CHAPTER III

SEGMENTATION OF RETINAL IMAGES
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3.1 INTRODUCTION
Assessment of characteristics of optic disk (OD), Microanysrms, exudates and blood vessel plays a vital role in clinical analysis. For these the task measurements of OD parameters including cup region, disc region, blood vessel thickness of most important vessel and branch vessel and vein diameter, exudates region, exudates perimeter, Microanysrms measurements are executed in this study. Blood vessel extraction is an important factor while investigating computerized screening structures for DR. Changes of retinal vessel cause visible impairments or permanent blindness. An automatic clinical decision system is designed to identify the retinal images as normal or abnormal. The capabilities which are being considered for category of retinal image in this study include OD measurements, blood vessel thickness, exudates place, exudates perimeter, Microanysrms measurements and vein diameter measurement. The various functions of retinal images are predicted in this research for normal and abnormal retinal images. The extracted capabilities are in addition fed into the different Artificial Neural Network classifiers for class of retinal image as normal or abnormal. End results are correlated with blood sample values of the same patients. Finally, this research gives the analysis for finding eye diseases in terms of the blood sample values. The proposed work can provide second important factor for medical image analysis.

3.2 DEVELOPMENT OF RETINAL DISEASE IDENTIFICATION SUPPORT SYSTEM (RDISS)
Retinal Disease Identification Support System (RDISS) is designed with six high focus area for its implementation to categories the retinal images is normal or abnormal.

They are:-

a) General pre-processing strategies consisting of
Image acquisition and digitization
Image denoising and enhancement
b) Segmentation and feature extraction
   RGB segmentation
   Exudates extraction
   Microaneurysms
   OD measurements
   Measurement of Blood vessel thickness
   Vein diameter
c) Classification
   SVM classifier
d) Comparing Classification result with blood sample values
e) Analysis for eye diseases in terms of the blood sample values

The proposed Block diagram of Retinal Disease Identification Support System (RDISS) for classifying of diabetic and retinal illnesses is displayed in Figure 3.1. This signifies Image Pre-processing, Segmentation, Feature Extraction, Classification, assessment and study. In the development of Retinal Disease Identification Support System, the analysis of DR detection relies upon at the regions of interest that are noisy in nature. To keep the image fine, highlighting picture functions and suppressing the noise. The image denoising and enhancement may be required. Noise now not only reduces the image quality and also causes feature extraction, analysis and recognition algorithms to be unreliable. Image enhancement Adaptive Histogram Equalizations is used for image enhancement.

In this, images RGB primarily based thresholding method is used for segmentation. The features extracted are OD, blood vessel thickness, Exudates extraction, Microaneurysms and vein diameter measurements. The capabilities of measurements are performed each for normal and abnormal retinal images. Further the extracted capabilities are fed to the classifier. Different ANN classifiers are used; out of which SVM classifier gives the good accuracy. Next step is comparing classifier outcomes with blood sample values.

The figure 3.1 indicates the block diagram of proposed work of extraction of diabetic and eye diseases from the retinal images using image processing set of rules. The figure 3.2 represents the layout of the work.
3.2.1 Block Diagram for Proposed Method

![Block Diagram for Proposed Method]

**Figure 3.1: Block Diagram for Proposed Method**
3.2.2 System Design

Figure 3.2: Lay Out of the Proposal
Following steps and methods are used in this research:

**Step 1.** Collecting retinal images from the hospital.

**Step 2.** Removing the noise of all this images using proposed filter.

**Step 3.** Feature extraction using image processing algorithms. They are

- **Blood Vessels**: Modified Kirsch’s operators are used.
- **Exudates**: Modified Fuzzy clustering algorithm.
- **Microaneurysms**: Improved Morphological distance based algorithm.
- **Optic Discs**: Combination of Watershed algorithm and Morphological operations.

**Step 4.** Creating GUI flat form using Matlab & Displaying results in GUI platform and Classification of retinal images.

**Step 5.** Comparing results with their blood sample values.

**Step 6.** Corresponding treatment.

Based on the literature survey the above algorithms are given best performance than other algorithms. This can be justified in the feature extraction stage based on the performance parameters of all the algorithms.

3.3. FUNDUS CAMERA

This is fundus digital camera. Retinal fundus image is the favored diagnostic model that is non-invasive, reliable, smooth and user friendly. In the standard ophthalmoscope, it permits to file analytical records and permit the professional session later, and the retinal fundus images result are very important with higher sensitivity and detection rate of abnormal retinal capabilities.

The virtual colour fundus pictures required for the investigation of automatic device for DR detection are provided with the aid of the government Eye Hospital, Guntur. The photographs are captured by using a ZEISS STRATUS OCT, Modern 3000 fundus digital camera. A changed virtual returned unit (Sony 3CCD colour video camera) is hooked up to the fundus digital camera to transform the fundus photo right into a virtual photograph. The digital snap shots are processed and saved on the hard drive of a Windows primarily based computer with a decision of 768 x 576 in 24 bit JPEG layout. This consists of eight-bits of (RGB) Red, Green and Blue layers with 256 pixels in every picture. The photographs are connected to the affected person information using the Visupac software, which is a patient database. The images are
typically acquired from the posterior poles view which includes the OD and Microaneurysms. The total one hundred ten photographs are captured by using the ophthalmoscope and are considered for checking out the machine after consulting with a professional ophthalmologist. Figure 3.3 indicates the image representation of the association of fundus digital camera taken from internet source.

Figure 3.3: Fundus Camera

3.4. IMAGE PRE-PROCESSING
The initial stage in retinal classification method is the image pre-processing. It is a significant stage in picture of the retina image evaluating the image version by standardizing the authentic image with a reference version. It enables in lowering the intra picture in addition to inter photo variability. When images are taken, the Pre-processing stage corrects the problem of illumination. Here image pre-processing can be done by using so many different kinds of filters. They are illustrated and also as compared with the overall performance of all the filters with the parameter together with (SNR), (RMSE), (PSNR) and (SI).
3.4.1 Noise Models

Unwanted information which may additionally reduce the evaluation of imaging system suffers from a common problem of “Noise”. Unwanted information which may additionally reduce the evaluation failing the form or size of items within the photo and edges are blurring or dilution of excellent information inside the picture can be termed as noise. It could be because of one or more of following causes.

a) Physical nature of the machine.
   B) Shortcoming of photograph acquisition systems.
   C) Image developing mechanism.
   D) Due to surroundings.

3.4.2 Types of Noises

3.4.2.1 Impulse Noise

In general terms, Impulse Noise (IN) may be defined as intensity rate of a single pixel, corrupted by way of any approach and the rate of signal pixel may be darkish or vibrant spots that aren't true imagery. Impulse noise may also corrupt any sign along with virtual photographs just because of occasional inversion of a single bit representing the depth value in some pixel. Figure 3.4 indicates the Graphical Representation of Impulsive Noise by John Wiley & Sons [80].

The general version of impulse noise is

\[ g(x, y) = \begin{cases} p_n \eta(x, y) & \text{if} \ f(x, y) = 1 \\ 1 - p_n \ f(x, y) & \text{else} \end{cases} \]

Where, \( p_n \) is the probability of distortion,

\[ \eta = 100 \text{ in percents is called the corruption rate,} \]

Noise Gray level at location x,y.

This equations are referred from image processing hand book by Divya .B.S and Nanjundaswamy.H.R.[81]
Impulse Noise (IN) may divide into 2 categories such as:

- **S& P Noise (S&PN).**
- **R V I Noise (RVIN).**

### 3.4.2.2. S &P Noise Model (SPN)

It is referred as meagre noise, impulse noise or confounds noise that is typically because of defective reminiscence locations, broken pixel factors within the digital camera sensors, with timing mistakes within the process of computerization. This degradation can be resulting from sharp, surprising disturbances inside the picture signal, its form is accidentally dispersed into either pixels over the photograph. The A and B are the probability less than 0.2, are the handiest two expected values existing in the S&P noise. The noise will trade out picture, If the number is more than this number. The critical value for 255 for S&P noise is zero for 8-bit photo, the S&P impulse noise replaces the intensity values in the photo by 0s and 255s with some positive possibilities.

\[
g(x, y) = \begin{cases} 
p_0 & 0 
p_{255} & 255 
1 - [p_0 + p_{255}] & f(x, y)
\end{cases}
\]

Since 0 is black and 255 is white, a corrupted image is included by way of white and black impulses (“S & P”).

This above equations are referred from image processing hand book by Divya .B.S and Nanjundaswamy.H.R.[81].

Causes for S&P Noise:

- Malfunction of the memory cell.
Camera’s sensor cells faults

3.4.2.3 Random Value Impulse Noise (RVIN)
It is also called as uniform noise is a sort of noise wherein pixel rate can be closer to the neighbouring pixel value. RVIN is harder to remove and detect because of its characteristics. Random impulse noise replaces the depth values within the photo \( f(x,y) \) by means of uniformly dispensed random numbers with some certain opportunity.

\[
g(x, y) = \begin{cases} 
p_n & \eta(x, y) = \text{random}[\eta_{\text{min}}, \eta_{\text{max}}] \\ 1 - p_n & \end{cases} \quad \text{----- 3}
\]

\( \eta_{\text{min}}, \eta_{\text{max}} \) are min and max intensities of impulses

This equations are referred from image processing hand book by Divya .B.S and Nanjundaswamy.H.R.[81].

3.4.3. FILTERS
In the automatic retinal disease diagnostic system, the pre-requisite level is the first stage. It consists of strategies such as enhancement, grey/green thing, denoising of image and so on. In case of a binary image, white pixels are commonly considered to constitute the prior level regions and after level region representing the black pixels.

In a grey scale picture, the height of the base plane indicates intensity of the image. Hence, the surface in three dimensional Euclidean spaces is indicated in the gray scale image.

The unwanted signal (noise) which appears into the retinal fundus picture is removed by using the filters.

The following filters are used in the pre-processing stage.

3.4.3.1. Mean Filter
The corrupted image \( g(x,y) \) in the area is defined by \( s_{xy} \) in the mean value in the computing filtering process.

The centered point \((x,y)\) in the image is represented by Let, \( \hat{f}(x,y) \) to the set rectangular sub image window of size \( m \times n \).

\[
\hat{f}(x, y) = \frac{1}{mn} \sum_{(s,t)\in s_{xy}} g(s, t) \quad \text{-------- 4}
\]

Where \( \hat{f}(x, y) \) = recovered image
\[ g(x,y) = \text{corrupted image} \]

This equations are referred from image processing hand book by Divya .B.S and Nanjundaswamy.H.R.[81].

The algorithm has the following steps are given.

1. **Step 1:** Digital input fundus image of two dimensional window of length 3x3 is taken from the corrupted input image.
2. **Step 2:** The above matrix is padded with zeros
3. **Step 3:** Consider the window of size 3 x 3. Start from matrix (1,1), vicinity the window
4. **Step 4:** Add all the elements and divide from nine ie, the entire wide variety of elements in matrix.
5. **Step 5:** After calculating, the output matrix is changed by the calculated value at (2, 2) Pixel role. The yield pixel worth is observed by using the usage of the mean of the neighborhood pixels.
6. **Step 6:** The method is repeated for all of the values inside the input matrix by way of sliding the Window to next role i.e. (1, 2) and shortly.

The input Image to the mean filter is displayed in Figure 3.5 (a) where the retinal fundus image is processed to delete the randomly occurring noise. The green component is extracted because the red and the blue band are noisy and green band gives the best contrast which is required for the blood vessel feature segmentation, to show how the mean filter is not much effective in removing noise that is auxiliary to the input image and passed through the mean filter and the output image from the RGB input image is as shown in Figure 3.5 (b).

![Figure 3.5 (a): Original Image](image1.png) ![Figure 3.5 (b): Output of Mean Filter](image2.png)
3.4.3.2. Median Filter

The nonlinear method of Median filtering is found used to delete the noise from the images. Which is widely considered and effective in removing noise S&P kind, during the edges are preserved. The neighborhood of that pixel is replaced by the Median filter with the value of center pixel of the neighborhood by the median of the gray levels.

\[ \hat{f}(x,y) = \text{median}_{(s,t)\in S_{xy}}[g(s,t)] \] 5

Where  
\( \hat{f}(x,y) \) = Recovered image  
\( g(s,t) \) = Noisy image  
\( S_{xy} \) = at the point(x,y), the sub-image window of length m x n is centered

This equations are referred from image processing hand book by Divya .B.S and Nanjundaswamy.H.R.[81].

The Subsequent phases for the algorithm are given below:

Step 1: Digital input fundus image of two dimensional window of length 3x3 is taken from the corrupted input image.

Step 2: The above matrix is padded with zeros.

Step 3: Consider the window of size 3 by 3. Start from matrix (1,1), place the Window.

Step 4: Sort the window matrix elements in ascending order.

Step 5: Using the median of the neighborhood pixels, the output matrix is replaced by the middle value at (2, 2) pixel position of the value of output pixel is found .

Step 6: The procedure is repeated for all the values in the input matrix by Sliding the window to next position i.e. (1, 2) and soon.

It is commonly used to delete the noise. Figure 3.6 (a) is the input Retinal Fundus Image ,after passing through the median filter the output image is as exposed in Fig.3.6 (b) is the virtual outcome of the algorithm in Matlab. The simulation is done in Matlab because image reading is easy by using the imread instruction but in other language the image reading only is done by using more instruction. This is the reason for using Matlab.
3.4.3.3. Improved Median Filter

Pre-processing stage will remove the noise (errors) cause during image taking and to reduced brightness effects on the image. In the Images the green bands gives blood vessel structure most effectively. Hence, the image green band was extracted.

The mathematical expressions for improved median filter are as follows:

\[
\hat{f}(x,y) = \begin{cases} 
  g(x,y) , & \text{gmin}>0, \text{gmax}<255 \\
  \text{gmed} , & 0<\text{gmed}<255 \\
  V_{\text{dmax}} , & \text{otherwise.}
\end{cases}
\]

Where, \(\hat{f}(x,y)\) = Recovered image  
\(g(x,y)\) = Noisy image

This equations are referred from Youlian Zhu ,Cheng Huang[2012][82].

**Algorithm Flow:**

Step 1: Consider a digital input fundus image and pad it with zero’s
Step 2: Consider a 3X3 matrix
Step 3: Sort the matrix in ascending order and calculate v0, \(p_{\text{mid}}\), \(p_{\text{max}}\) and \(p_{\text{min}}\)
Step 4: \(p_{\text{min}}\)\(<p(x,y)<p_{\text{max}}\) and \(p_{\text{min}}>0\), \(p_{\text{max}}<255\)  
If the condition is satisfied then it is uncorrupted image, consider the next 3X3 matrix and continue otherwise
Step 5: \(p_{\text{min}}\)\(<p(x,y)<p_{\text{max}}\) and \(0<p_{\text{med}}<255\)  
If the condition is satisfied, replace \(p(x,y)\) with \(p_{\text{mid}}\) otherwise, find \(V_{d}\) and replace \(V_{d_{\text{max}}}\) by \(p(x,y)\)
1) Input image

```
1 2 3 4
5 6 7 8
9 9 8 7
6 5 4 3
```

2) Zero padding

```
0 0 0 0 0 0
0 1 2 3 4 0
0 5 6 7 8 0
0 9 9 8 7 0
0 6 5 4 3 0
0 0 0 0 0 0
```

3) Consider a sorted 3X3 matrix as follows

```
0 0 0
0 0 1
2 5 6
```

4) \(V_o=\{0,0,0,0,1,2,5,6\}\) and \(p_{med}=0, p_{min}=0, p_{max}=6\)

5) \(p_{min} < P_{[x,y]} < p_{max}\), \(p_{min} > 0, p_{max} < 255\).

\[
0 < 1 < 6, 0 > 0, 6 < 255 \Rightarrow \text{corrupted}
\]

6) \(p_{min} < p_{med} < p_{max}\) and \(0 < p_{med} < 255\).

\[
0 < 1 < 6 \quad \text{and} \quad 0 < 0 < 255 \Rightarrow \text{changed pixel } P_{[x,y]}
\]

7) \(V_d=\{0,0,0,0,1,1,3,1\}\). \(V_d_{max}=3\), replace the \(P_{[x,y]}\) by \(V_d_{max}\) in the image

8) Repeat the steps from 3 for each pixel in entire image.

The above filter is commonly used for removing the noise Fig. 3.7 (a) is the input Retinal Fundus Image. After passing through the improved median filter, the output image is as displayed in Fig. 3.7 (b).
3.4.3.4. Proposed Filter

Proposed filter consists of the below equations. The Median filter performance after removing the S&P noise is superior to the Mean filter. The median filter technique produces blurred image, losing the image details and smooth image sharpness, with the outcome enhanced. During the denoising procedure, it require a filter which to remove the mixed noise to produce a better quality image with less loss of value of information of the image. The mathematical expressions are as shown below:

\[
\hat{f}(x, y) = \frac{1}{mn} \sum_{(s,t) \in S} g(s, t) \quad ------------------ 7
\]

\[
\hat{h}(x, y) = \frac{\text{median}\{\hat{f}(x, y)\}}{(s,t) \in S} \quad ------------------ 8
\]

\[
\begin{aligned}
\hat{I}(x, y) &= \hat{h}(x, y) , & h_{\text{min}} > 0, h_{\text{max}} < 255 \\
&= \text{h}_{\text{med}} , & 0 < \text{h}_{\text{med}} < 255 \\
&= V_{d_{\text{max}}} , & \text{otherwise}
\end{aligned}
\quad ------------------ 9
\]

\[
\hat{k}(x, y) = \frac{mn}{\sum_{(s,t) \in S} \frac{1}{\hat{I}(x, y)}} \quad ------------------ 10
\]

Where \( g(s,t) \) = Noise image,

\( \hat{f}(x, y) \) = Output image of equation 7,

\( \hat{h}(x, y) \) = Output image of equation 8,

\( \hat{I}(x, y) \) = Output image of equation 9,

\( \hat{k}(x, y) \) = Proposed filter output image.
Strategy levels for designing proposed filter:
- A RGB retinal image is considered for experimental use.
- The gray scale image is converted into RGB retinal image
- The above input image is added to the mixed noise.
- First the above mixed noise image is filtered by equation 7.
- The above output image is filtered by mid value of the images given in equation 8.
- The average value of all over the image given in equation 10 is the output image of each pixel value.
- Hence the above image is converted into color image. The De-noised image is found to be a gray image.
- The De-noised image is the final output.

Output Results:

![Input retinal Image](image1)

![Output of the proposed Filter](image2)

Figure 3.8 (a): Input retinal Image  Figure 3.8 (b): Output of the proposed Filter

The above proposed filter is used for removing the noise Fig. 3.8 (a) is the input Retinal Fundus Image. After passing through the proposed filter, the output image is as displayed in Fig. 3.8 (b).

3.4.4. PARAMETERS FOR EVALUATION

The filter performance can be calculated by using different types of parameters like SNR, MSE, SI, RMSE and PSNR.

3.4.4.1 MSE

It determines the mean value of the squares of the errors indicating the distinction between the calculated and expected value. Randomness is the pre-dominant cause of the difference. Given a noise free image is \( \hat{f}(x,y) \) and it’s noisy approximation is \( J(a,b) \), Mean Square Error is represented as in formula is given below:
\[ MSE = \frac{1}{xy} \sum_{a=0}^{x-1} \sum_{b=0}^{y-1} [\hat{k}(a, b) - J(a, b)]^2 \]  

The above equation is referred from Alain Hore, Diemel Zion [2010][83].

The original retinal image and filtered image received via specific filtering strategies are proven in Figures 3.5 to 3.8. The RMSE, SNR, SSIM, MSE and PSNR values of image filtered by 5 unique varieties of filters is displayed in Tables from 1 to 5. MSE of results of all the filters are illustrated in the table 1 and also represented in the graphical way.

**Table 1: Noise Variances Vs MSE of Different Filters**

<table>
<thead>
<tr>
<th>Noise Variance</th>
<th>MSE Mean filter</th>
<th>MSE Median filter</th>
<th>MSE Improved Median filter</th>
<th>MSE Proposed filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>5.05e+4</td>
<td>5.21e+4</td>
<td>5.805e+4</td>
<td>4.955e+4</td>
</tr>
<tr>
<td>0.002</td>
<td>5.23e+4</td>
<td>5.48e+4</td>
<td>6.008e+4</td>
<td>5.02e+4</td>
</tr>
<tr>
<td>0.003</td>
<td>5.18e+4</td>
<td>5.62e+4</td>
<td>6.27e+4</td>
<td>5.067e+4</td>
</tr>
<tr>
<td>0.004</td>
<td>5.24e+4</td>
<td>5.71e+4</td>
<td>6.45e+4</td>
<td>5.099e+4</td>
</tr>
<tr>
<td>0.005</td>
<td>5.26e+4</td>
<td>5.77e+4</td>
<td>6.68e+4</td>
<td>5.12e+4</td>
</tr>
<tr>
<td>0.006</td>
<td>5.31e+4</td>
<td>5.89e+4</td>
<td>6.77e+4</td>
<td>5.14e+4</td>
</tr>
<tr>
<td>0.007</td>
<td>5.34e+4</td>
<td>5.97e+4</td>
<td>6.92e+4</td>
<td>5.155e+4</td>
</tr>
<tr>
<td>0.008</td>
<td>5.38e+4</td>
<td>6.06e+4</td>
<td>7.09e+4</td>
<td>5.17e+4</td>
</tr>
<tr>
<td>0.009</td>
<td>5.43e+4</td>
<td>6.11e+4</td>
<td>7.25e+4</td>
<td>5.176e+4</td>
</tr>
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<td>0.02</td>
<td>5.73e+4</td>
<td>6.71e+4</td>
<td>9.023e+4</td>
<td>5.35e+4</td>
</tr>
</tbody>
</table>
According to Table 1, in this work mixed noise is applied on JPEG file format using different types of filter Algorithm. A Noise Variance comparison is done on the basis of performance parameter MSE (Mean Square Error). Based on the values from the table 1 plotted the graph noise variance vs all different filters. Each one differentiated with different colors in the graph. It can be observed in the graph all the noise variance points of MSE value is small i.e. smaller value gives better noise removal results. It concludes that proposed filter gives better results compared to all other filter.

3.4.4.2 PSNR

It is a extensive time period for the ratio among most viable strength of a signal and corrupting noise’s power that affects its representation. Logarithmic decibel scale is used for expressing the PSNR because of the wide dynamic variety of the signals. PSNR is commonly used to compute the pleasant of recovery of the corrupted noisy images. Greater value of PSNR shows better satisfactory of the reconstituted photograph in most of the cases. It is defined thru MSE (mean Squared errors). PSNR is represented in terms of dB as written by equation:

$$PSNR = 10 \log \left( \frac{\text{max}^2}{\text{MSE}} \right)$$

The above equation is referred from Alain Hore, Diemel Zion[2010][83].
Where, MaxI is the image maximum pixel value. MaxI value is 255 when 8 bits per sample are used to represent the pixels. Noise absence case I and J images are same and MSE is zero in this example.

PSNR of all the filters results is illustrated in the table and also represented in graphical way.

Table 2: Noise Variances Vs PSNR of Different Filters

<table>
<thead>
<tr>
<th>Noise Variance</th>
<th>Mean filter (db)</th>
<th>Median filter (db)</th>
<th>Improved Median filter (db)</th>
<th>Proposed filter (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>28.72</td>
<td>27.20</td>
<td>24.81</td>
<td>29.24</td>
</tr>
<tr>
<td>0.002</td>
<td>28.22</td>
<td>26.41</td>
<td>23.99</td>
<td>28.86</td>
</tr>
<tr>
<td>0.003</td>
<td>27.85</td>
<td>25.89</td>
<td>23.39</td>
<td>28.54</td>
</tr>
<tr>
<td>0.004</td>
<td>27.60</td>
<td>25.37</td>
<td>22.80</td>
<td>28.36</td>
</tr>
<tr>
<td>0.005</td>
<td>27.43</td>
<td>24.98</td>
<td>22.34</td>
<td>28.30</td>
</tr>
<tr>
<td>0.006</td>
<td>27.20</td>
<td>24.67</td>
<td>21.95</td>
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</tr>
<tr>
<td>0.007</td>
<td>27.01</td>
<td>24.31</td>
<td>21.50</td>
<td>28.04</td>
</tr>
<tr>
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<td>26.87</td>
<td>24.05</td>
<td>21.19</td>
<td>27.98</td>
</tr>
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<td>26.72</td>
<td>23.75</td>
<td>20.78</td>
<td>27.93</td>
</tr>
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<td>23.56</td>
<td>20.50</td>
<td>27.83</td>
</tr>
<tr>
<td>0.02</td>
<td>25.36</td>
<td>21.83</td>
<td>18.05</td>
<td>27.18</td>
</tr>
</tbody>
</table>

Figure 3.10: Graphical Representation of Noise Variances Vs PSNR of Different Filters

According to Table 2, in this work mixed noise is applied on JPEG file format using different types of filter Algorithm. A Noise Variance comparison is done on the basis
of performance parameter PSNR(Peak Signal to Noise Ratio). Based on the values from the table plotted the graph Noise variance vs all different filters. Each one differentiated with different colors in the graph. It can be observed from the graph all the noise variance points of PSNR value is HIGH i.e. higher value gives better noise removal results. It concludes that proposed filter gives better results compared to all other filter.

3.4.4.3 Images Similarity Index (ISMI):
To calculate the resemblance among the two images. The picture eminence depends on a noise-free image is measured by ISMI.

\[
ISMI = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}
\]

\(\mu_x\) is the average of \(x'\)
\(\mu_y\) is the average of \(y'\)
\(\sigma_x^2\) the variance of \(x\)
\(\sigma_y^2\) is the variance of \(y\)
\(\sigma_{xy}\) the covariance of \(x\) and \(y\)

\(C_1 = (k_1L)^2\) and \(C_2 = (k_2L)^2\) are values used to alleviate the division with weak denominator.

\(L\) = the pixel dynamic range value.
\(k_1 = 0.01\) and \(k_2 = 0.03\) are the default values.

The range of ISMI is between -1 and 1, and if value is 1 then both images are identical.

The above equation is referred from Alain Hore, Diemel Zion[2010][83].

ISMI of all the filters results is illustrated in the table and also represented in graphical way.
Table 3: Noise Variances Vs ISMI of Different Filters

<table>
<thead>
<tr>
<th>Noise Variance</th>
<th>ISMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean filter</td>
</tr>
<tr>
<td>0.001</td>
<td>0.77</td>
</tr>
<tr>
<td>0.002</td>
<td>0.75</td>
</tr>
<tr>
<td>0.003</td>
<td>0.73</td>
</tr>
<tr>
<td>0.004</td>
<td>0.72</td>
</tr>
<tr>
<td>0.005</td>
<td>0.71</td>
</tr>
<tr>
<td>0.006</td>
<td>0.69</td>
</tr>
<tr>
<td>0.007</td>
<td>0.68</td>
</tr>
<tr>
<td>0.008</td>
<td>0.67</td>
</tr>
<tr>
<td>0.009</td>
<td>0.66</td>
</tr>
<tr>
<td>0.01</td>
<td>0.65</td>
</tr>
<tr>
<td>0.02</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Figure 3.11: Graphical Representation of Noise Variances Vs ISMI of Different Filters

According to Table 3, in this work mixed noise is applied on JPEG file format using different types of filter Algorithm. A Noise Variance comparison is done on the basis of performance parameter ISMI(Image Similarity Index). Based on the values from the table 3 plotted the graph Noise variance vs all different filters. Each one differentiated with different colors in the graph. It can be observed from the graph all the noise variance points of ISMI value is HIGH i.e. higher value gives more similarity between original and resultant image. It concludes that proposed filter gives better results compared to all other filter.
3.4.4.4 SNR

It is the ratio between a noise and the signal. The value is low gives better noise removal.

\[
SNR = \frac{P_{signal}}{P_{noise}}
\]

The above equation is referred from Alain Hore, Diemel Zion[2010][83].

SNR of all the filters results is illustrated in the table and also represented in graphical way.

**Table 4: Noise Variances Vs SNR of Different Filters**

<table>
<thead>
<tr>
<th>Noise Variance</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>filter (db)</td>
</tr>
<tr>
<td>0.001</td>
<td>26.77</td>
</tr>
<tr>
<td>0.002</td>
<td>26.28</td>
</tr>
<tr>
<td>0.003</td>
<td>25.91</td>
</tr>
<tr>
<td>0.004</td>
<td>25.65</td>
</tr>
<tr>
<td>0.005</td>
<td>25.49</td>
</tr>
<tr>
<td>0.006</td>
<td>25.26</td>
</tr>
<tr>
<td>0.007</td>
<td>25.07</td>
</tr>
<tr>
<td>0.008</td>
<td>24.92</td>
</tr>
<tr>
<td>0.009</td>
<td>24.78</td>
</tr>
<tr>
<td>0.01</td>
<td>24.62</td>
</tr>
<tr>
<td>0.02</td>
<td>23.42</td>
</tr>
</tbody>
</table>

**Figure 3.12: Graphical Representation of Noise Variances Vs SNR of Different Filters**

According to Table 4, in this work mixed noise is applied on JPEG file format using different types of filter Algorithm. A Noise Variance comparison is done on the basis
of performance parameter SNR(Signal to Noise Ratio). Based on the values from the table 4 plotted the graph Noise variance vs all different filters. Each one differentiated with different colors in the graph. It can be observed from the graph all the noise variance points of SNR value is HIGH i.e. higher value gives better noise removal. It concludes that proposed filter gives better results compared to all other filter.

3.4.4.5 RMSE
The variations between value expected by using a version or an estimator and the values sincerely determined is measured. The square root of mean rectangular error is found extremely far. It should be very low possible.

\[
\text{RMSE} = \sqrt{\text{MSE}} \quad \text{------------------ 14}
\]

The above equation is referred from Alain Hore, Diemel Zion[2010][83]. The smaller value of RMSE suggests the better enhancement technique however the excessive PSNR rates additionally suggests the higher noise removal. The original noisy photograph and filtered picture received by means of diverse filtering techniques are shown in Figure 3.5 to 3.8. Visual contrast of PSNR and RMSE of Gaussian noise and salt and pepper noise with recognize to mean filter out, Median filter out, advanced median clear out and proposed filter are proven in graphical representation in figures 3.9 to 3.13. Tables 6 to 9 display the RMSE and PSNR values of photograph filtered by 4 various types of filters. RMSE of all the filters results is illustrated inside the tables and also represented in graphical way.
Table 5: Noise Variances Vs RMSE of Different Filters

<table>
<thead>
<tr>
<th>Noise Variance</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean filter</td>
</tr>
<tr>
<td>0.001</td>
<td>6.72e+3</td>
</tr>
<tr>
<td>0.002</td>
<td>6.74e+3</td>
</tr>
<tr>
<td>0.003</td>
<td>6.77e+3</td>
</tr>
<tr>
<td>0.004</td>
<td>6.82e+3</td>
</tr>
<tr>
<td>0.005</td>
<td>6.84e+3</td>
</tr>
<tr>
<td>0.006</td>
<td>6.87e+3</td>
</tr>
<tr>
<td>0.007</td>
<td>6.89e+3</td>
</tr>
<tr>
<td>0.008</td>
<td>6.90e+3</td>
</tr>
<tr>
<td>0.009</td>
<td>6.92e+3</td>
</tr>
<tr>
<td>0.01</td>
<td>6.94e+3</td>
</tr>
<tr>
<td>0.02</td>
<td>7.16e+3</td>
</tr>
</tbody>
</table>

Figure 3.13: Graphical Representation of Noise Variances Vs RMSE of Different Filters
According to Table 5, in this work mixed noise is applied on JPEG file format using different types of filter Algorithm. A Noise Variance comparison is done on the basis of performance parameter RMSE(Root Mean Square Value). Based on the values from the table 5 plotted the graph Noise variance vs all different filters. Each one differentiated with different colors in the graph. It can be observed from the graph all the noise variance points of SNR value is HIGH i.e. higher value gives better noise removal. It concludes that proposed filter gives better results compared to all other filter.

When the mixed noise is added to the original image, The MSE and RMSE of the ensuing filters image is increased, decreasing the SNR, PSNR, SSIM of the subsequent filter image, displayed in 2 to 6 tables. The proposed filter has lower MSE compared to other filters is showcased in table -1. The improved median filter has highest MSE, whereas the Median filter has MSE close to the proposed filter. The proposed filter with the utmost PSNR compared to other filters, at all variances, is represented in the 2nd table. The improved median filter has lowest PSNR, whereas the Median filter has PSNR adjacent to proposed filter. The proposed filter with the highest SSIM is represented in table – 3. The improved median filter has lowest SSIM whereas the Median filter has SSIM near to the proposed filter. During all test cases the proposed filter has the utmost SNR compared to other filters. The Improved median has the meagre SNR. Information is provided in table – 4. In Table 5, proposed filter has the meagre RMSE during all the testing cases are proposed in the table – 5. The highest RMSE has the improved median filter.

To match among all filters, Graphs are plotted using the tables. The diamond shaped violet line indicates proposed filter, green line triangular shaped signifies IMEDF, red line square shaped represents MEDF and the blue line Hexagon shaped is used to indicate MF subsequently. The proposed filter has utmost value of PSNR, SSIM, SNR and meagre value of MSE, RMSE, is displayed in the graphs.

3.5 FEATURE EXTRACTION
Therefore, the four parameters found in the retinal images are:
**Blood Vessels:**
Blood vessels of a diabetic retinopathy patient undergo extra branching and these vessels go thinner and thinner or narrower.

**Exudates**
With varying sizes, shapes or patches, the Exudates are found to be hard white or in yellowish colour. The Exudates are found occurring, when the lipid or fat leaks from abnormal blood vessels.

**Microaneurysms**
The small red dots called Microaneurysms are the saccular pouches engendering in the local distension of capillary walls. Causes hemorrhages in the thin to rupture effortlessly.

**Optic discs**
The optic disk is the bright round section, where the blood vessels originate. The geometric round shape of the optic is irregular.

### 3.5.1 Blood Vessels Feature Extraction
The detection of blood vessel features from the retinal images is a tedious process. Kirsch edge detection algorithm used to extract the blood vessel of retinal image effectively has been proposed. Accurate detection of blood vessels from retina is a critical prospect in the systematic eye diseases diagnosing. Since the blood vessels are distributed in various directions, morphology processing with multi-directional structuring elements is used to import from the fundus images vessels.

#### 3.5.1.1 Original Kirsch's edge detection
The Kirsch's operator or Kirsch's compass kernel is non-linear part detection, analyzing the threshold power maximum in some pre-determined directions. The user opts for a single kernel mask and interchanges it in 45% degree increments thru all 8 compass instructions: N, E, S, W, NW, SW, SE, and NE.

The Kirsch's masks are defined as follows:
The Kirsch operator of the edge magnitude is calculated in the most magnitude across all guidelines. Area records for an exceptional pixel are received by revealing the brightness of pixels. At the factor with almost equal brightness, all the pixels within the neighborhood are found same. With huge associates, brighter than the others, is considered at that factor. Using a 3x3 table of pixels to shop a pixel and its buddies at the same time, calculating the derivative, the Kirsch's aspect detection has set rules.

The convolution table is known as 3x3 pixels indicated, with its actions amongst the photo in the convolution-fashion algorithm.

\[
N = \begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix} \quad W = \begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & 3 \\ -3 & -3 & -3 \end{bmatrix} \quad S = \begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 0 & 3 \end{bmatrix}
\]

\[
E = \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix} \quad NW = \begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}
\]

\[
SW = \begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \quad SW = \begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & 3 \end{bmatrix} \quad NE = \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix}
\]

**Figure 3.14:** 256 x 256 images with 3 x 3 neighborhood of pixels
The convolution table at 3 unique places of an image: the first characteristic (analyzed whether the pixel at [1, 1] is on a side), the last operation and at the placement to analyzed if or no longer the pixel at [i,j] is indicated in the picture 3.14.

<table>
<thead>
<tr>
<th>IMG[i-1,j-1]</th>
<th>IMG[i-1,j]</th>
<th>IMG[i-1,j+1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMG[i,j-1]</td>
<td>IMG [i,j]</td>
<td>IMG [i,j+1]</td>
</tr>
<tr>
<td>IMG [i+1,j-1]</td>
<td>IMG [i+1,j]</td>
<td>IMG [i+1,j+1]</td>
</tr>
</tbody>
</table>

**Figure 3.15: Table detecting edge at coordinate [i,j] with their contents.**

Its 8 neighbors are designated in the picture 3.15. The image is moved across the table, pixel by pixel. The convolution table will move through 64516 different locations is represented in the overhead picture is 256x256 pixel image. In the picture 3.16 both the presence of an edge and the direction of the edge as displayed. It is identified by the Kirsch's edge detection algorithm, with 8 directions such as N, NE, E, SE, S, SW, W, and NW.

<table>
<thead>
<tr>
<th>NE_SW orientation</th>
<th>N_S orientation</th>
<th>E_W orientation</th>
<th>NW_SE orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast 110</td>
<td>North 010</td>
<td>East 000</td>
<td>Northwest 100</td>
</tr>
<tr>
<td>Southwest 111</td>
<td>South 011</td>
<td>West 001</td>
<td>Southeast 101</td>
</tr>
</tbody>
</table>

**Figure 3.16: Eight directions with four demonstrations**

For each direction, Fig.3.16 represents a sampled image with the convolution table, and the encoding direction. The edge is represented in white color and direction in the
black arrow. Grouping the 8 directions into 4 orientations: NE_SW, N_S, E_W, and NW_SE. Computing the presence and direction of an edge is accomplished in ensuing steps:

The above algorithm is referred from Kirsch.R(1971)[84].

- Eight directions derivatives are calculated.
- The maximum derivative and values are found.

EdgeMaxma = Eight derivatives, maximum values.
DirectMaxma = EdgeMaxma direction.
- Maximum derivative should be checked in the threshold.

IfEdgeMaxma > 383
then ,Edge = Correct
Direct = DirectMaxma
Other wise
Edge=Wrong
Direct=000

3.5.1.2 PROPOSED METHOD
The proposed algorithm tries to minimize the processing time and to find limited edges. Hence, it uses above-mentioned Kirsch's six edge operators such as N, S, E, W, NW and SW. N and S help to detect the vertical lines, E and W help to detect the horizontal lines. NW and SW can detect the diagonal lines. NE and SE operators are avoided in the proposed work. The proposed method in the flow chart is displayed with the proposed algorithm expounded in the picture 3.17 below.

Algorithm Edge detect (image)
// choose Edge operators N, S, E, W, NW, SW
E_O [1: n] = IN, S, E, W, NW, SW
for i: =1 to n do
// convolute the image by the Edge operator
}
Edge[i] = image 0 E_O[i]
// Find the maximum value of the Edge image
M= max (Edge [i]) // Obtain the maximum intensity pixels and assign other to 0
for k: =1 to 6 do
[m, n] = size (Edge [i])
// Assign an empty F_image with m x n size
  E= Edge[k]
Do For i: = 1 to m
  {
    Do for j: = 1 to n
      {
        if (E[i, j] = M) then,
        F_image (i, j): = F_image [i, j] + E [i, j]
      }
  }
// Normalize intensity
Do for i: =1 to m
  {
    Do for j: = 1 to n
      {
        if ( F_image> 255)
        F_image (i, j) = 255
      }
  }
// Display the F_image, it contains the edges of the given image.
This proposed work chooses the maximum intensity value as threshold value instead of threshold detection because threshold value depends on the intensity of the image. It helps to detect strong edges only (which are having higher degree of edges).
Output Results:

Figure 3.18 (a): Original image
Figure 3.18 (b): Output of the kirsch edge detector
Figure 3.18 (c): Proposed edge detector

Figure 3.18: Comparison results of edge detectors image (a) Original image (b) output of the kirsch edge detector (c) Proposed edge detector

The dataset of 110 retinal photographs is used to assess the method. Before being subjected to segmentation, the images that suffered from non-uniform illumination and poor contrast have been subjected to pre-processing. The real time images are taken and compared with various edge detectors. The Comparison result of various edge detectors with the proposed edge detector is displayed in the Figure 3.18 (a, b and c). The results of the proposed edge detector will be the visually pleasing one. Moreover, it is a time consuming method and has a low computational complexity.

3.5.1.3. PERFORMANCE EVALUATION OF EDGE DETECTION

A number of researchers have considered the problem of measuring edge detector performance. The proposed detector is compared with other edge detectors such as Log, Sobel, Prewitt and Robert cross. The performance of the edge detector is analyzed. When the evaluation is based on a specific application reduces the generality of the evaluation method, the general-purpose evaluation is difficult to define. These features are then passed on to the recognition system for recognizing 3D objects. In fact, it is very difficult to set the criteria for measuring the performance of the edge detector. Even then, the following criteria can be used to Analyze. They are:

- The false edges probability.
- The missing edges probability
- The edge angle error
- The edge estimate and the true edge of mean square distance
To work in automatic threshold determination, Studies in the evaluation of different edge detectors have contributed. A number of characteristics of the edges were identified in Venkatesh S 1992 [85], Abdou I E 1979 [86] and Kitchen L 1981 [87] for comparing edges.

1. The edge points are identified correctly.
2. The edge points are identified incorrectly.
3. The missed edge points are identified (false negatives).
4. The number of multiple detections for a single edge, related to the thickness are identified.
5. The detachment among the identified edge, true edge and the edge endurance.

These characteristics are assessed for comparing the quality of edges of the objects. The Pratt’s Figure of Merit evaluates edge location accuracy by the displacement of detected edge points from an ideal edge and the Pratt’s figure of merit for various edge detectors are shown in the Table 6 for the retinal image in Figure 3.18.

The Figure of Merit is defined by:

$$R = \frac{1}{I_N} \sum_{i=1}^{I_A} \frac{1}{1 + \alpha d^2}$$  \hspace{2cm} 15$$

Where, \(I_N = \max (I_I, I_A)\)

- \(I_I = \) number of ideal edge points
- \(I_A = \) number of actual edge points
- \(d = \) displacement of actual edge points from ideal edge
- \(\alpha = \) scaling constant.

The proposed edge detector is tested for different images and the Pratt’s figure of merit for the real time retinal image is shown in Figure 3.18. The table 6 shows the comparison results of Pratt’s figure of merit of the proposed edge detector with other edge detectors for the retinal image.
### Table 6: Various edge detector performances with Pratt’s figure of merit

<table>
<thead>
<tr>
<th>Detector</th>
<th>Pratt’s Figure of Merit (FOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log</td>
<td>0.3949</td>
</tr>
<tr>
<td>Prewitt</td>
<td>0.3567</td>
</tr>
<tr>
<td>Sobel</td>
<td>0.34980</td>
</tr>
<tr>
<td>Robert</td>
<td>0.3000</td>
</tr>
<tr>
<td>Kirsch</td>
<td>0.4039</td>
</tr>
<tr>
<td>Proposed</td>
<td>0.4356</td>
</tr>
</tbody>
</table>

The proposed edge detector gives a better result than the other detectors. In the artificially added noisy image, the proposed edge detector gives 4% better results than log edge detector, 8% better than prewitt edge detector, 9% better than sobel edge detector, 13% better than Robert cross edge detector and 3% better than kirsch edge detector.

#### 3.5.2 Exudates Feature Extraction

Exudates are different shapes and sizes with small yellow and white color patches. It is one of the early stage symptoms for DR. The accumulations of protein and lipid inside the retina are called Exudates. Characteristically, they vary in brilliance, reflection, and colored lesions.

#### 3.5.2.1 The Fuzzy c-means (FCM):

The procedure of gathering statistics belongs to two or more clusters. The process of clustering produces a choice for the c division reducing the weight inside the institute adds the squared errors objective characteristic JFCM:

\[
J_{FCM} = \sum_{i=1}^{N} \sum_{j=1}^{c} u_{ij}^{m} |x_{i} - v_{ji}|^{2} \quad \text{------------------16}
\]

Here, \( X = \{x_{1}, x_{2}, \ldots, x_{n}\} \) Rp

\( Rp = \) the p- dimensional vector space of the data set,
\( p = \) the data items in total
\( c = \) With \( 2 \leq c \leq n-1 \), is the total clusters
\( V = \{v_{1}, v_{2}, \ldots, v_{n}\} \) the c centers are the clusters.

The p-dimension center of the cluster I, is \( v_{i} \).
The U = \{uij\} designates an uncertain division of matrix with uij = ui (xj), is the mark of association of x_i in the cluster, the p-dimensional calculated data is x_i in the jth.

The information matrix gratifies:

1. \[0 < \sum_{i=1}^{n} u_{ij} < n, \quad \forall \ i \in \{1, \ldots, C\}\]
2. \[\sum_{i=1}^{C} u_{ij} = 1, \quad \forall \ j \in \{1, \ldots, n\}\]

Where, \(0 \leq U_{ij} \leq 1\), \(\forall \ i, j\)

The amount of fuzziness of the ensuing class is resolute with the parameter \(m\) is a weighting exponent on each fuzzy membership; it is a hard and fast quantity more than one. Under the constraint of U, the objective characteristic of JFCM is minimized. Precisely, yielding of JFCM with appreciates to Ui and Vi, but are not enough situations for JFCM to be at its nearby severe will be as the subsequent:

\[u_{ij} = \sum_{k=1}^{C} \left( \frac{||x_j - v_k||}{||x_j - v_i||} \right)^{\frac{m-2}{m-1}}\]  for \(i = 1, 2, \ldots, C\) and \(j = 1, 2, \ldots, n\)

\[V_i = \frac{\sum_{j=1}^{n}(u_{ij})^m x_j}{\sum_{j=1}^{n}(u_{ij})^m}\]  for \(i = 1, 2, \ldots, C\)

The above equations are referred from James.C.Bezdek,Robert Ehrlich,William Full(1984)[88].

Though the FCM is considered to be beneficial clustering procedure, its association never agrees flourishing to the information, Furthermore, involving in the inaccurate and inevitably reduction of some noise.

3.5.2.2 Spatial Fuzzy C-Means (SFCM)

The essential features of a photo are that neighboring pixels have comparable function values, and the chance belonging, though the cluster is more. In the clustering, the spatial data is found essential, but it is not applied in a preferred FCM algorithm. The spatial feature is described below:

\[S_{ij} = \sum_{k \in NB(x_j)} U_{ik}\]  \(\sum_{k \in NB(x_j)} U_{ik}\)

In consideration with the neighborhood of each pixel, the membership function is the weighted summation of the spatial function. The pixel \(x_j\) belongs to \(i^{th}\) clustering of the
spatial function $S_{ij}$ signifies the probability. The $i^{th}$ clustering of the neighborhood pixels belong to spatial function, it is found to be the largest. Otherwise it will be lowest. The incorporation $S_{ij}$ of the membership is as follows:

$$U_{ij}^* = \frac{u_{ij}^p s_{ij}^q}{\sum_{k=1}^c u_{kj}^p s_{kj}^q}$$  \hspace{2cm} (22)

for $i = 1, 2, ..., c$ and $j = 1, 2, ....... n$

The above equations are referred from A.Meena,K.Raja(2013)[89].

The relative importance of both functions are controlled by the parameters are $p$ and $q$. The spatial functions simply fortify the original membership in a homogenous region, with the unaffected clustering outcome. At each clustering iteration, there are two steps involved. In the spectral domain, the first step is to calculate the membership function. To map the membership information of each pixel to the spatial domain is the second step. Analyzing the Spatial function from the above two steps.

3.5.2.3. PROPOSED ALGORITHAM FOR EXUDATES:

To analyse whether the central pixel to be accurate and inaccurate, the membership of central pixel with the one of neighbouring pixels in a window are compared. In the clustering process, the spatial relationship is significant, which can be defined as,

$$S_{ij}^* = \sum_{k \in H(x_j)} U_{ik} \beta_{k1} + \frac{\sum_{k \in H(x_j)} U_{ik} \beta_{k2}}{\sum_{k \in H(x_j)} U_{tk}}$$  \hspace{2cm} (23)

Where, $H(x_j)$ indicates a centre of the square window on pixel $x_j$ in the spatial domain. Newly proposed spatial features are two categories. The wrong classified pixels from corrupted regions can be easily corrected and controlled by using $\beta_{k1}$ coefficient is the first category. The second category i.e. membership function quantitative according to distance between pixel is controlled by $\beta_{k2}$ coefficient.

$$\beta_{k1} = \frac{1}{1 + \exp(\theta_1 \| j-k \|)}$$  \hspace{2cm} (24)

$$\beta_{k2} = \frac{1}{1 + \exp(\theta_2 \| x_j - x_k \|)}$$  \hspace{2cm} (25)

The spatial function is represented in terms of membership function as follows
The objective function is based on the clustering optimization is the key for the success of the cluster analysis and to acquire the enhanced quality clustering. The data points assigned to them should be minimized and the distance between clusters should be maximized to meet a suitable objective function is the distance between the two clusters. A novel process entitled MS-FCM, which prominently enriches the presentation of FCM due to the learning of parameter $\alpha$. The above parameter is illustrated:

$$\alpha = \exp \left(-\min \frac{\|v_i-v_k\|^2}{\beta} \right)$$  \hspace{1cm} 27$$

Here, $\beta$ is a variance. Is illustrated as

$$\beta = \frac{\sum_{j=1}^{n}\|x_j-\bar{x}\|^2}{n} \text{ where } \bar{x} = \frac{\sum_{j=1}^{n}x_j}{n}$$  \hspace{1cm} 28$$

A new parameter to each vector is proposed with the novel parameter suppressing this common value of $\alpha$ replacing. Consequently, in the case of noise data, these weights authorises a superior classification. Thus, the weight is intended as follows:

$$W_{ji} = \frac{1}{1+\exp \left(-\frac{\|x_j-v_i\|^2}{\sum_{j=1}^{c}\|x_j-\bar{x}\|^2\cdot\alpha/n} \right)}$$  \hspace{1cm} 29$$

To improve the fuzzy and typical partition, the weight is used. The function MS-FCM is illustrated below:

$$J_{msfcm} = \sum_{k=1}^{n} \sum_{i=1}^{c} \left( u_{ik} W_{ji} \right) |x_k - v_i|^2$$  \hspace{1cm} 30$$

Modified FCM method is described in steps below:

1: data set is taken
2: Fix $m > 1$ and $2 \leq c \leq n - 1$ and it gives
3: find $U_{ij}$ with $V_i$ by Equation. (3).
4: find $\beta_{k1}$ and $\beta_{k2}$ by using equation. (8) and (9).
5: calculate $S^*_{ij}$ and $W_{ji}$ by using equation. (7) and (13).
6: by using equation (10) updated the membership matrices, by using equation(4) update the centroids.
7: Stop the iteration if $\|V_{new} - V_{old}\| \leq \epsilon$ new, otherwise, go to step 4.

3.5.2.4. PERFORMANCE ANALYSIS

Among the two varieties of cluster validity features, the quantitative comparison can be accomplished. Explicitly, to estimate the overall performance of clustering in extraordinary methods, the fuzzy partition and feature shape are defined:

$$V_{pc}(U) = \frac{1}{n} \left( \sum_{k=1}^{c} \sum_{i=1}^{n} u_{ik}^2 \right)$$  \hspace{1cm} 31$$

$$V_{pe}(U) = -\frac{1}{n} \left( \sum_{k=1}^{c} \sum_{i=1}^{n} u_{ij} \log u_{ik} \right)$$  \hspace{1cm} 32$$

The above equations are referred from Keh Shih Chuang, Hong Long Tzeng, Sharon Chen (2006)[90].

The partition with fuzziness approach higher performance is the concept of these validity features. The fine clustering is reached when the value $V_{pc}$ is maximal or $V_{pe}$ is minimum. Table 7 is the $V_{pc}$ and $V_{pe}$ and variety of iteration of the 3 algorithms is displayed.

**Table 7: Performance parameters of all the methods**

<table>
<thead>
<tr>
<th>Types of Noise</th>
<th>Methods</th>
<th>$V_{pc}$</th>
<th>$V_{pe}$</th>
<th>Iterations</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P</td>
<td>FC Method</td>
<td>0.8631</td>
<td>0.10920</td>
<td>86</td>
</tr>
<tr>
<td>S&amp;P</td>
<td>SFC Method</td>
<td>0.8644</td>
<td>0.10550</td>
<td>74</td>
</tr>
<tr>
<td>S&amp;P</td>
<td>Proposed method</td>
<td>0.9234</td>
<td>0.0546</td>
<td>51</td>
</tr>
</tbody>
</table>
Output Result:

![Figure 3.19 (a):](image1) ![Figure 3.19 (b):](image2) ![Figure 3.19 (c):](image3)

**Figure 3.19: Comparison results of clustering methods (a) Original image (b) output of the FCM Algorithm (c) Proposed exudates extraction algorithm.**

This new set of rules has been provided for tracing the exudates in retinal snap shots. For diagnosing eye diseases, the extraction of this feature is vital. To perceive the bounds of vivid gadgets sharply with unique contours in one shot, the proposed algorithm is found extremely beneficial. This algorithm allows extracting the exudates of the retinal image quickly. The figure 3.19 (a) is the input retinal image and 3.19 (b) & (c) are the output images of different clustering algorithms.

### 3.5.3 Microaneurysms

Microaneurysms are the first clinically evident signs of diabetic non-proliferative eye disease, so the recognition of microaneurysms can be the first step in prevention of diabetic retinopathy progression. This describes a method for extracting microaneurysms from fundus images using morphological operations. The green channel of input size normalized image is subjected to proposed filter for de-noising. Adaptive histogram is applied to enhance the image. Segmentation and morphological operations are performed to detect the retinal features such as blood vessels and optic disc and also pathologies like exudates, large hemorrhages and noise to facilitate extraction of microaneurysms. The extracted microaneurysms are verified by an expert for their correctness.
3.5.3.1 Morphological Distance Based Algorithm with k-nearest neighbor’s classifier:

Step 1: The pre-processing stage removes the noise of the photograph, will increase the assessment and produces a shading correction on the manner to stability the non-uniform illumination during the photo. The next step uses a morphological transformation that gives diameters smaller than \( \lambda \) and it fills in all of the black dots.

Step 2: after the transformation, the grey value of the crammed-in dots is higher than in the superior pre-processed photo, at the same time as the vessels and different factors stay absolutely unaffected. The black top-hat step makes use of shape and length requirements to isolate the black additives contrasted in competition to the history.

Step 3: The automatic threshold step identifies all factors inside the black pinnacle-hat picture which is probably feasible \( \mu \)A applicants.

Step 4: later, for classification (k-NN) classifier is used. It makes use of the houses estimated to discover them as each actual \( \mu \)A or fake +ves primarily based at the gaining knowledge of set within the small database. The classifier acts like a human grader with the useful resource of taking into consideration skills including length, comparison, circularity, and colour. And finally correct microaneurysms are extracted.

3.5.3.2 Morphological operations

\[
\begin{align*}
\text{Dilation:} & \quad \delta_B(f)(y) = \max_{b \in B(x)} f(y + b) \\
\text{Erosion:} & \quad \varepsilon_B(f)(y) = \min_{b \in B(x)} f(y + b) \\
\text{Opening:} & \quad y_B(f) = \delta_B(\varepsilon_B(f)) \\
\text{Closing:} & \quad \varphi_B(f) = \varepsilon_B(\delta_B(f))
\end{align*}
\]

The above equations and algorithm is referred from Jean Sera, Pierre Soille[91].
3.5.3.3 Proposed modified morphological operations with active contour

Segmentation stage involves edge detection of microaneurysms and blood vessels. Thresholding is applied for removal of exudates and noise. Blood vessels are eliminated by using morphological operations. Finally, optic disc is detected and eliminated using active contour, leaving microaneurysms in the resulting images.

Step 1. Load the retinal image.
Step 2. Noise added to the original image.

Step 2: Segmentation

i. Apply edge detector to find the edges of blood vessels and pathologies.
ii. The candidate microaneurysms are selected by filling them based on their shape and size.

Step 3: Morphological operation: morphological opening with large ball shaped structuring element of size 11 is used to eliminate blood vessels.

Step 4: Boundary of optic disc is marked using an active contour method and is eliminated by converting the pixels inside the boundary to background.

Step 5: Area Calculation: The resultant image is divided into four quadrants and the area occupied by microaneurysms in each quadrant is calculated.

Step 6. The correlation coefficient, PSNR is evaluated between the output image and input image for the proposed Modified morphological method.

Output Results

Figure 3.20 (a): Figure 3.20 (b): Figure 3.20 (c):

Figure 3.20: Comparison results (a) Original image (b) output of the morphological operations (c) Proposed Microaneurysms extraction algorithm.

The figure 3.20 (a) is the input retinal image and 3.20 (b) & (c) are the output images of different morphological algorithms. The above figure shows that the number of dots in the original image is not properly extracted using morphological operation.
3.5.3.4. Performance observation
From the above results, it can be observed that edges and segmented image are clear in details and free of noise. Statistical results in the table 8 indicate the proposed method given better results than the existing morphological method and also better for the parameters. The detection results visual analyze show that the proposed method suppress the noise completely.

Table 8: Performance parameters for morphological methods

<table>
<thead>
<tr>
<th>Method</th>
<th>PSNR</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphological operations</td>
<td>66.8</td>
<td>0.8346</td>
</tr>
<tr>
<td>Proposed modified morphological operations</td>
<td>89.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Detection and study of microaneurysms can be accomplished with the numerous mathematical expressions. Techniques of morphology can be attained with the Comparative analysis. With the intention to find out microaneurysms in a less complicated way by using way of the use of mathematical idea as an opportunity the other strategies of segmentation, thresholding and vicinity developing.

The above figure 3.20(a) and 3.20(b) shows the input and output image of the retina.

3.5.4 Optic Disc Feature Extraction
Optic disc is a oval in shape and the brightest a part of the retina. the diabetic retinopathy affected patient the oval shape is irregular.

3.5.4.1. Watershed Transformation (Vincent Soille Algorithm)
A development of the watershed rework was presented by Vincent & Soille [92]. Since, it is implementation in some element and reproduce their set of rules in pseudocode, In this algorithm, following are taken:

Step 1: pixels are Sorted w.r.t ascending value.

Step 2: A flooding step, intending degree by using degree and beginning from the minima. The development makes use of a FIFO queue of pixels, this is, a _rst-in-_rst-
out facts structure on which the given operations can be done: _fo add(p; queue) it provides p pixel at the end of the queue, _fo do away with(queue) returns and removes the _rst information of the queue, _fo init uses an empty queue, and _fo empty(queue) is a check which returns actual if the queue is empty or else false.

The method gives to each minimum and its related basin with the aid of iteratively flooding the graph using a breadth- _rst set of rules, as follows:

Step 3: In the next step, grey stage all nodes h are _rst given in the label masks. Then, the above nodes which have classified neighbours from the previous new release are inserted inside the queue. If a pixel is adjoining to 2 or more one-of-a-kind basins, it is indicated as a watershed node by the label wshed. It has a same label, If the pixel reached from nodes. Which is combined with the corresponding basin.

The above algorithm is referred from Hanzheng Wang [93].

3.5.4.2. Proposed algorithm for optic disk extraction
The modified watershed method to extract the optic disk and this algorithm follows the below steps:
Step 1: Follow open and close reconstruction to the grey scale picture.

Through applying the open-reconstruction and close-reconstruction filtering to gray scale photograph, put off the burrs within the photo, fill the small holes in picture and clean the bounds, meanwhile, do no longer trade the size and form of the pics. This pre-treatment makes it less difficult to segment the optic disk image.

Step 2: Estimate the gradient picture of the filtered picture.

Observe the gradient transform to the picture got in step 1. Within the gradient photograph, the gradients of the bounds among optic disk and background in authentic photograph are a good deal large than that of place in optic disk.

Step 3: Use the adaptive threshold algorithm (ATA) to get the binary image of the gradient picture.
Remodel the gradient photo were given in step 2 to binary picture the usage of ATA algorithm. ATA algorithm is an adaptive set of rules that could find the quality binary threshold. The threshold determined by ATA is objective and reasonable, that may result in a terrific linearization overall performance. After linearization, the boundaries between optic disk and historical past can be detected.

Step 4: After detecting the optic disk limitations, and fill the regions to perform the extraction of the optic disk in photograph and Fill the blood vessel regions.

Step 5: Observe open operation to the filled picture.

Open operation can delete the region smaller than shape detail and cut off slim connection. This will save the segmenting non-existent optic disk, use the open operation to reduce the small false optic disk regions.

Step 6: Practice the space remodel to filled image.

Apply distance rework to the photograph were given in step 5 to get a gray scale picture. Get the supplement image as a new distance photo and use the proposed filter to remove the noise. Inside the new distance picture, the values of pixel increase from the internal region to outer place. The value of innermost pixel in optic disk is the smallest, and the value of outermost pixel in optic disk is the most important. And the background pixel value is 255.

Step 7: Follow Watershed transform to grey scale distance image.

Find the nearby minimal factor inside the distance picture, that’s the centre of the optic disk. Used the minimum factors to mark each optic disk place and use the pixel of fee 255 to mark the background. Then practice the watershed set of rules to the gap photograph to section the adhesion optic disk and mark the optic disk areas.

Step 8: Upload the segmentation result to the unique picture

Add the segmentation end result to the authentic picture to show the final end result.
Output images

Figure 3.21 (a): Original noisy real world image (b) output of the watershed transform (c) Proposed optic disk extraction algorithm.

The figure 3.21 (a) is the input retinal image and 3.21(b) & (c) are the output images of optic disk extraction algorithms. The above figures performance is calculated in the above parameters.

3.5.4.3. Performance parameters:

Accuracy: Accuracy is defined as the condition or the quality of the result is being true i.e., as simple as freedom from error or the defected portion of an object.

Sensitivity: True positive: In clinic sick people properly recognized as sick

Sensitivity= Number of correct positive/Number of correct Positive+ Number of wrong Negative

Specificity: True negative: Healthy people properly recognized as healthy

Specificity=No of True Negative/No of True Negative+ No of False Positive.

In general, Positive = identified and negative = discarded, as a result:

- True positive = properly identified
- True negative = properly rejected

The above parameters are referred from Alireza Baralioo,Moatafa Hosseini[94].

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Watershed algorithm</th>
<th>Proposed algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>58.09</td>
<td>90.11</td>
</tr>
<tr>
<td>Specificity</td>
<td>95.70</td>
<td>99.60</td>
</tr>
<tr>
<td>Accuracy</td>
<td>92.10</td>
<td>98.37</td>
</tr>
</tbody>
</table>
The segmented optic disc consists of a center point and a radius. The proposed algorithm is confirmed for the performance of evaluation 110 real time retinal fundus images. The results of distinguished images are presented here in fig 3.21 a, b & c. The equalized image represents the higher disc radius thus gives better segmented disc. Also the threshold is different for different images if equalisation is not used. While after equalization same threshold may be used for most of the images. The threshold used with equalization for this is 251.

The proposed method identifies the optical disc efficiently if the proper threshold is selected analytically. The Figure presents the input and output of the retinal image. It was given that the proposed method performs efficiently. Figure presents the result of the detected optical disc for different type of input retinal images after thresholding. It can be observed that method performs well for both right and left eyes images.

3.6 CLASSIFICATION METHODS

3.6.1 Artificial Neural Network (ANN)

The mathematical models that imitate the properties of biological nervous system and the functions of adaptive biological learning is the ANNs collection. It is a self-learning machine that adjustments its parameters based on outside or inner facts that flows through the network during the learning phase. The input, an output, and one or more hidden layers, and the layer consists of neurons are the compared ANNs. The often suitable to solve problems that are too complex to be solved by the conventional techniques, or hard to find algorithmic solutions are the advantage of ANNs. The ones which do not have common rules to determine their size, to consume long time for training are the disadvantage of ANNs. There are three types of ANNs that are frequently used within the field of cancer detection and class:

The back propagation neural network (BPN), the self-organizing map (SOM) and the hierarchical ANN. Many researchers used the ANNs in the classification of diabetic.

3.6.2. SVM Classification

Retraining the influential functionality, the Support Vector Machine (SVM) is found useful for cataloguing. They are implemented to classify or for the reversion. Belonging to the group, they are administered with appraisal approaches. Progressive
thru Vladimir Vapnik, SVM signify an addition to nonlinear replicas of the comprehensive representation with the set of rules. The categorizing facts, each belonging to considered one of two training, are analyzed to determine to which class a statistics point belongs. There are numerous hyper planes that could classify the information. The most significant parting, or margin, amongst the two training, is the excellent hyper aircraft signification. H3 does not separate the two lessons. H1 does, with a small margin and H2 with the most margins. So the hyper aircraft that maximizes the gap from it to the nearest statistics factor on each facet is selected. If this kind of hyper aircraft exists, it's far referred to as the most-margin hyper plane and the corresponding linear classifier is called the most margin classifier. The advantage of using SVM is that it achieves higher classification rates compared to other classification techniques. There are two cases for SVM-linear SVM and non-linear SVM. The linear SVM is only used here.

Classification rates for different feature extraction techniques to distinguish between normal and abnormal diabetic.

<table>
<thead>
<tr>
<th>Features</th>
<th>ANN</th>
<th>SVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exudates</td>
<td>96%</td>
<td>99%</td>
</tr>
<tr>
<td>Microanesayms</td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td>Cup To Disk Ratio</td>
<td>70%</td>
<td>74%</td>
</tr>
</tbody>
</table>

The above concept was referred from Evgeny Byvatov, Uli Fechner, Jens Sadowski, and Gisbert Schneider[95].

3.7 Creating GUI Flat Form Using Matlab & Displaying the Screen Layouts
The evaluation is applied to all of the 110 samples with age organization various 26 to 65. Analysis has been made on the ordinary images (unfastened from diabetics), as a first step. For the diabetics, the above procedure is repeated for abnormal retinal images. The screen shots are displayed below from figure 3.22 to 3.37 for normal and abnormal patients. Screen Layout gives the message like normal or abnormal. If it is abnormal, then it indicates the abnormality stage, i.e. displayed in the image.
Normal patients:

**Figure 3.22: Simulated Images of all Features**

**Figure 3.23: Simulated Images of all Features**
Figure 3.24: Simulated Images of all Features

<table>
<thead>
<tr>
<th>Original Image</th>
<th>Filter Output</th>
<th>Blood Vessels</th>
<th>Exudates</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
<td><img src="image3.png" alt="Image 3" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
</tbody>
</table>

MicroAnerysmns  Optic Discs

Figure 3.25: Simulated Images of all Features

<table>
<thead>
<tr>
<th>Original Image</th>
<th>Filter Output</th>
<th>Blood Vessels</th>
<th>Exudates</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
<td><img src="image3.png" alt="Image 3" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
</tbody>
</table>

MicroAnerysmns  Optic Discs

87
Figure 3.26: Simulated Images of all Features

First Extraction Blood Vessels Affected

Figure 3.27: Simulated Images of all Features
Figure 3.28: Simulated Images of all Features

Figure 3.29: Simulated Images of all Features
Figure 3.30: Simulated Images of all Features

Figure 3.31: Simulated Images of all Features
Figure 3.32: Simulated Images of all Features

Figure 3.33: Simulated Images of all Features
<table>
<thead>
<tr>
<th>Original Image</th>
<th>Filter Output</th>
<th>Blood Vessels</th>
<th>Exudates</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Figure 3.34: Simulated Images of all Features**

<table>
<thead>
<tr>
<th>Original Image</th>
<th>Filter Output</th>
<th>Blood Vessels</th>
<th>Exudates</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Figure 3.35: Simulated Images of all Features**
Figure 3.36: Simulated Images of all Features

Figure 3.37: Simulated Images of all Features
3.8 Comparing Segmented Results with Their Blood Sample Values Comparison

Formula

In this step, the patient retinal image segmented results are compared with the same patient’s blood sugar values using blood sugar machine. This will gives the severity of the disease and also performance of the segmented results. This comparison can be illustrated in the table and that table represents patient name, blood sugar values, retinal image, segmented result of retinal image and severity.

- Based on the above results, here it gives the formula. That will give the relation between blood sugar level Vs retinal diagnosis features.
  - ie. Only one feature = 90 to 130 mg/dl
  - Two features = above 130 to 180 mg/dl
  - Any three feature = above 180 to 200 mg/dl
  - All four gives = above 200 mg/dl
### 3.8.1 Comparison Results Table

**Table 11: Comparison between Blood Sugar Values Vs Segmented Results**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lakshmi</td>
<td>80</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>Latha</td>
<td>90</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>3</td>
<td>Nageswara rao</td>
<td>90</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>4</td>
<td>RVDKumari</td>
<td>70</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Normal</td>
</tr>
</tbody>
</table>
### 3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Saroja</td>
<td>80</td>
<td><img src="image1" alt="Simulation Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>6</td>
<td>Venkat esh</td>
<td>90</td>
<td><img src="image2" alt="Simulation Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>7</td>
<td>Yellam andha</td>
<td>90</td>
<td><img src="image3" alt="Simulation Image" /></td>
<td>Normal</td>
</tr>
<tr>
<td>8</td>
<td>Aruna kumari</td>
<td>100</td>
<td><img src="image4" alt="Simulation Image" /></td>
<td>Blood vessels effected</td>
</tr>
</tbody>
</table>
### 3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values(mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Aishwarya</td>
<td>100</td>
<td><img src="image" alt="Simulation Results" /></td>
<td>Blood vessels affected</td>
</tr>
<tr>
<td>10</td>
<td>Kavitha</td>
<td>110</td>
<td><img src="image" alt="Simulation Results" /></td>
<td>Blood vessels affected</td>
</tr>
<tr>
<td>11</td>
<td>Krishna</td>
<td>120</td>
<td><img src="image" alt="Simulation Results" /></td>
<td>Blood vessels affected</td>
</tr>
<tr>
<td>12</td>
<td>Lalitha</td>
<td>100</td>
<td><img src="image" alt="Simulation Results" /></td>
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</tr>
</tbody>
</table>
### 3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Parvathi</td>
<td>130</td>
<td><img src="image1.png" alt="Simulation Image" /></td>
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<tr>
<td>14</td>
<td>Ramesh</td>
<td>100</td>
<td><img src="image2.png" alt="Simulation Image" /></td>
<td>Blood vessels effected</td>
</tr>
<tr>
<td>15</td>
<td>Shoba</td>
<td>130</td>
<td><img src="image3.png" alt="Simulation Image" /></td>
<td>Blood vessels effected</td>
</tr>
<tr>
<td>16</td>
<td>Srinivas</td>
<td>130</td>
<td><img src="image4.png" alt="Simulation Image" /></td>
<td>Blood vessels effected</td>
</tr>
</tbody>
</table>
### 3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Sumathi</td>
<td>120</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Blood vessels effected</td>
</tr>
<tr>
<td>18</td>
<td>Vasundhara</td>
<td>100</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Blood vessels effected</td>
</tr>
<tr>
<td>19</td>
<td>Venkatesh</td>
<td>110</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Blood vessels effected</td>
</tr>
<tr>
<td>20</td>
<td>Yedukondallu</td>
<td>120</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Blood vessels effected</td>
</tr>
</tbody>
</table>
3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Babu</td>
<td>140</td>
<td>![Image]</td>
<td>Exudates effected</td>
</tr>
<tr>
<td>22</td>
<td>Eaupadam</td>
<td>140</td>
<td>![Image]</td>
<td>Exudates effected</td>
</tr>
<tr>
<td>23</td>
<td>Lakshminarayana</td>
<td>130</td>
<td>![Image]</td>
<td>Exudates effected</td>
</tr>
<tr>
<td>24</td>
<td>Pushpavathi</td>
<td>130</td>
<td>![Image]</td>
<td>Exudates effected</td>
</tr>
</tbody>
</table>
### 3.8.1 Comparison Results Table (Contd…)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Patient Name</th>
<th>Blood Sugar Values (mg/dl)</th>
<th>Simulation Results</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Raju</td>
<td>130</td>
<td><img src="image" alt="Simulation Image" /></td>
<td>Exudates effected</td>
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<tr>
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<tr>
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<td>Venkatesh murthy</td>
<td>130</td>
<td><img src="image" alt="Simulation Image" /></td>
<td>Exudates effected</td>
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3.9. RESULTS AND DISCUSSION

The structures of the RFI, like RGB segmentation, Exudates extraction, Microaneurysms, OD measurement, Measurement of Blood vessel thickness, and Vein diameter have been extracted in this proposal. For the augmentation of the decision support system, the images extracted from fundus camera. Then the system performance is analysed by using the real time patient’s images taken from government eye hospital fundus camera. By using the extracted features, the performance of techniques is analysed and compared. The sequential process of the proposed work is illustrated as given below. The Normal and abnormal retinal fundus images is displayed in pictures 3.22 to 3.37 and pictures 3.22 to3.26 show the normal image of the retina. Picture 3.5 to 3.9 displays the enhanced retinal image after denoising. Figure 3.18 displays the blood vessel segmentation obtained in OD measurement. Figure 3.19 shows the exudates segmented image. Figure 3.15 show the exudates image. Figure 3.20 shows the optic disk measurement. Finally, Figure3.21 shows the filtered image. The sequential process of the sampled results of an abnormal image is displayed in the picture 3.28 to 3.37. The evaluation is applied to all of the 110 samples with age organization various from 26 to 65.
3.10 CORRESPONDING TREATMENT

3.10.1 Retinopathy of Prematurity
No remedy is usually recommended at some stage in the early ranges. However, close monitoring is essential.

3.10.2 Diabetic Retinopathy
Explicit remedy depends on the character of the hassle. The retina may be handled with laser therapy, Proliferative disorder and swelling or leaking of retina, treated with laser surgery.

Laser treatment can help stop the growth of new vessels

Figure 3.39: Laser Treatment Machine

- Laser surgical procedure is used to correct the Bleeding that cloud imaginative and prescient via the way of eliminating all or part of the vitreous.
- To maintain diabetic retinopathy from getting worse, the Blood sugar and blood stress ought to be controlled

3.10.3 Central Serous Retinopathy
An ophthalmologist has to display the affected person cautiously for 3 to 6 months. If the condition is not found improved, it can be restored with the laser treatment.