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Segmentation of Retinal Blood Vessels using Optimized Features for detection of Diabetic Retinopathy

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Abstract: ***Nowadays in working age of populations the most common cause of blindness is diabetes, people are unaware about that their eyesight get affected due to diabetes. There are other diseases with which patients can be suffer like cataract, glaucoma, bleeding of blood vessels, etc. A diabetic retinopathy is a damage caused by diabetes to the blood vessels in a eyes. In one data set there are large numbers of features but not all are useful in classification. The useless redundant features reduce the performance of output. In our case we have used only small relevant features rather than using all the features that contain both relevant and irrelevant features. To achieve better results there is need to minimize the number of features along with maximizing the performance of classification. In this paper, to achieve the objective firstly we have extracted the features using the Independent Component Analysis for both series of vessels and non vessel images (normal and abnormal). Then further extracted features are optimized using various optimization methods which actually optimize the selected features of images taken from DRIVE dataset for both vessels and non-vessels to improve the recognition accuracy. Afterwards, the Support Vector Machine classifier has been applied to test the results for both normal and abnormal images dataset. The accuracy of LION optimization for normal and abnormal images is 0.96691, 0.9672 respectively which is 13.06% better than Particle swarm optimization and 98.95% better than Firefly in case of normal images. The sensitivity results for normal and abnormal images for using LION is 0.97106, 0.97128 which is 8% better then particle swarm optimization and 47.98% from firefly for normal images. The simulation results show that LION is better in terms of accuracy, sensitivity, entropy, etc., as compared to other optimization methods for both normal and abnormal set of images.***

Keywords: *Vessel images, Non vessel images, Particle Swarm Optimization (PSO), Firefly, LION, Support Vector Machine (SVM), Accuracy, Sensitivity*

I. INTRODUCTION

The important information for eye care specialists is provided through structure of retinal vessels whose changes indicate different diseases. The arteriosclerosis, hypertension, diabetes, cardio vascular disease, and stroke diseases can be detected through retinal vessels extracted information [1]. In overall the world, most of working age people are affected by blindness through diabetic retinopathy that mainly occur due to blood vessel structure changes. We can utilize attributes of retinal blood vessels like length, width, tortuosity, angles and branching pattern. The retinal vessels automated segmentation is considered as a first step for ophthalmic disorder in computer aided diagnosis system development. The diabetic retinopathy, vessel diameter measurement in relation with diagnosis of hypertension, computer assisted laser surgery and etc are screening programs. They are implemented by analysis and automatic detection of the vasculature. A large number of death and visual loss has been occurred due to spreads of diabetes on retina. In most of the cases the loss of major vision has been saved by periodic screening with early recognition of retinal vessel. So, for diagnosis of subsequent retinal disease a accurate retinal vessel segmentation is required.

The process of retinal vessels segmentation is not an easy task. There are different challenges that have been faced as with retinal vessels there are optic disc, fovea structures that are present in retinal image [2]. Secondly the detection of objects has become hard due to wide range of widths and lower contrast of thin vessels in retinal vessels. The use of automated analysis of optic fundus based on computer is one of the possible solutions for above mentioned measurements. This computer based analysis helps in detecting blood flow, vessel distribution and extra vessel growth changes that shows its widely acceptance by medical community. The optic nerve is proved to be the most important organs in anatomy of human retina [3].

The retinal blood vessels automatic segmentation method has been categorized into two categories named as supervised and unsupervised [4]. In case of supervised learning, the already trained classifier is used and samples are labelled manually and sample pixels are classified into two classes named as vessels and non vessels. In real applications pre-classified data is not available and in those case use of supervised proved to be better mainly in health images. There are different data available and for each individual the use of biometric identification is unique that uses retinal vascular tree [5]. There is a need of training for performing retinal blood vessels manual segmentation that is very time consuming too.

In this paper, we have given a overview of steps involved in retrieving data from different images to diagnose a diabetic patients. We have used DRIVE data sets for taking sample images that has been gone through different steps that classify those images into normal and abnormal image. It is classified on the basis of the fact that if a symptom of diabetic patient has been seen in retinal image of any patient than it will come under the category of abnormal image and in case no such effects has been found then it comes under normal image [6]. The brief description of whole steps and algorithms, techniques involved to classify those images is given in different sections of paper.

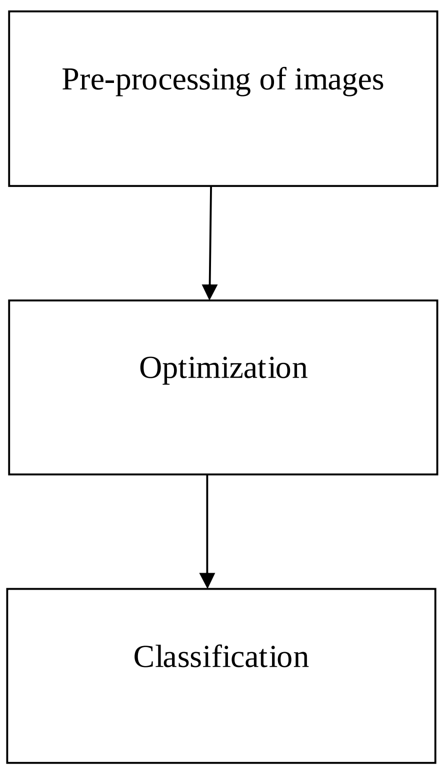
II. FRAMEWORK

Proposed algorithm: In this paper we have proposed an approach and its each step has been briefly given in this section. The whole process is divided into three steps given below:

Step.1: The features of both normal and abnormal images will be extracted: In order to extract the features firstly the image from a drive dataset has been uploaded and then preprocessed using Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm [7]. The edges of the preprocessed image have been detected along with all required features that help in detecting the symptoms of diabetic retinopathy.

Step. 2: After the features have been extracted from the uploaded image the next step is to optimize the extracted features. In order to perform optimization step, we have used three algorithms such as PSO, Firefly and Lion individually [8]. There are two types of features for normal and abnormal images that are separately optimized.

Step. 3: The test images are further classified as normal and abnormal after optimization the features using Support Vector Machine (SVM) classifier that helps in evaluating the performance. We have tested all optimization algorithms individually in terms of different parameters.



The above are the three broad steps that have been performed to get both normal and abnormal image and then it is tested in terms of different factors using different algorithms.

III.PRE-PROCESSING

The first and foremost important task is to pre-process an image that helps in order to analyse it in superior way. There are different techniques to perform the task of pre-processing such as contrast enhancement that is further classified into two local and global parts [9]. In this section of paper we have surveyed different papers on different contrast enhancement techniques and their impact on the segmentation process of image. There are different techniques that can be used such as histogram equalization, histogram specification, AHE and BSB-CLAHE [10]. Most of the researchers have also used CLAHE contrast based enhancement and Wiener filter method that helps in enhancing a image and results show that optimal output has been achieved using local enhancement technique rather than global. There is different types of noises present in a image to remove it different filters has been used in it along with Gamma correction technique that helps in transferring image into dynamic range. In our paper we have also used CLAHE due to its good results as a pre-processor the abbreviation for CLAHE is contrast limited adaptive histogram equalizer. In paper [11], authors have used CLAHE that helps in avoiding amplification of noise presented in image along with that it limit a contrast in homogeneous area. In paper [12], different pre-processing techniques for verbal bone segmentation has been analysed by authors to do so they have used various different methods such as histogram equalization (HE), gamma correction (GC) and contrast limited adaptive histogram equalizer (CLAHE). In order to get good results in segmentation different image enhancements steps are involved and in case of X-ray images it is very critical task. The contrast magnification like subsequent modules has been used that helps in increasing sharpness of images captured from autonomous disease diagnosis system. Even in these cases use of CLAHE technique have shown an accurate results as compared to other existing techniques [13].

In pre-processing, the images have to go through different steps in our case we have firstly used CLAHE to enhance the contrast of different images available in dataset. The step we have performed is the detection of edges for segmentation as an important role is played by blood vessel detection and segmentation techniques for automated retinopathy analysis systems [14]. The task of image segmentation can be done manually but it require a lots of expertise and very time consuming as there is need to divide one single image into essential regions. The edge detector is one of the methods that considered local or abrupt changes for segmenting an image. It has been seen that a use of computational intelligence makes a retinal analysis very efficient. There are different types of data sets available in our case we have used DRIVE dataset. The reason behind choosing DRIVE dataset is its usability by different researchers that have achieved very accurate results. In paper [15], a DRIVE test has been used by authors and results show a accuracy of 94.61% with 73.38% of sensitivity as compared to existing techniques of blood vessel segmentation. In this paper feature of blood vessels has been extracted using Independent component analysis (ICA) after being segmented using edge detector and its results has been tested using MATLAB over graphical user interface (GUI) tool.

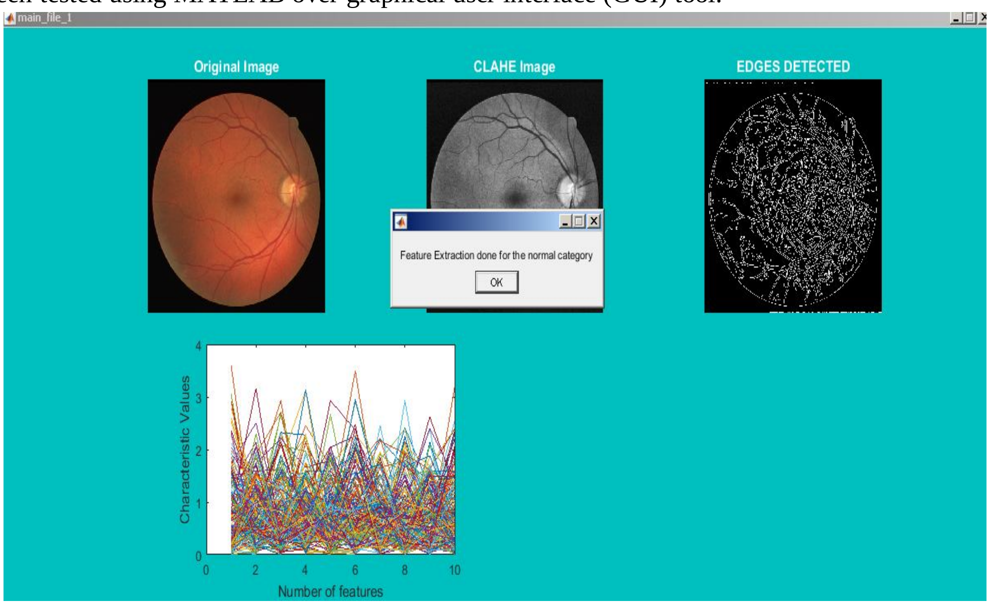


Fig. 2: Features extracted for normal image

There are large numbers of techniques available for detecting an image that helps in locating sharp discontinuities after identifying an image [16]. The boundaries are characterized by detecting abrupt changes in pixel density that is called discontinuities. The edges as well as noises both contain a content of large frequency that makes it difficult to perform a task of edge detection in case of noisy

images. The Sobel, Robert, Canny, Prewitt and Laplacian of Gaussian (LoG) are different techniques of edge detection. There is a series of images that can be vessels and non vessels whose features are extracted using Independent component analysis (ICA) [17].
After the task of segmentation using edge detector a information present in different images has been extracted using different feature extraction methods. The building of features by extracting features and pattern recognition are comes under the pre-processing steps. In feature extraction we mainly reduce the dimensionality that restricts the resources which is the main set of required data. This reduced and required information will be further manipulated according to our requirement [18]. In our work we want to enhance blood vessels images for this we have used ICA as a feature extractor.

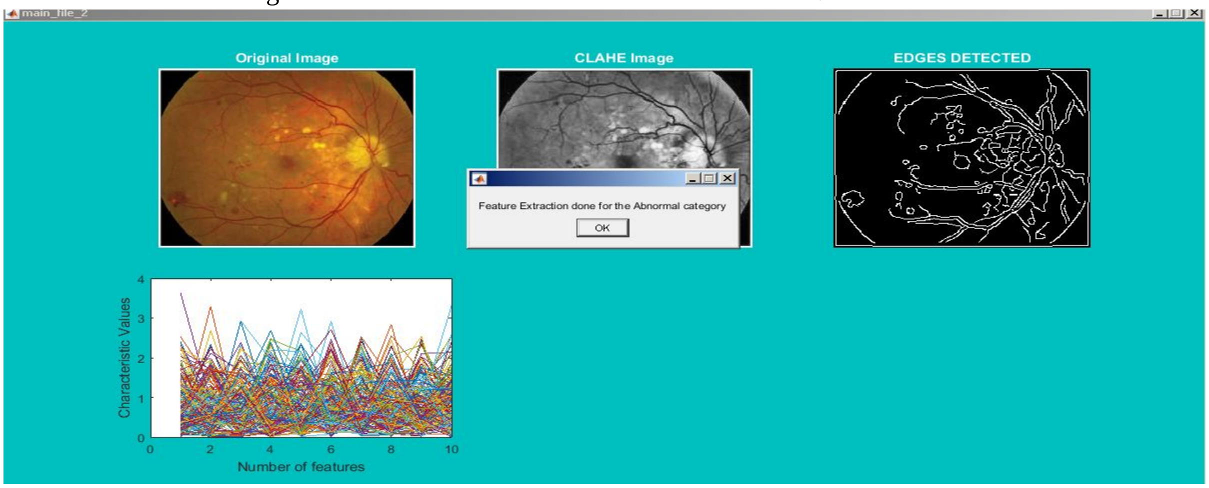


Fig. 3: Feature extracted for abnormal image

IV. OPTIMIZATION OF EXTRACTED FEATURES

The pre-processing task has been done by enhancing contrast after that edges has been detected then extracted a features which comes under a second step of framework. The next step after pre-processing is to optimize extracted features using different available algorithms [19]. There is large number of available algorithms that can be used to perform this task in our case we have used three different algorithms Particle Swarm Optimization (PSO) then Firefly and Lion algorithms.
In this step firstly the extracted features has been given to Particle Swarm Optimization (PSO) algorithm that will further optimized the extracted results and gives optimized features as its output [20]. The PSO algorithm has ability of rarely falling into local optimal that makes it efficient for feature extraction. PSO is a meta-heuristic nature inspired technique that simulates the bird flocking behaviour [21]. It uses randomly generated population that search for optimal solution by updating velocity and position according to gbest and pbest value.

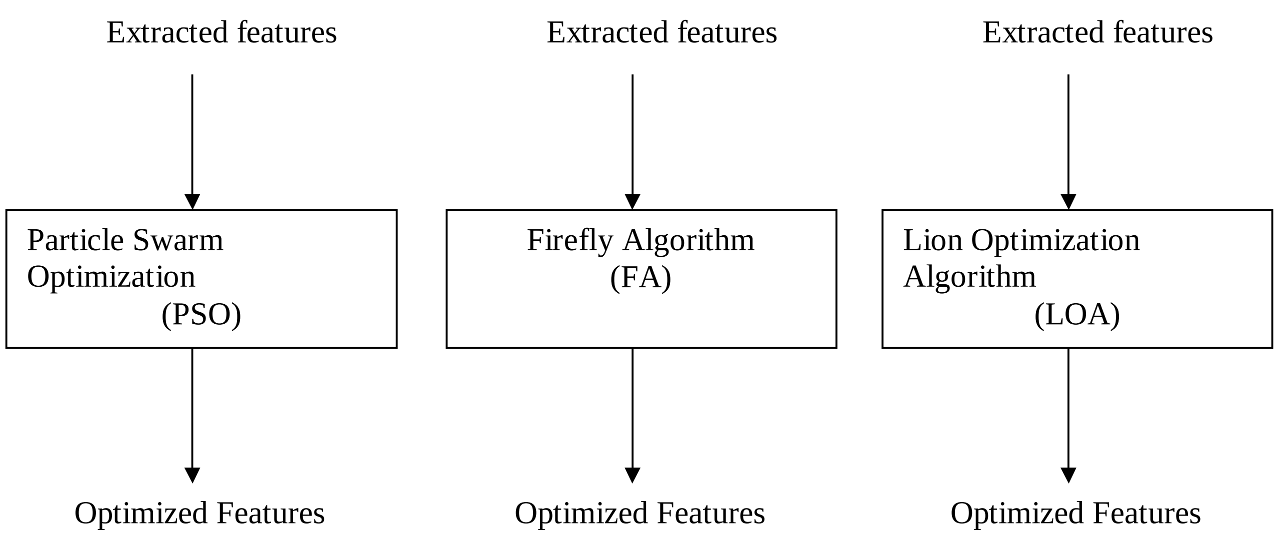


Fig. 4: Flow of optimization of extracted features using different algorithms

The second algorithm used is firefly that will get attracted towards the brighter one if no brighter firefly exist then it will randomly move to get the optimized result [22]. This algorithm will quickly search for optimal and near optimal feature subset that minimize the used fitness function. The third and last algorithm used for optimizing a extracted features is Lion Optimization Algorithm (LOA). In its case, each solution has specific gender and each gender has its own searching strategy that assists it to look for optimal point. The general aim in using several prides is that each pride focuses on a specific region and balance between exploration and exploitation [23]. Its character of LOA increases capability of it to fit for the optimization on multi-modal problems.

V. CLASSIFICATION

After the feature optimization process, the test images will be classified as normal and abnormal images using classification process using Support Vector Machine. In our previous paper we have used Naive Bias classifier to classify the optimized images into normal and abnormal images on the basis of different extracted features from them.

The reason behind using SVM rather than Naive Bayes is its use and obtained results by different researchers for diabetic retinopathy. In [1], a brief discussion about the different stages of Diabetic Retinopathy has been done and it has been stated that DR can be classified into four stages name as Mild non-proliferative retinopathy, Moderate non-proliferative retinopathy, Severe non proliferative retinopathy and Proliferative retinopathy. The image processing and support vector machine (SVM) techniques has been used for analysing a image that helps in achieving a accuracy of around 82% .

VI. EXPERIMENTAL RESULTS

In this paper in order to perform retinopathy an input images available in DRIVE dataset gone through different steps. This section gives the results for using PSO, FA and LOA three algorithms in terms of different parameters for both normal and abnormal images. As it is stated in previous sections the first steps is to upload a image and pre-processed it. In pre-processing the image will go through different steps, a first step is to use CLAHE algorithm that will extract contrast of image then its edges will be extracted using different edge detection methods and in the last it will be segmented using ICA. The motive behind performing all task of pre-processing is to extract different features available in image that helps in analysing that uploaded image have symptoms of diabetic or not.

The second step is to optimize a extracted features that helps in getting good results. In this paper as mentioned above we have used three different algorithms and tested it in terms of different parameters such as sensitivity, accuracy, specificity, positive predicted and false positive rate.

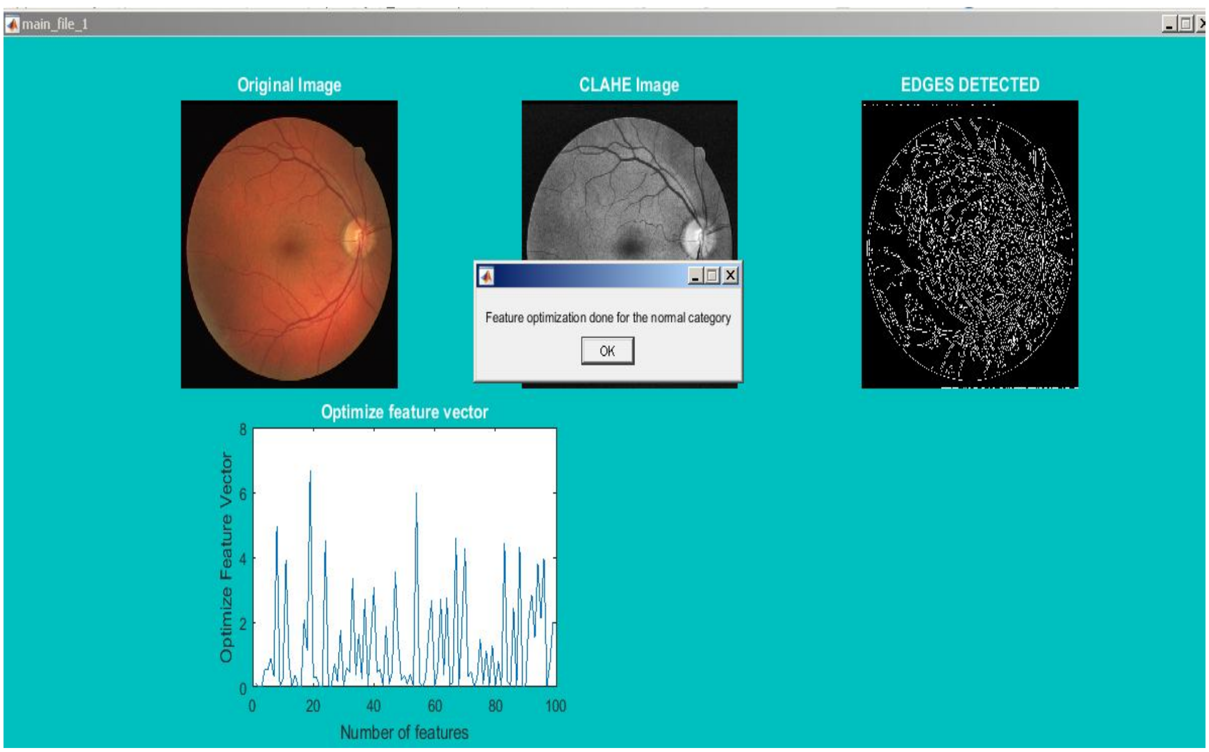


Fig. 5: Normal image Feature optimized using PSO

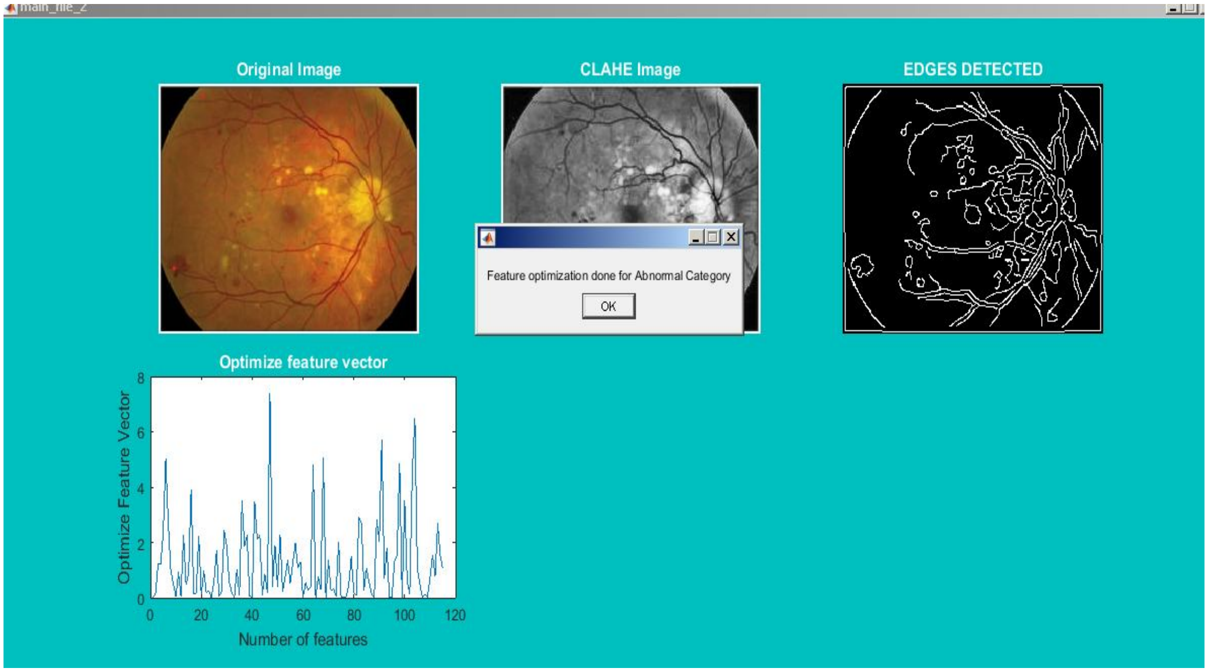


Fig. 6: Abnormal image Feature optimized using PSO

The above two figures, fig. 5 and fig. 6 show a output of optimized features using PSO algorithm. This algorithm is tested for both normal and abnormal images along with tested it in terms of different parameters. The below are two tables that gives the results for different algorithms in terms of different parameters. The Table 1 gives results for normal images and Table 2 for abnormal images.

Table1: This table shows the simulation results for normal images using PSO, Firefly & LION

Algorithm	Abnormal images				
	Sensitivity	Specificity	Accuracy	Positive Predicted	False Positive Rate
PSO	0.89928	0.94209	0.84137	0.9395	0.057912
Firefly	0.51164	0.76151	0.27315	0.68207	0.23849
LION	0.97128	0.99592	0.9672	0.99581	0.004082

Table2: This table shows the simulation results for Abnormal images using PSO, Firefly & LION

Algorithm	Normal images				
	Sensitivity	Specificity	Accuracy	Positive Predicted	False Positive Rate
PSO	0.89335	0.94721	0.84056	0.9442	0.052793
Firefly	0.50507	0.50507	0.01014	0.50507	0.49493
LION	0.97106	0.99585	0.96691	0.99575	0.0041462

The below Fig. 7 and Fig. 8 shows, a graph for normal or abnormal image accuracy and sensitivity for PSO, Firefly and LION three different algorithms.

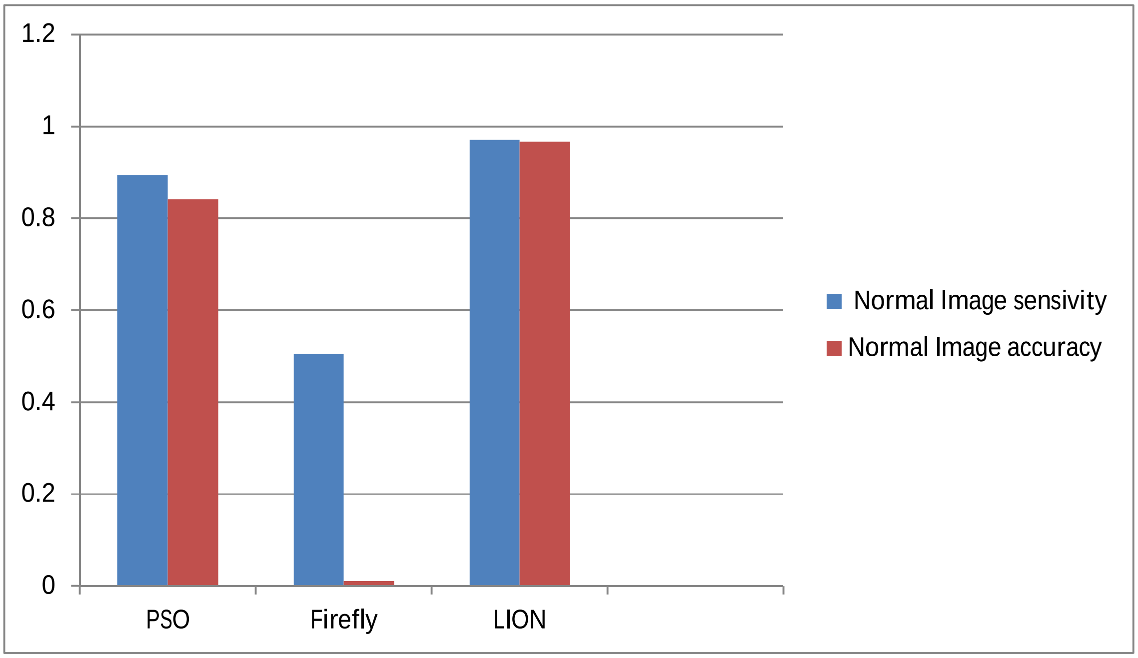


Fig. 7: Graph for normal image accuracy and sensitivity values for PSO, Firefly and LION algorithm

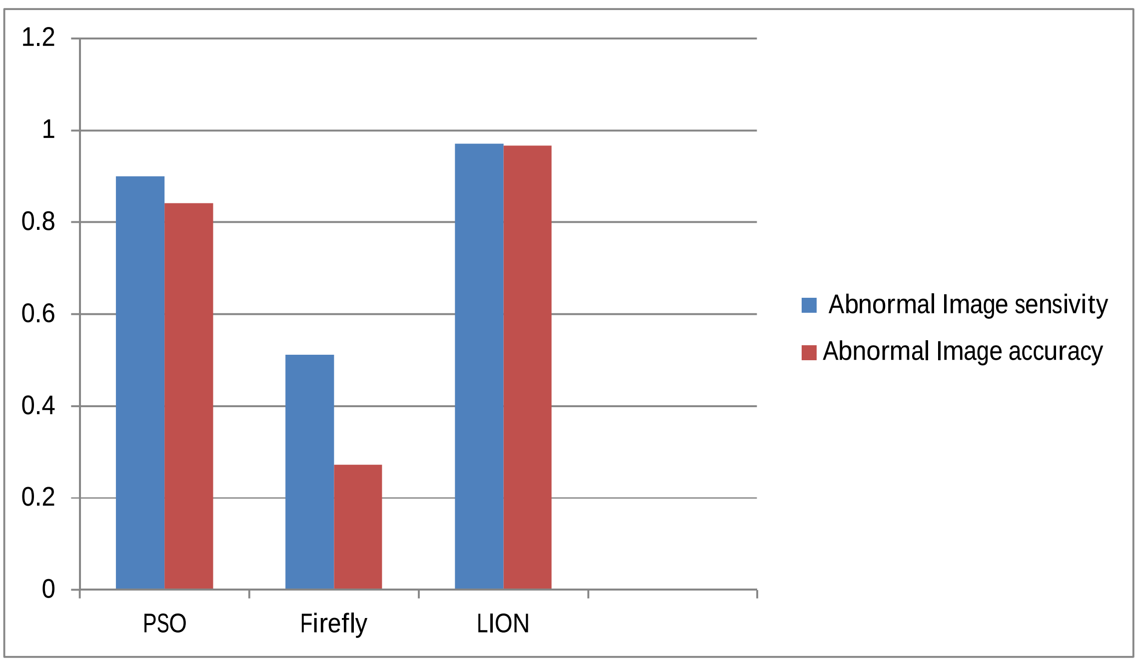


Fig. 8: Graph for normal image accuracy and sensitivity values for PSO, Firefly and LION algorithm

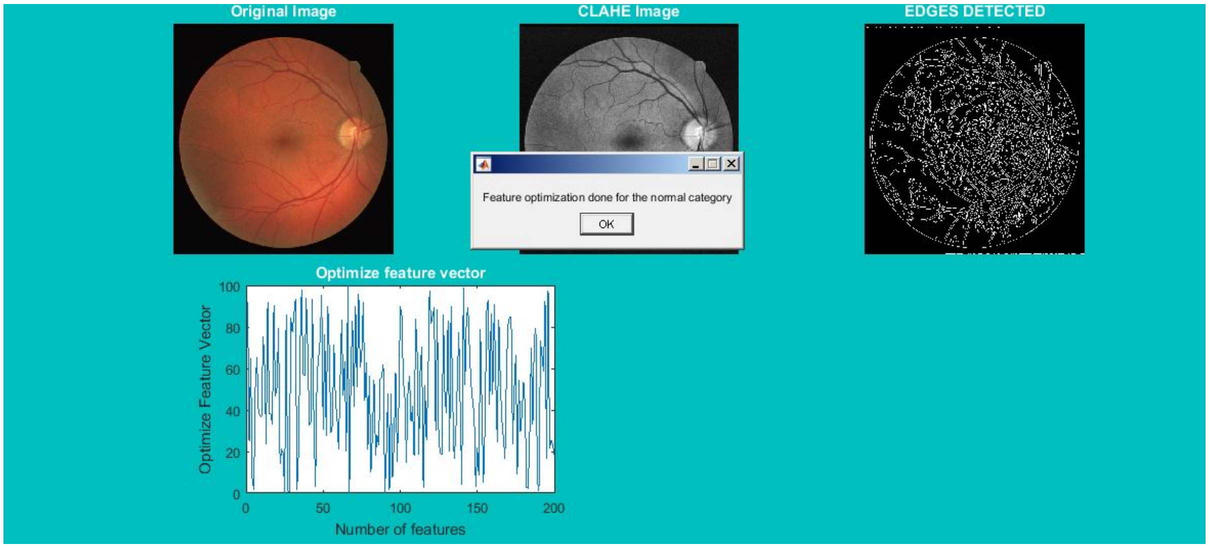


Fig. 9: Normal image Feature optimized using Firefly

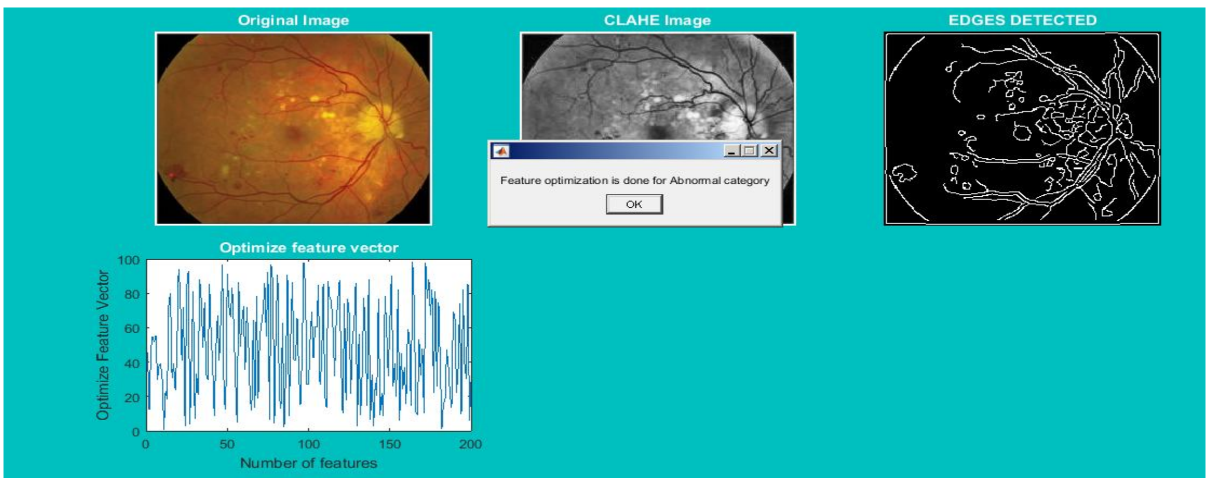


Fig. 10: Abnormal image Feature optimized using Firefly

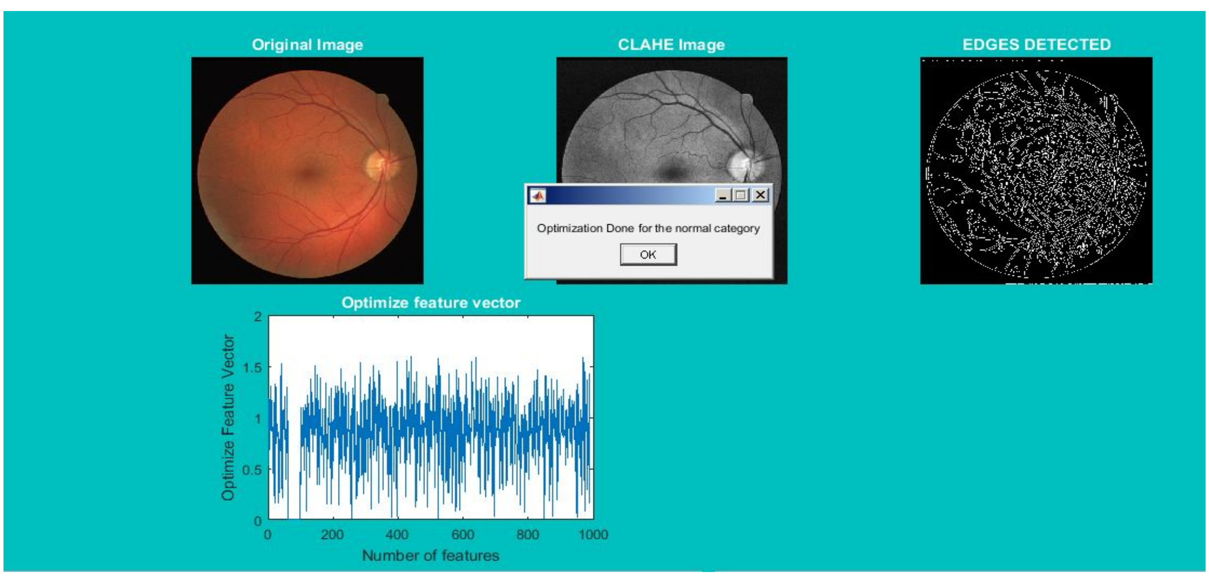


Fig. 11: Normal image Feature optimized using LION

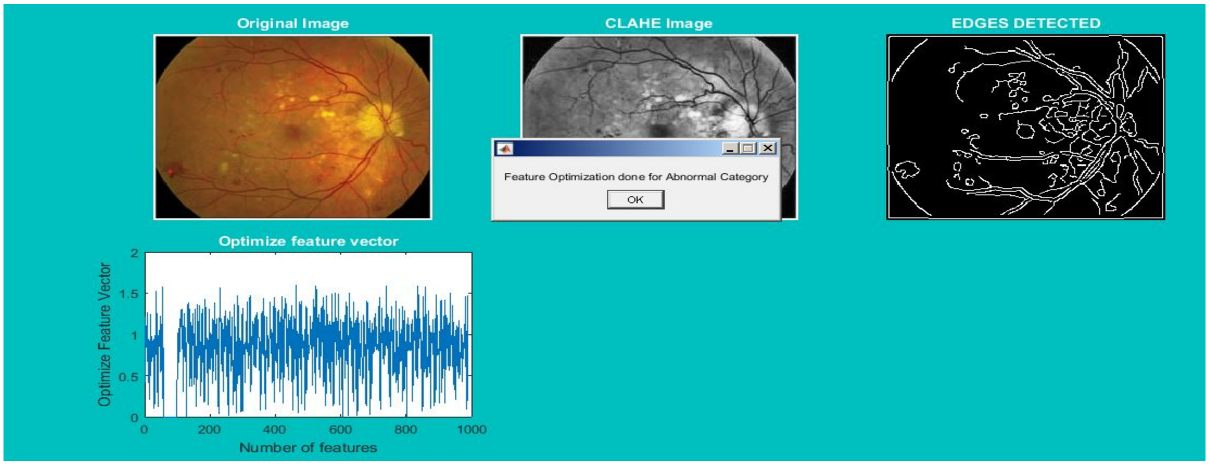


Fig. 12: Abnormal image Feature optimized using LION

After the feature optimization process, the test images will be classified as normal and abnormal images using classification process using Support Vector Machine and performance will be evaluated.

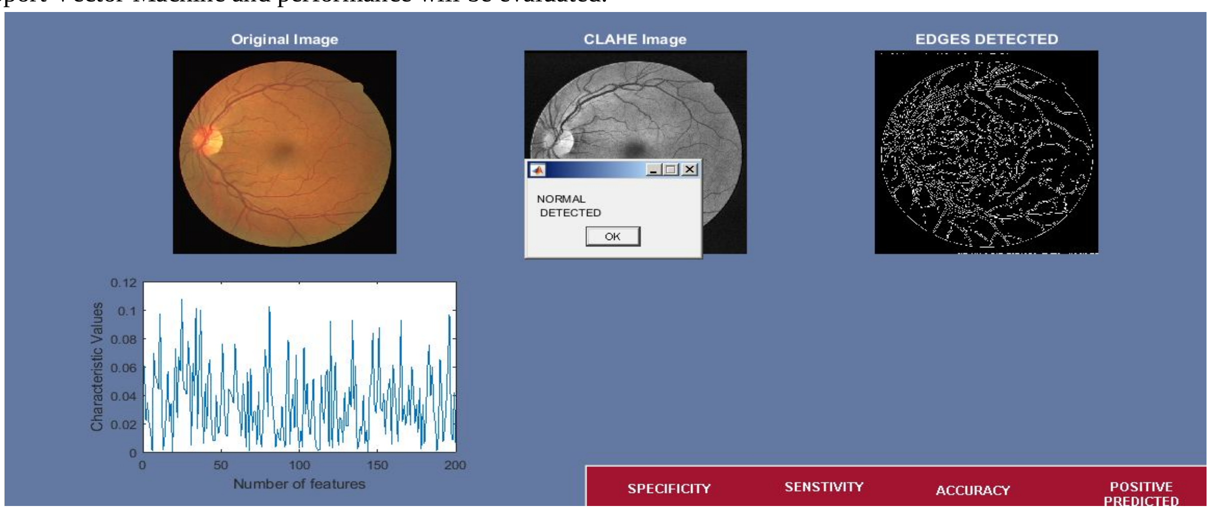


Fig. 13: Classification as Normal images using Support Vector Machine classifier

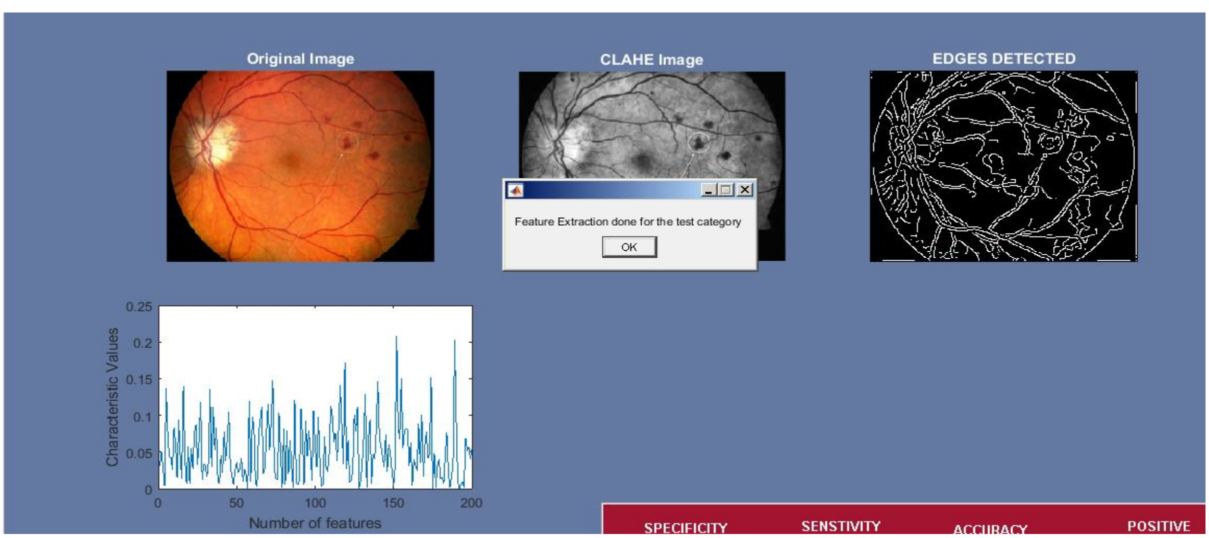


Fig. 14: Feature extraction for test category

Table3: This table shows the simulation results for normal images using PSO, Firefly & LION

Optimization Technique	Normal image			
	Entropy	Min Pixel	Max Pixel	Intensity
PSO	4.3503	6.6575	1.1864e-08	1.1958
Firefly	0.21671	99.6169	0	49.0256
LION	5.7983	1.594	0	0.83621

Table 4: This table shows the simulation results for abnormal images using PSO, Firefly & LION

Optimization Technique	Abnormal image			
	Entropy	Min Pixel	Max Pixel	Intensity
PSO	4.1779	7.4099	6.3473e-05	1.263
Firefly	0.045415	98.2905	0.97855	47.7536
LION	5.7538	1.6008	0	0.8276

The above shown Table3 and Table4 gives result of PSO, Firefly and Lion algorithms in terms of Entropy, Min Pixel, Max Pixel and intensity for both normal and abnormal images.

VII. CONCLUSION

There are large range of algorithms available that have been used by different researchers for diabetic retinopathy. In our case we have used PSO, Firefly and LION evolutionary algorithms to optimize the extracted features. In the first step the image has been uploaded that will go through different pre-processing steps. We have used DRIVE dataset and all data sets contain both redundant and useful data. The images will be pre-processed using CLAHE algorithm and edges are detected by performing segmentation. The features of images are extracted using PCA algorithm for both normal and abnormal images. The use of redundant data will reduce the success rate of getting the output thats why our main motive is to use accurate data. The normal images are those that don't have symptoms of diabetic retinopathy and non vessels or abnormal images are vice a versa. The extracted features are optimized by applying different optimization algorithms. We have used MATLAB and analyzed results in terms of sensitivity, Specificity, Accuracy, Positive and false positive predicted rate. The accuracy of LION optimization for normal and abnormal images is 0.96691, 0.9672 respectively which is 13.06% better than Particle swarm optimization and 98.95% better than Firefly in case of normal images. The sensitivity results for normal and abnormal images for using LION is 0.97106, 0.97128 which is 8% better then particle swarm optimization and 47.98% from firefly for normal images. The simulation results show that LION is better in terms of accuracy, sensitivity, entropy, etc., as compared to other optimization methods for both normal and abnormal set of images. In future we will work on hybrid approach that will help in getting more optimized and accurate results.

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