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Detection of Diabetic Retinopathy using Machine Learning

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Abstract:

Diabetic retinopathy (DR) is an eye condition that occurs when blood vessel damage in the retina. The blurriness, floaters, dark areas of vision and difficulty perceiving colours are symptoms of such disease. Here, we proposed a machine learning based approach for diabetic retinopathy detection. In the paper, our proposed methodology is divided into several stages viz., pre-processing, segmentation, feature extraction and classification. The proposed model is simulated in MATLAB and the analysis of results is performed with in terms of accuracy, precision and recall. Our scheme outperforms over existing schemes in terms of above parameters.

Keywords: Optical segmentation, Textural features, KNN, Diabetic retinopathy, Machine Learning

1. INTRODUCTION

Diabetic retinopathy disease affects the people having diabetes. This disease is very dangerous to retina, the light-sensitive facing at the back of the eye. Diabetic retinopathy is a severe vision - threatening malady of diabetes. Diabetes causes harm to body's potentialof using and storingglucose (sugar). The disease increases the blood sugar level to a large extent which can cause harmto the entire body, along with the eyes. With the time, diabetes cause damage to tiny blood vessels all over the body, including the retina [1]. In this disease, the leakage of blood and other fluids starts from the tiny blood vessels. Due to this disease, swelling in retinal tissues begins that result in blurry or cloudy vision. In general, this disease causes harm to eyes. If a person has diabetes from a long time, there are more chances that person will progress DR. Diabetic retinopathy may cause complete blindness if it is not treated in time. NDPR and PDR are the two major categories of DR. NDPR is the milder form of DR and does not show any symptoms.PDR refers to the most advanced stage of DR (Diabetic Retinopathy [2]. In this type of DR, new, irregular blood vessels are generated in the retina.

Biomedical image processing is somehow alike to biomedical signal processing. The images obtained by optical imaging technologies are examined, improved and displayed by this technique. Image processing in medical field enables the doctors to visualize the inner body organs and hence simplifies the diagnosis process. This technique allows doctors to do keyhole surgeries reach without the need to open the extra body. It is possible to adjust the image processing tools designed for analyzing the distant sensing to examine the outcomes of medical imaging systems. The process of DR (Diabetic Retinopathy) detection based on image processing includes various stages [3]. These stages are known as preprocessing, dark object segmentation, spot lesions classification and rule-based grading. The color image of human retina clicked using a digital camera is used as input image for DR detection. The results are binary images displaying the availability of spot lesions and the seriousness of diabetic retinopathy disease [17,18]. The first stage of pre-processing contributes significantly in the preparation ofretinal fundus image for segmentation. It is essential to perform image preprocessing due to the continuous variation in image quality in accordance withthe scenarios of image acquisition [4]. To illustrate, many times, thepicturecapturing is carried out under some complex conditions. This causes non-uniformly illuminated, noisy or poor contrast images. These sorts of images generally affectthe efficacy of the segmentation algorithmic approach. Hence, the captured RGB image should pass through several preprocessing methods. In green-channel extraction approach, the partitioning of color test images is performed into two sets on the basis of the size. Then, the resizing of all input images is carried out to 600 × 800 pixels [5]. Green-channel produces maximal local contrast amidpixel values of an image together with the color image components. ODremains present in the middle third of the image. Hence, the approaches to eliminate the optic discprimarily concentrate on the middle third of the green intensity image f_G as a ROI. Then, a filtering method is implemented to preprocess the image of eye retina.The background removal process is focused on to remove the background gaps in lighting from a picture formaking the analysis process of foreground artifacts easy. The dark spot segmentation process includes various steps for the competent segmentation of dark spot lesions. Dark spot lesions are generally composed of microaneurysms and hemorrhages. The h-Maxima transformation phase applies h-maxima transform to process the image attained from the pre-processing stage. This key motive of this step is the reduction in the number of intensity levels.In the second step of thresholding, the segmentation of both MAs and HAs is performed by applying thresholding process on the intensity image H_h. Thresholding is a prevalent image segmentation approach [6]. This approach aims to create a binary image with pixel value either 1 or 0.The thresholding process results in the generation of blood vessels and some unnecessary pixels. These aspects occur as false positive in the achieved binary image. Thus, few post-processing methods are implemented in improving the image quality and recollecting the required objects (e.g. microaneurysms and hemorrhages). Further, the classification of dark spot lesion is carried out into a different classis based on various features such as size, shape, unevenness, boundary sharpness, brightness, color, and depth. These lesions comprise cotton-wool spots, hard exudates, drusen, microaneurysms, and hemorrhages. Thedivision of severity levels of DR disease is carried out into four classes. These classes are known as normal, mild, moderate and severe Non-proliferative Diabetic Retinopathy. Researchers have developed various classification algorithms so that the diseases can be classified based on its severity. Some popular classification algorithms are SVM, KNN, NB etc. Support vector machine algorithm generates a hyperplane in multidimensional space to partition different classes. This algorithm builds an optimum hyperplane in iterative manner [7]. This hyperplane is adopted to minimize the error rate. SVM algorithm aims to fins a maximal marginal hyperplane (MMH). This hyper planeis able to divide the dataset into classes. KNN (K-Nearest Neighbors) is a fundamental and popular machine learning algorithm. The use of this algorithmfor classification is quite common. This is a supervised machine learning algorithm. Apart from disease detection, this algorithm is used to serve different purposes. These purposes include intrusion detection, data mining [14,15] and pattern recognition.

The remaining paper is divided into various sections. Section 2 details Literature Review. Section 3 details about the proposed methodology. Results and discussion is presented in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

Shailesh Kumar, et.al (2018) proposed an advanced diabetic retinopathy detection technique [8]. In this method, color fundus images were used to extract the exact area and locate the number of microaneurysm. Number and area that were the attributes of MA had been verified. Some pre-processing methods were also applied in this approach such as green channel extraction, morphological process and histogram equalization. Principal Component analysis, morphological process and averaging filtering had been utilized to detect the microaneurysms. In this method, Linear SVM was carried out to categorize the DR. After the experiment, the sensitivity was counted as 96% and the specificity was evaluated 92% of DR detection system.

ÖmerDeperlıoğlu, et.al (2018) suggested a technique to make a diagnosis of DR from images [9]. In the proposed method, image processing and deep learning methods had been used. A practical technique that had HSV, V transform algorithmic approach and equalization of histogram methods had utilized. The Gaussian low-pass filtering technique, on the retinal fundus image had been used at last, in this approach. The Convolution Neural Network was used for the categorization, when the image processing was completed. While testing the accuracy, sensitivity, specificity and F score had been observed as 97%, 96.6%, 93.3% and 93.3% respectively. The experimental results demonstrated that for the diagnosis of DR from the image of retinal fundus, the recommended technique was accurate and efficient.

SehrishQummar, et.al (2019) proposed a diabetic retinopathy detection technique that was based on computer vision [10]. This method was useful to detect the DR and its various stages automatically. But these techniques were incapable to classify the various stages of diabetic retinopathy especially for early stages, correctly. The primary complicated features were not encoded properly by these techniques. To enhance the classification and to encode the rich features of various stages of DR, the group of five Convolution Neural Network models had been utilized. This ensemble of CNN was trained by the Kaggle Dataset of retina images that was publicly available. It had been evaluated that the suggested approach was efficient for the detection of all DR stages. The performance of this recommended technique was observed better than other existing methods on the same Kaggle dataset.

NarjesKarami, et.al (2017) recommended a technique that was Dictionary Learning–based [11]. This technique was useful for detecting the Diabetic retinopathy automatically from the digital fundus images. This detection method was planned on the basis of the learned dictionaries by K-SVD and it was an atomic fundus image demonstration. The differentiation of normal and diabetic classes had been done by the learned dictionaries using K-SVD and the discriminative atoms were designed. The atomic representation of images was done by acquiring the discriminative atoms. The finest sparse representation was on the basis of the classification rule. The class which had least number of the finest specific atoms the test image belonged to that class. The experiment of the suggested technique utilized 30 color fundus images. The testing results of discriminative DL-based technique demonstrated that the normal images acquired accuracy 70% and the diabetic images achieved 90% accuracy.

FarrikhAlzami, et.al (2019) proposed a fractal dimension-based research [12]. This method described the differentiation between the healthy subjects and DR patients as well as DR severe levels of patients of diabetic retinopathy. The MESSIDOR dataset and classifier known as Random Forest were utilized in this experiment. The results demonstrated that fordifferentiating the healthy subjects and DR patients, the fractal dimensions were efficient. But the suggested method was unable to provide the adequate outcomes for the serious classification of person who suffered from DR. The exploration of other various features was also required for the future directions. To acquire further information regarding DR grade level, the attention was needed for the red lesion detection.

Enrique V. Carrera, et.al (2017) suggested a computer-assisted detection technique to detect the DR [13]. This method was designed on the basis ofdigital process of retinal pictures and proved efficient to detect the diabetic retinopathy from patients in advance. The grade of non-proliferative DR was classified automatically at any retinal image easily in this method. First of all, the blood vessels, microaneurysms and hard exudates were isolated in initial image processing. In this way, the features were extracted. The support vector machine used these features to examine the retinopathy grade of every retinal image. The proposed method was tested by using 400 retinal images on the database. These images had been labeled according to 4-grade scale of non-proliferative DR. In the experimental result, the sensitivity and predictive capacity was evaluated as 95% and 94% respectively. The robustness of the algorithm had been calculated also.

3. RESEARCH METHODOLOGY

a. Input image: Input image refers to the coloured retinal image. Generally, a fundus camera is used to click the image of eye retina. The output is the binary image. This image includes MAs, HAs, and reveal the seriousness of diabetic retinopathy disease.

b. Pre-processing: Pre-processing stage helps in the preparation of retinal fundus image for segmentation. It is essential to apply image pre-processing due to the change in image quality as per the conditions of image acquisition. For example, sometimes, image capturing takes place under some complex conditions. This causes non-uniformly illuminated, noisy or poor contrast images. These types of images generally influence the efficacy of the segmentation algorithm. Hence, it is essential to apply several image pre-processing methods on the captured RGB image. Some commonly employed pre-processing methods are removal of OD and retrieval of green-channel.

Figure 1: Input Image

Figure 1 shows the use of RGB picture in the form of input to detect diabetic retinopathy. The blind spots are shown in the figure which may be the retinopathy shots.

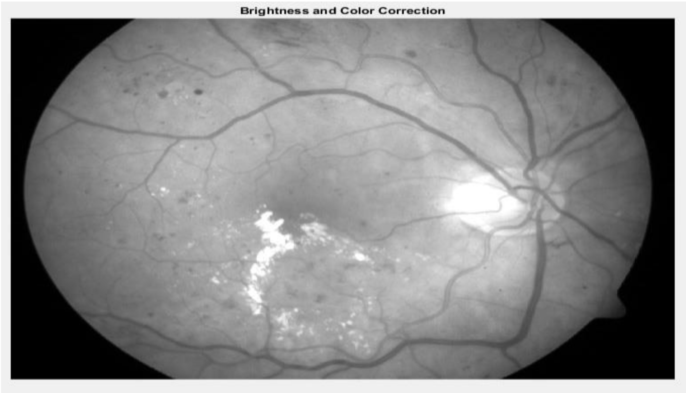


Figure 2: Brightness and colour correlation

As shown in figure 2, the brightness and colour correlation of the input image is shown. In the step of colour correlation image is converted to gray scale. The gray scale image show hidden portions of the image

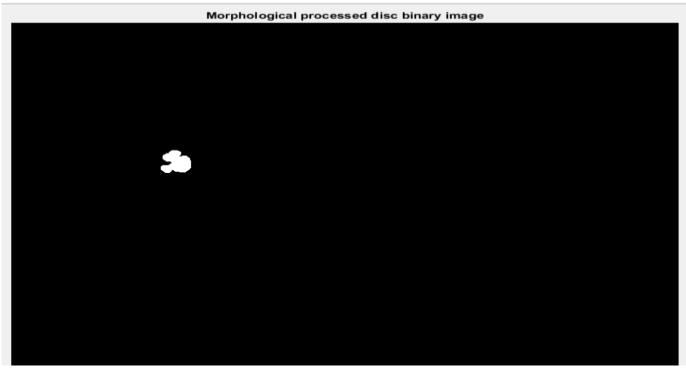


Figure 3: Morphological Operation

As shown in figure 3, the morphological operation is applied on the highlighted image to identify the different portion from the image

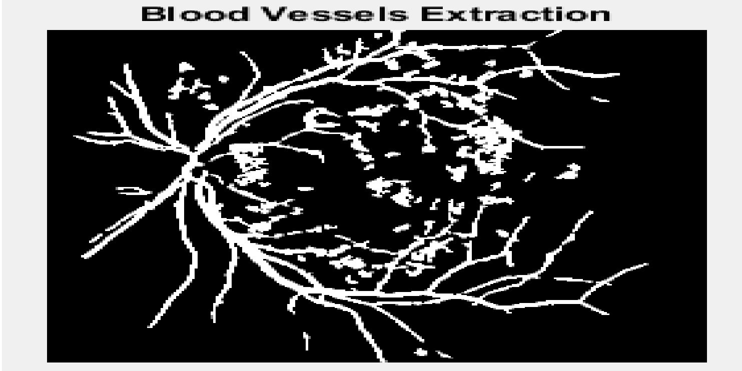


Figure 4: Detection of Blood Vessels

As shown in Figure 4, the technique of blood vessel extraction is applied through the morphological operation.

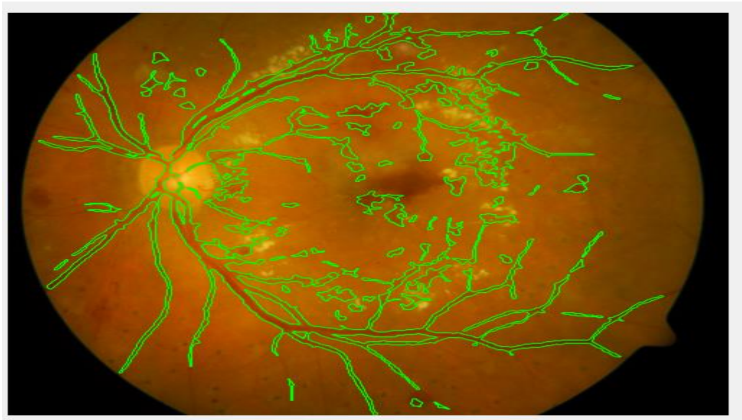


Figure 5: Marking of blood vessels

As shown in Figure 5, the morphological operation detect the blood vessels which are marked on the image

Figure 6: Normalization of the image

As shown in the Figure 6, the brightness and colour correlation image is converted to normalized form. The image normalization is the process in which every pixel of the image lies between the 0 and 1.

- Green-channel extraction: This procedure aims to partition colored test pictures into two sets based on the size. Then, the resizing of all input images is carried out to 600 × 800 pixels. Green-channel creates maximal local contrast among the values of image pixels with the components of colored RGB picture. Firstly, the extraction of green-channel I_G is performed from the RGB image as a result of uniqueness of microaneurysms and hemorrhages features [8]. The green image merely involves 256 levels, while other color images generally contains 2^{24} levels. This conversion decreases computation time and needs less space for storing.

- OD (Optic Disc) removal: In this process, few important attributes, such as optic disc and fovea are removed from the retina imagery. Fovea looks as a dark spot and occurs in eye retina's middle. Typically, Optic disc (OD) has some features. These features are identified as extreme brightness, round outline, and persistent magnitude. These features depict its actual place within picture. Few dark artifacts may occur in the OD. Sometimes, these objects may be mistakenly identified as MAs or HAs. Due to this reason, extraction of OD contributes significantly in the elimination of these puzzling objects. Optic disc occurs can be seen in central third portion of the picture because of the location of the image capturing tool. Hence, the methods for optic disc removal generally consider the middle third of the f_G as a ROI. After it, a filtering approach is employed to process the image of eye retina. Median filter is a popular filtering approach, used for the preprocessing of retinal image. Different from other filtering approaches, the median filter performs image preprocessing and do not blur the sharp boundaries, i.e. the edges of optic disk.

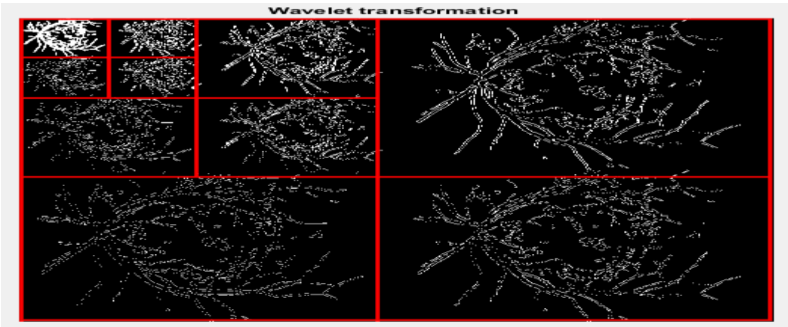
- 

Figure 7: Wavelet Features

As shown in figure 7, the technique of wavelet is applied for the feature extraction.

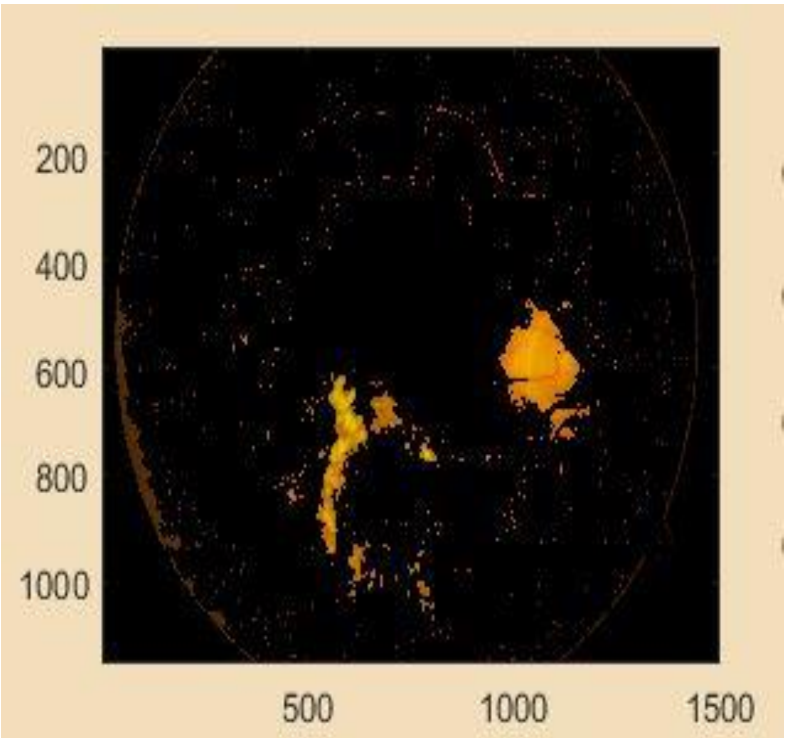


Figure 8: Segmentation of OD

Figure 8 reveal that the technique of optical segmentation is used to separate some portion from the image. The optical disk segmentation is the region-based segmentation which segment circular portions from the image.

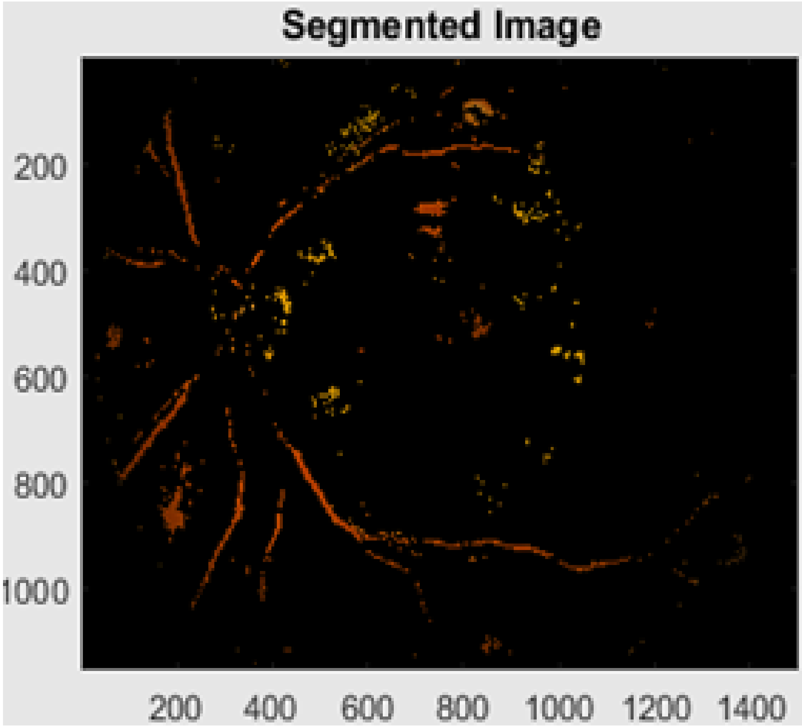


Figure 9: Segmentation

As shown in figure 9, the technique of optical disk segmentation is applied to segment portion from the image

c. Feature extraction: The thresholding process results in the occurrence of blood vessels and some redundant pixels as FP in the achieved binary picture . So, certain post-processing methods needs to be applied essentially for purifying picture and holding the required artifacts. These objects generally include MAs (Microaneurysms) and HAs (Haemorrhages). GLCM (Gray level co-occurrence matrix) is a well-known texture-based feature extraction algorithm. This algorithm performs an operation on the images based on the second-order statistics to find out the textural relationship between pixels. In general, this operation is performed using two pixels. GLCM algorithm finds out the frequency of combinations of these pixels' intensity levels.In other way, this algorithm signifies the frequency formation of the pixel pairs. The GLCM features of an image are described as a matrix with the same number of rows and columns just like grey values in the image. The elements of this matrix rely on the frequency of the two particular pixels. Both pixel pairs may fluctuate based on their neighbourhood. These matrix elements include the second-order statistical probability valuesthat depend on the grey level of the rows and columns. When intensity values are wide, the transient matrix turns quite large. This generates a time-consuming process load. A GLCM feature matrix can efficiently represent animage with fewer parameters using several properties such as autocorrelation, contrast, correlation, cluster prominence, cluster shade, dissimilarity, energy, entropy, homogeneity etc

the textual and wavelet attributes are extracted. The textural and wavelet features are the physical features of the input image

d. Classification: - In this research work, the KNN classifier is applied for the classification of diabetic and non-diabetic images. KNN (K-Nearest Neighbors) is a commonly used popular ML (Machine Learning) algorithm. This algorithm performs classification in competent manner. This algorithm is referred as a supervised machine learning algorithm. Different purposes such as intrusion detection, data mining [14] and pattern recognition can be served using this algorithm. Due to the non-parametric nature, this algorithm can be not be reused in realistic scenarios. This means that this algorithm does not assumes anything regarding the allocation of data. This algorithm makes use of some already existing data. This data is known as training data. This data performs the classification of coordinates into groups, identified by a feature. This algorithm computes the distance between data points.

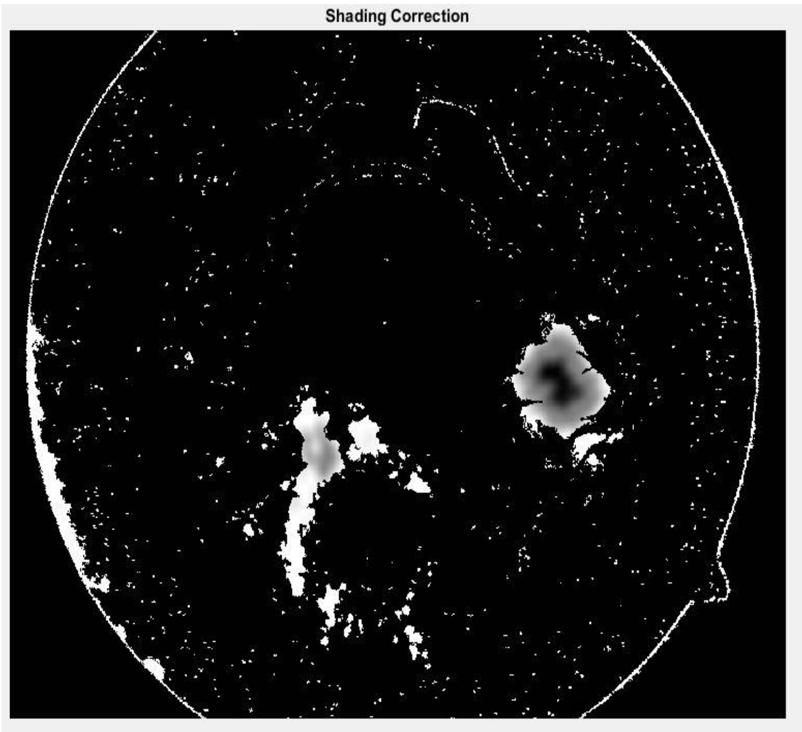


Figure 10: Shading correlation

Figure 10 shows the use of classification to apply shading correlation technique. The classification approach classifies images into dual classes of diabetic and non-diabeti

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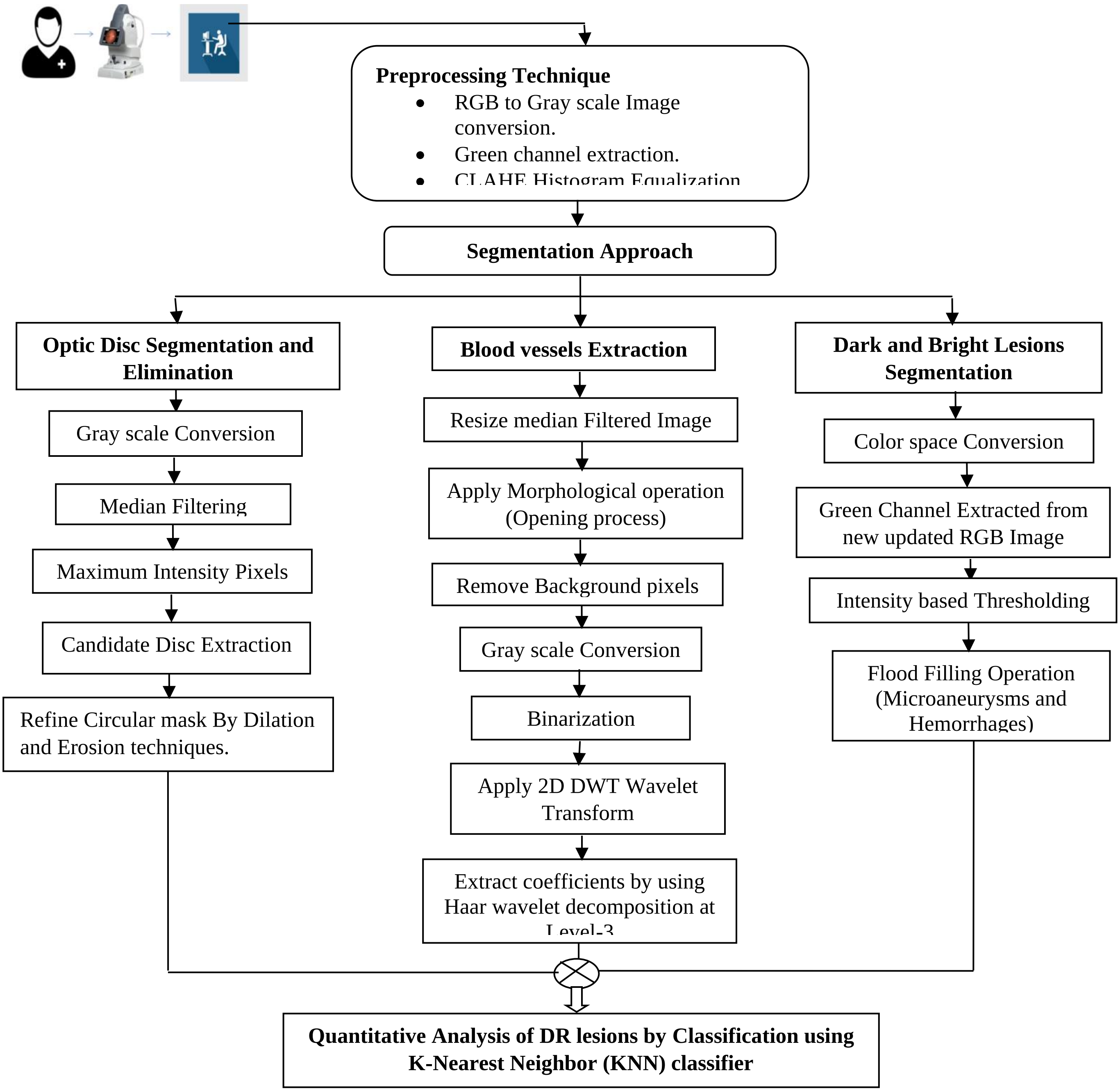

4. RESULT AND DISCUSSION

This work presents a novel approach for detecting diabetic retinopathy disorder. The comparison of new technique is carried out against earlier algorithm with respect to various parameters like accuracy, precision and recall.

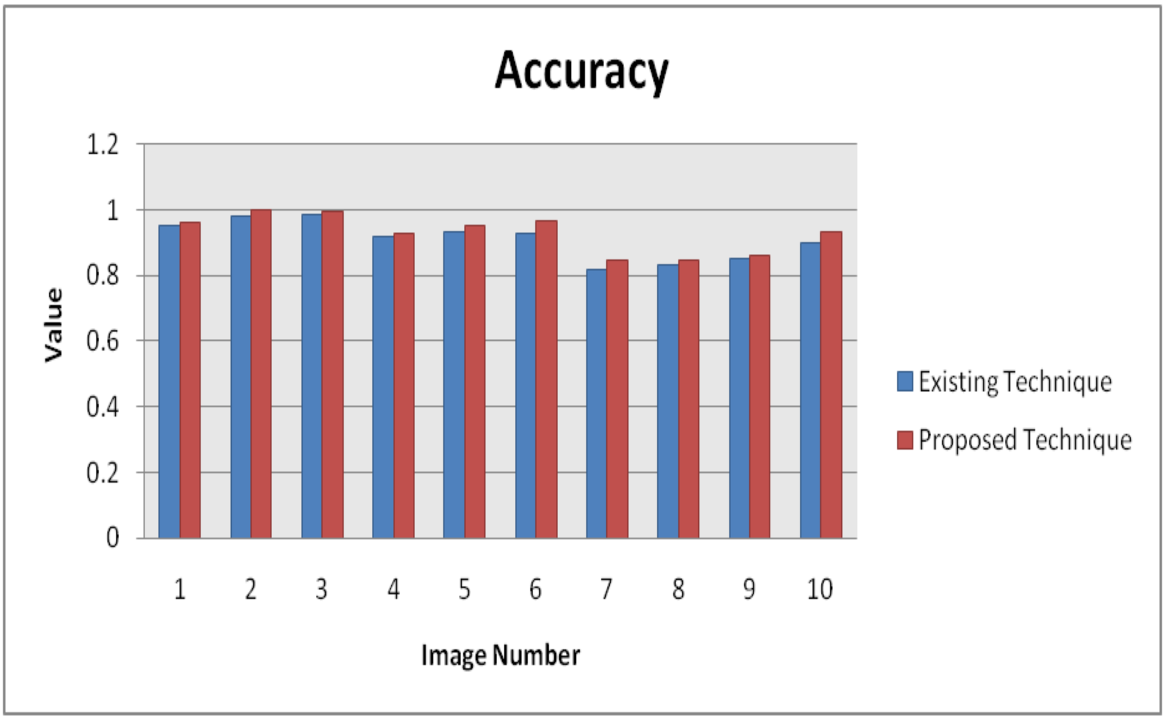

Figure 12: Accuracy Analysis

Figure 12 shows accuracy-based comparison between proposed and algorithms for DR diagnosis. The proposed algorithm outperforms earlier approach in terms of accuracy.

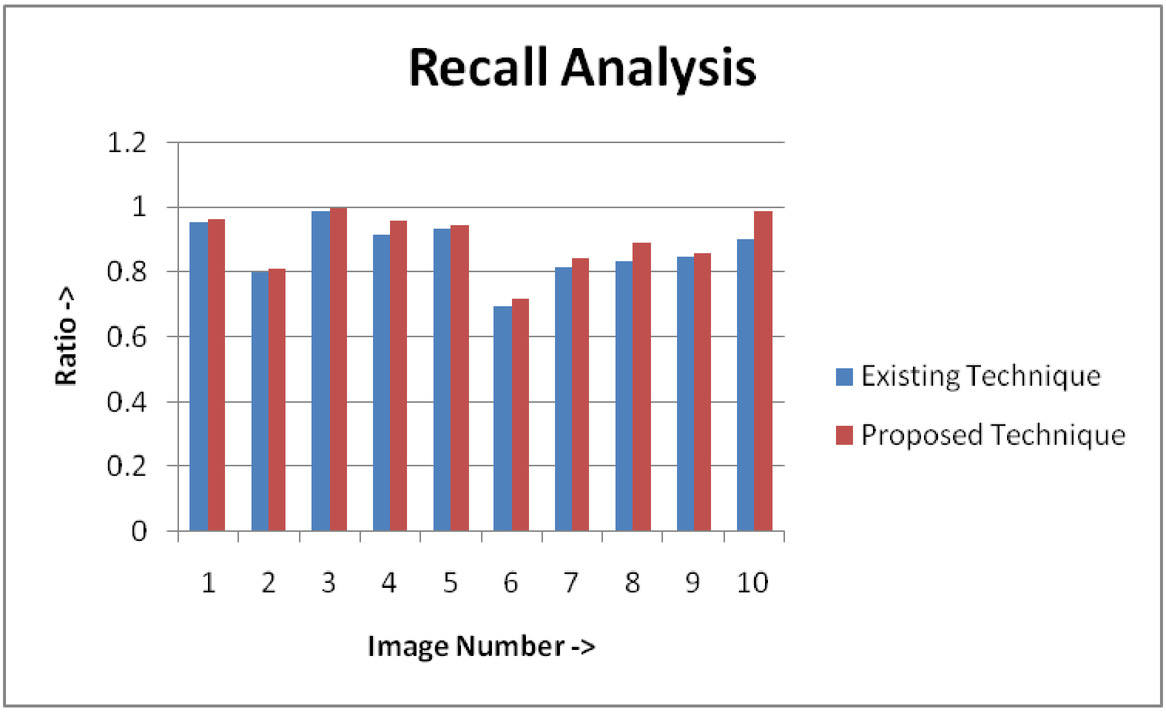

Figure 13: Recall Analysis

Figure 13 shows recall-based comparison between proposed and algorithms for DR diagnosis. The proposed algorithm outperforms earlier approach in terms of recall.

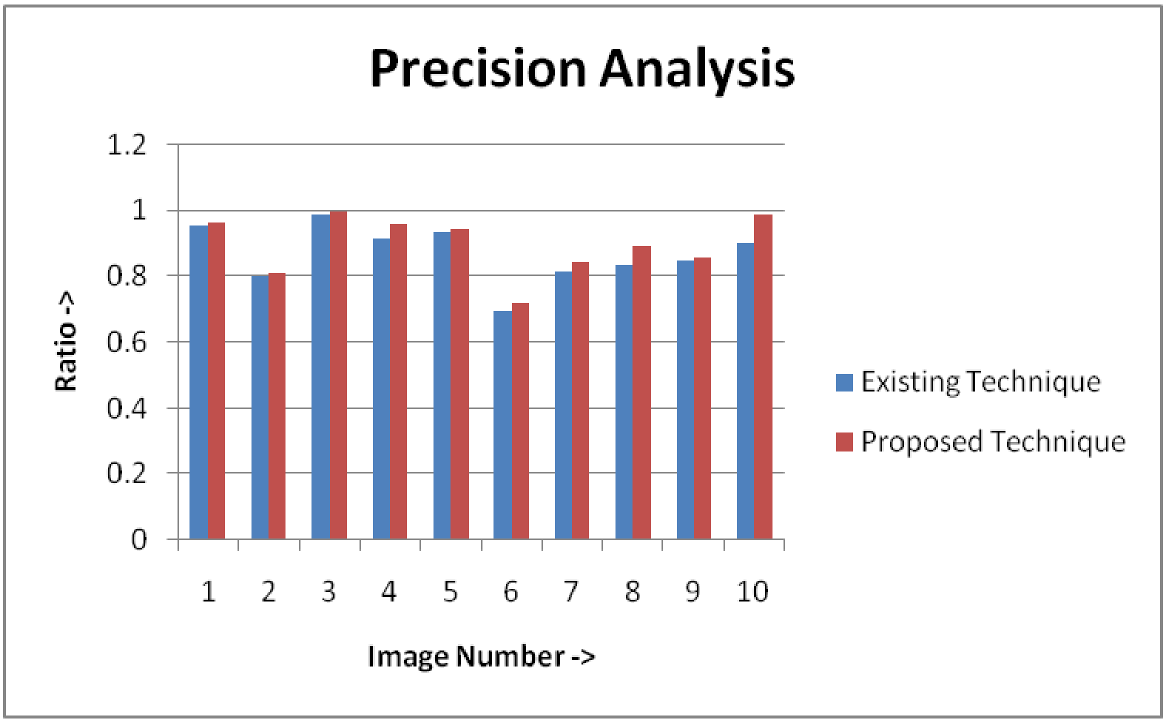

Figure 14: Precision Analysis

Figure 14 shows precision-based comparison between proposed and algorithms for DR diagnosis. The proposed algorithm outperforms earlier approach in terms of precision.

5. CONCLUSION

The work concludes that diabetic retinopathy detection is the major challenge of image processing and machine learning. This disorder can be detected by applying a series of processes. These processes are pre-processing, segmentation, feature extraction and classification. KNN classifier is applied in the proposed model for the classification of diabetic and non-diabetic portion. The newly devised model achieves high level of accuracy, precision and recall.

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