COMPARATIVE ANALYSIS

The comparative analysis of the proposed system has been evaluated using comparative measures such as accuracy between detected MAs, Exudates, Hemorrhage, and Optical Disc. The comparative analysis of those detected using mean and STD has been recorded in table 6. Figure 8 represents the comparative analysis of the detection accuracy.

**TABLE 6**  
COMPARATIVE ANALYSIS OF DETECTION ACCURACY

	MAs	Exudates	Haemorrhage	Optical Disk
Mean	7.0	7.9	7.1	7.8
STD	1.6	1.1	1.4	1.3



**Fig. 8. Comparative analysis of the detection accuracy**

From the graphical representation, it has been observed that the detection of optical disc and exudates is way more accurate than the hemorrhage and MAs. On the other hand, when comparing optical disc and exudates, the latter has the minimum STD which indicates the higher accuracy.

## Correlation:

Correlation analysis has been evaluated using detection accuracy of MAs, Exudates, Hemorrhages, Optical disc. Table 7 represents the correlation analysis of detection accuracy.

**TABLE 7**  
CORRELATION ANALYSIS OF DETECTION ACCURACY

	MAs	Exudates	Haemorrhages	Optical Disc
MA	1	0.502538	0.394738	0.594011
Exudates	0.502538	1	0.286269	0.63674
Haemorrhages	0.394738	0.286269	1	0.446716
Optical Disc	0.594011	0.63674	0.446716	1

From the table 7, the correlation analysis has been estimated where the detection of exudates and optical disc has remarkable association with MAs detection. When comparing the exudates with optical disc, the exudate is having higher association with optical disc with the correlation coefficient accuracy of 0.6. However, the optical disc and the hemorrhage shares very low association with the optical disc.

## ANOVA:

ANOVA analysis is done for the proposed system, where the p-value has been estimated. In order to have the low probability error, the p-value should be low. The analyzed values have been recorded in table 8.

**TABLE 8**  
ANOVA ANALYSIS

	Co-eff	STD error	T stat	P-value	Lower 95%	Upper 95%
Intercept	-0.24	0.175	-1.37	0.1769	-0.59	0.11
Ophthalmologist	1.04	0.1107	9.39	1.91E-12	0.81	1.26

From the table 8, the p-value of the so called analysis is observed to be 1.91E-12, which is < 0.05. This signifies the lowest probability error.

## 7 CONCLUSION

The Diabetic Retinopathy is regarded as the predominant optic disease that leads to blindness. Diagnosis and detection at early stage is vital for the patients. But the identification of retinal identification is really challenging for the ophthalmologists. Several image processing based techniques are employed for the DR detection. In this work, an identification technique was developed on the basis of digital

image processing to obtain the fundus image from the affected retina. A MATLAB based analysis and classification of the fundus into Exudates, Micro aneurysm, Optical Disk and hemorrhage was done. It also examine the proliferative and non-proliferative stage of DR. For the purpose, morphological operations such as erosion and dilation are implied for the learning of fundus positioning pattern and detection of four eye defects. Different performance analysis validates the proposed mechanism and observed 98% accuracy in the detection of PDR and NPDR within a period of 39 seconds. In spite of the high accuracy achievement, further enhancement promotes the detection rate of the system. In addition to performance analysis, comparative analysis has been estimated where detection accuracy of MAs, Exudates, Hemorrhages, Optical disc have been estimated. Moreover, ANOVA analysis has been done, where the p-value is 0.5 (lower probability error).

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