



# “Morphological Techniques and Median Filter Apply to Calculate Intra Ocular Pressure for Glaucoma Diagnosis”

Dnyaneshwari D. Patil<sup>1</sup>, Ramesh R. Manza<sup>2</sup>, Sanjay N. Harke<sup>3</sup>

<sup>1</sup>Institute of Biosciences and Biotechnology, MGM- Aurangabad, (India)

<sup>2</sup>Department of CS & IT, Dr. Babasaheb Aambedkar Marathwada University, (India)

<sup>3</sup>Institute of Biosciences and Biotechnology, MGM-Aurangabad, (India)

## ABSTRACT

Analyses of different field of view retinal fundus images, and diagnose glaucoma with our region of interest IOP i.e. intra ocular pressure. For measurement of intra ocular pressure in retina we have used retinal blood vessels which are perform measure role in human vision. For this purpose we have used 1866 High resolution retinal fundus images from five different dataset. And analyze the result from each individual.

**Keywords-** IOP (Intra ocular pressure), ONH-(Optic Nerve head), ROI (Region of interest), WHO (World health organization), CLAHE (contrast-limited adaptive histogram equalization)

## I. INTRODUCTION

The inadequate fluid flow between the iris and cornea of eye leads to glaucoma. Human eyes are the most important organs in the human body. In human eyes, the retina converts light rays into electrical impulses. Then these signals or impulses are sent through the optic nerve to the brain, where they are predictable as images. This optic nerve of an eye consists of several retinal nerve fibers to connect retina to the brain. These retinal blood vessels are damaged when intra ocular pressure inside human eyes increases and it leads to glaucoma [1]. Glaucoma is a disapproving eye health condition affecting up to 60.5 million people world-wide. It is a time progressive disease and the principal cause of permanent visual loss. Glaucoma is commonly found in metropolitan and semi metropolitan areas of industrial developed countries. According to a survey of WHO i.e. World Health Organization glaucoma is the second leading cause of blindness. In India, near 11 million people are troubled from glaucoma. Out of the 11 million, 1.5 million peoples are losses their vision [2].

## II. METHODOLOGY

For this experiment we have use median filter method for image enhancement and morphological operations with some significant methods for feature extraction. In following points we have seen detailed knowledge about all the methods used for succession of this experiment.

### 2.1 ROI (Region of Interest)

Main region of interest for this experiment is retinal blood vessels, with their structural tendency. Like Area, Diameter, Length, Thickness, Tortuosity/IOP, with these structural features of our ROI we can diagnose glaucoma.

## 2.2 IOP (Intra Ocular Pressure)

In the healthy eye, central chamber of the eye produces the aqueous fluid. This fluid then flows around the lens, and enters into the drainage meshwork and then comes out of the eye. If drainage meshwork is blocked, fluid does not move out of the eye, as a result, fluid surrounded by the eye increases. This increases the pressure surrounded by the eye and causes damages to the optic nerve or retinal blood vessels and in turn leads to loss of vision. For measuring pressure inside the eye tonometer is used. This device measures the pressure in terms of millimeters of mercury (mmHg). In normal eye, IOP is usually between 10-20 mmHg. Higher IOP inside the eye may increase the risk of glaucoma, but does not mean that the person has glaucoma because in some cases normal people may have advanced IOP [3]. The following formula is used to calculate IOP of an eye.

$$\text{IOP} = \frac{\text{Aqueous fluid formation rate}}{\text{Out flow rate}} + \text{Venous pressure}$$

## 2.3 Feature Selection

There are different features in a high resolution retinal fundus image that can be extracted for capturing the Glaucomatous structures. These are namely CDR value, shape, Optic Nerve Head (ONH), histogram models, blood vessel and NRR area, and loss of retinal nerve fibers. Here we have worked on neuro retinal blood vessels shape or tortuosity.

## 2.4 Retinal blood vessels

It looks like a bunch of scratches that a colored light is been distributed evenly on the normal eye. In normal eye retinal blood vessels mostly seen in the inferior temporal area, followed in the area of the superior temporal, superior nasal and inferior nasal [4]. Retinal blood vessels can be observed by ophthalmoscopy and wide angle photos without the red color.

## 2.5 Preprocessing & Image Enhancement

Pre-processing is done to the retinal fundus image which includes color conversion, resizing the image, removal of noise from the original images by using median filter pre-processing is an improvement of the image data that contains undesired distortions or enhances some image features relevant for further processing and analysis task presented in the retinal image [5]. The standard objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application.

## 2.6 Feature Extraction

Feature extraction is the method of generating features to be used in the diagnosis and classification tasks. Feature extraction consists of simplifying the quantity of possessions required to illustrate a enormous set of data accurately. Image features can refer to: Global properties of an image: average gray level, shape of intensity, histogram etc. Local properties of an image, refers to some local features as image. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

### 2.7 Mathematical Calculations on Extracted Features

For proper diagnosis we have some statistical values. So, after extracting feature like retinal blood vessels for diagnose glaucoma, we have calculated their structural parameters like Area, Diameter, Length, Thickness and Tourtacity or Intra ocular pressure.

### III. IMPLEMENTATION

Many glaucoma patients are unconscious of the disease until it has reached its superior stage. Subjective examination of the disease is usually time consuming. Thus, the information obtained may not be reliable. Optic nerve assessment by specialist is subjective and the availability of Heidelberg Retinal Tomography and Ocular Computing Tomography equipment is limited due to the high cost involved. Therefore, an automatic and economic system is highly desirable for detection of glaucoma in large-scale screening programs. Manual analysis of eye images is somewhat time consuming and the quality of parameters measurements varies between experts. Hence, there originate the need for an automated technique. Automatic analysis of retina images is becoming an crucial screening tool now days. In early stage of glaucoma, Patients do not usually have any optical signs or indication. As the disease advancement it causes of losing the vision and the patients may sustain from tunnel visual sense. Therefore early diagnosis of this disease is necessary to prevent the permanent visual disorder [6].

### IV. WORK FLOW DIAGRAM OF EXPERIMENT NO.5

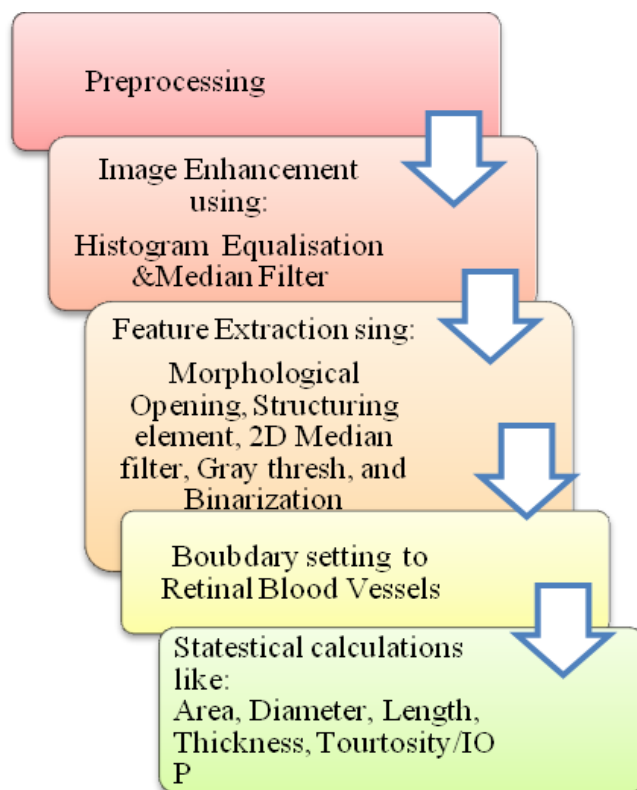


Fig. 4 Work Flow Diagram for proposed experiment

#### 4.1 Explanation of each step from Implementation

From following points we have seen detailed explanation of each step which is successive to our proposed algorithm to diagnosis glaucoma.

##### 4.1.1 Original Image

For our proposed automated system for glaucoma diagnosis, we have used 1866 retinal fundus images from different datasets. Which have different field of view, but all are in RGB form. Following figure we have taken from HRF data set i.e. High resolution fundus images. This image we have taken input for this experiment and all the remaining images from resize to final image are output of the same image.



Fig. 4.1.1 (a) Structure of retinal blood vessels (b) Sample image from HRF dataset.

##### 4.1.2 Resize Image:

The previous sampled image we have seen 60 FOV with 3504X2336 pixels image size, likewise all the data sets have different FOV and different image sizes, so for uniqueness we have resize all the images in 400X600 pixels for our convenient purpose of efficient Glaucoma diagnosis.

##### 4.1.3 Green Channel Extraction:

After resize image we have move towards preprocessing so the first step of preprocessing is color channel separation. As per our need of features we have selected green channel, because the intensity of green channel is more as compare to red and blue. And we need more intensity to segment retinal blood vessels from retinal fundus image. Following formula gives us idea about green channel separation.

$$g = \frac{G}{(R + G + B)} \quad (1)$$

Where, g= is a Green channel, R=Red, G=Green, B=Blue [7],[8].

##### 4.1.4 Complemented green channel:

In the output image, after complemented procedure dark areas become lighter and light areas become darker. In the complement of an intensiveness or RGB image, each pixel value is deduct from the maximum pixel value backed up by the class (or 1.0 for double-precision images) and the difference value is used as the pixel value in the output image.

##### 4.1.5 Apply Histogram Equalization on green image

By applying histogram equalization it enhances the contrast of the grayscale/ green image by transforming the values using contrast-limited adaptive histogram equalization (CLAHE). Tiles- CLAHE operates on small regions in the image, rather than the whole image. Apiece of tile's contrast is enhanced, so that the histogram of the output region roughly matches the histogram specified by the distribution parameter. The neighboring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The contrast,

especially in homogeneous areas, can be limited to avoid amplifying any noise that might be present in the image [9].

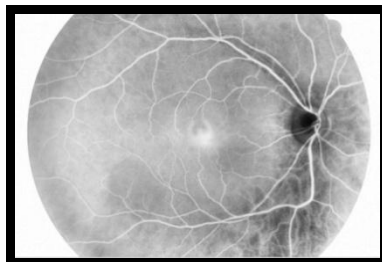


Fig. 4.1.5 Histogram equalized image

#### 4.1.6 Apply Structuring Element

Directly before seen structuring element first we have see what is morphology? And how that structuring element is used in that morphology, Morphological image processing (or *morphology*) describes a range of image processing techniques that deal with the shape (or morphology) of features in an image. Morphological techniques are typically applied to erase imperfections introduced during segmentation, and so typically operate on bi-level images. Structuring elements can be any size and make any shape. However, for simplicity we will use rectangular structuring elements with their origin at the middle pixel Fundamentally morphological image processing is very like spatial filtering The structuring element is moved across every pixel in the original image to give a pixel in a new processed image The value of this new pixel depends on the operation performed There are two basic morphological operations: **erosion** and **dilation**

**Erosion** of image  $f$  by structuring element  $s$  is given by  $f \ominus s$

$$g(x, y) = \begin{cases} 1 & \text{if } s \text{ fits } f \\ 0 & \text{otherwise} \end{cases}$$

The structuring element  $s$  is positioned with its origin at  $(x, y)$  and the new pixel value is determined using the rule:

**Dilation** of image  $f$  by structuring element  $s$  is given by the formula  $f \oplus s$

$$g(x, y) = \begin{cases} 1 & \text{if } s \text{ hits } f \\ 0 & \text{otherwise} \end{cases}$$

The structuring element  $s$  is positioned with its origin at  $(x, y)$  and the new pixel value is determined using the rule

value is determined using the rule

combinations of erosions and dilations can be performed through the main morphological operation i.e. compound operation. The most widely used of these *compound operations* are Opening & Closing. For this experiment we have used morphological opening for getting more sufficient resultant images or features [10].

#### 4.1.7 Apply Morphological Opening

The opening of image  $f$  by structuring element  $s$ , denoted  $f \circ s$  is simply an erosion followed by a dilation

$$f \circ s = (f \ominus s) \oplus s$$

The output of applying morphological opening operation on our fundus image we can see in following table

#### 4.1.8 2-D Median Filter

Input retinal image is preprocessed by converting input image into green level and after applying filter to that image. First, we need to enhance the image that we are going to use, for that applies a basic filter technique that is median filter to highlight certain features or remove other features. The median filter is a non-linear filter type



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and which is used to reduce the effect of noise without blurring the sharp edge. The operation of the median filter is – first arrange the pixel values in either the ascending or descending order and then compute the median value of the neighborhood pixels. Smoothing is done through filtering technique.

**4.1.9 Background Removed from image**

After reducing the effect of noise from image, we have concentrated on our feature i.e. retinal blood vessels. For that purpose we have remove background from the image for more highlighting retinal blood vessels.

After removing background from image again we have repeated some steps on our output image like Histogram equalization on Median Filter image, then Adjust adaptive histogram Image, then apply Morphological opening on histogram equalize image, then again removed remaining background from image, then Adjust background removed image, and then move towards our next steps like Gray thresh on adjusted image and all.

**4.1.10 Gray thresh on adjusted image**

Gray thresh performs global image threshold using Otsu's method, computes a global threshold that can be used to convert an intensity image to a binary image with conversion of RGB image to black-n-white and its normalized intensity value that lies in the range [0, 1]. The gray thresh method uses Otsu's method, which chooses the threshold to minimize the intra-class variance of the black and white pixels. Multidimensional arrays are converted automatically to 2-D arrays using reshape.

**4.1.11 Binarization gray thresh image**

In binarization of gray thresh image we have converted gray thresh image into binary image that represents whole image converting in to black and white. And in other hand, binarisation converts the grayscale image to a binary image. The output image replaces all pixels in the input image with luminance greater than level with the value 1 (white) and replaces all other pixels with the value 0 (black). Specify level in the range [0,1]. This range is relative to the signal levels possible for the image's class. Therefore, a level value of 0.5 is midway between black and white, regardless of class. To compute the level argument, we have used the gray thresh method.

**4.1.12 Apply Morphological Opening on Binaries image**

After gray thresh method we have again apply morphological opening for getting more clear results.

**4.1.13 Boundary setting on Retinal Blood Vessels**

After feature extraction we have apply boundary to retinal blood vessels for highlighting all parts. Here we have used canny edge detection method for boundary setting. Following resultant table shows figure of boundary applied to retinal blood vessels for clear visualization of all the parts present over retinal fundus image.

**4.1.14 Calculate Area, Diameter, Length, Thickness, & Tortuosity (IOP) of Retinal blood vessels**

After extraction of retinal blood vessels we calculate area, diameter, length, thickness, and tortuosity, of extracted blood vessels. Following are the formulas for the area, diameter, length, thickness, and tortuosity.

Area  $Area = \pi \times r^2 \dots\dots\dots(1)$

Diameter  $Diameter = \sqrt{Area/\pi} \dots\dots\dots(2)$

Length  $Length = Area/2 \dots\dots\dots(3)$



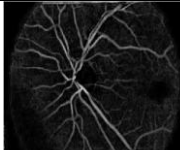
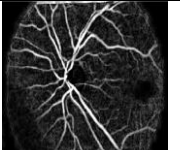
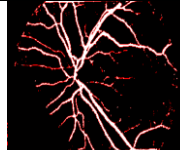


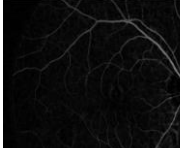
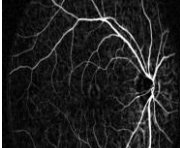


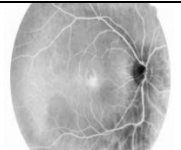
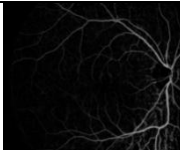

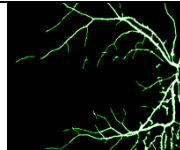
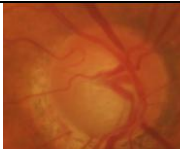
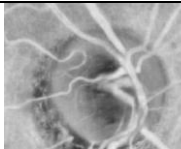
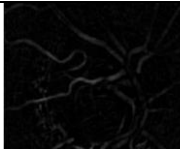
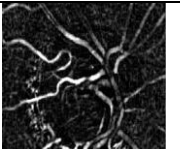
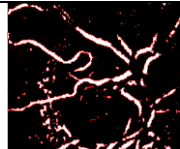

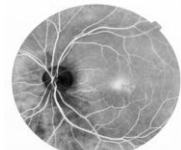
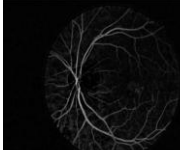
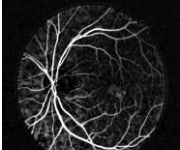
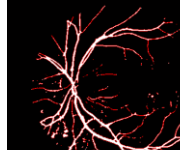
Thickness  $Thickness = Area / Length \dots\dots\dots(4)$

Tortuosity  $Tortuosity = Length / Distance \dots\dots\dots(5)$

**V. RESULTS OBTAINED FROM EXPERIMENT**

From above formulas we have calculated area, diameter, length, thickness and tortosity for glaucoma diagnosis. And through the minute difference between figures we have classify the intensity of glaucoma. Following first table show the imagery result occur from our proposed algorithm. And second table shows the statistical values getting by using above formulas.

**5.1 Table. Imagery Results from all Database for the proposed experiment**

Sr. No.	Data Base Name	Original Image	Enhance Image	2D Median Filter Image	Morphological Open Image	Final retinal blood vessels Image
1	DRIONS-DB					
2	HRF					
3	RIM-ONE					
4	DRISHTI					
5	MESSIDORE					

**5.2 Table. Statistical Results from all Data Base:**

Sr. No.	Data Base Name	Area	Diameter	Length	Thickness	Tourtosity/IOP
1	DRIONS-DB:	6616.88	45.89	50.00	2.00	28
		10667.50	58.27	31.00	2.00	14
		13507.88	65.57	26.00	2.00	31
		12269.50	62.49	53.00	2.00	33
		10589.25	58.06	17.00	2.00	16
2	HRF Normal Images:	8.33	1.63	107.00	2.00	9
		11.33	1.90	120.00	2.00	14
		12.33	1.98	21.00	2.00	7
		14.00	2.11	18.00	2.00	36
		8.33	1.63	20.00	2.00	10



2.1	HRF Glaucoma Images	8.67	1.66	45.00	2.00	45.69
		11.67	1.93	22.00	2.00	12.94
		7.67	1.56	92.00	2.00	47.38
		8.67	1.66	251.00	2.00	71.37
		5.00	1.26	310.00	2.00	16.89
3	RIM-ONE Normal Images:	7462.29	49	16	2	22.0
		8068.33	51	113	2	16.7
		5697.33	43	21	2	13.1
		7543.13	49	2	2	20.0
		7869.50	50	42	2	17.3
3.1	RIM-ONE Glaucoma Images:	7566.25	49.08	45.00	2.00	13.68
		8784.38	52.88	38.00	2.00	19.57
		9772.46	55.77	7.00	2.00	49.50
		9033.75	53.62	20.00	2.00	22.36
		9382.67	54.65	170.00	2.00	31.92
4	DRISHTI Training Images:	171.00	7.38	34.00	2.00	23.71
		12.00	1.95	91.00	2.00	26.17
		10.33	1.81	33.00	2.00	14.84
		10.33	1.81	48.00	2.00	19.76
		12.67	2.01	106.00	2.00	22.57
4.1	DRISHTI Testing Images:	6.00	1.38	5.00	2.00	26.83
		24.33	2.78	17.00	2.00	17.89
		8.67	1.66	48.00	2.00	17.58
		8.00	1.60	54.00	2.00	53.81
		11.33	1.90	23.00	2.00	24.69
5.1	MESSIDORE (Base 11):	4149.67	36.34	7.00	2.00	22.14
		9.67	1.75	44.00	2.00	38.89
		6.67	1.46	38.00	2.00	10.85
		10.00	1.78	11.00	2.00	20.43
		10.00	1.78	4.00	2.00	28.28
5.2	MESSIDORE (Base 12):	8.33	1.63	206.00	2.00	39.61
		21.67	2.63	31.00	2.00	48.41
		22.00	2.65	108.00	2.00	33.73
		5569.46	42.10	66.00	2.00	25.38
		6.67	1.46	67.00	2.00	29.10
5.3	MESSIDORE (Base 13):	5.67	1.34	60.00	2.00	47.43
		10.33	1.81	11.00	2.00	22.00
		8.00	1.60	4.00	2.00	40.00
		15.67	2.23	236.00	2.00	25.93
		14.67	2.16	205.00	2.00	26.78
5.4	MESSIDORE (Base 14):	5082.29	40.22	35.00	2.00	44.81
		5061.58	40.14	16.00	2.00	28.28
		4046.96	35.89	11.00	2.00	12.79
		3962.83	35.52	149.00	2.00	17.55
		4430.25	37.55	28.00	2.00	23.25
5.5	MESSIDORE (Base 21):	4372.21	37.31	27.00	2.00	31.39
		4265.79	36.85	21.00	2.00	20.11
		4275.13	36.89	39.00	2.00	19.80
		5166.79	40.55	75.00	2.00	47.92
		4343.83	37.18	60.00	2.00	15.76
5.6	MESSIDORE (Base 22):	3653.71	34.10	6.00	2.00	26.83
		3853.29	35.02	17.00	2.00	20.03
		3690.29	34.27	4.00	2.00	17.89
		3715.58	34.39	36.00	2.00	22.77
		4251.13	36.79	74.00	2.00	28.01
5.7	MESSIDORE (Base 23):	5924.38	43.43	217.00	2.00	30.80
		3793.96	34.75	11.00	2.00	15.56





		3853.88	35.02	18.00	2.00	23.05
		5569.46	42.10	66.00	2.00	25.38
		3988.79	35.63	19.00	2.00	24.95
5.8	MESSIDORE (Base 24):	5238.42	40.83	6.00	2.00	21.21
		4828.71	39.20	148.00	2.00	14.99
		4669.29	38.55	3.00	2.00	13.42
		4420.08	37.51	47.00	2.00	14.35
		4248.63	36.77	44.00	2.00	35.12
5.9	MESSIDORE (Base 31):	4394.29	37.40	12.00	2.00	11.94
		3584.75	33.78	43.00	2.00	14.29
		3574.25	33.73	51.00	2.00	28.51
		4137.92	36.29	340.00	2.00	65.37
		4990.58	39.86	61.00	2.00	50.48
5.10	MESSIDORE (Base 32):	3839.33	34.96	41.00	2.00	22.24
		4069.42	35.99	116.00	2.00	21.29
		3864.13	35.07	59.00	2.00	17.08
		3781.63	34.69	75.00	2.00	10.12
		4992.92	39.87	284.00	2.00	28.40
5.11	MESSIDORE (Base 33):	4032.79	35.83	45.00	2.00	28.75
		3678.21	34.22	18.00	2.00	22.33
		4621.88	38.36	74.00	2.00	16.61
		4545.08	38.04	531.00	2.00	19.23
		4648.29	38.47	14.00	2.00	16.27
5.12	MESSIDORE (Base 34):	3860.29	35.05	72.00	2.00	32.79
		3710.54	34.37	23.00	2.00	15.47
		4117.58	36.20	40.00	2.00	32.77
		4893.96	39.47	17.00	2.00	19.01
		3926.96	35.36	29.00	2.00	16.29

5.3 Table. Results in System Classified Form:

Sr. No.	Data Base Name	Normal	Glaucoma			Glaucoma %	Normal %
			Mild	Mode	Moderate		
1	DRIONS-DB	26	32	09	43	76.36	23.64
2.1	HRF (Normal)	12	01	00	02	20.00	80.00
2.2	HRF(Glaucoma)	06	01	00	08	60.00	40.00
3.1	RIM-ONE (Normal)	137	25	22	41	39.11	60.89
3.2	RIM-ONE (Glaucoma)	89	29	23	59	55.50	44.50
4.1	DRISHTI(Training)	13	14	06	17	74.00	26.00
4.2	DRISHTI(Testing)	15	21	08	07	70.59	29.41
5.1	MESSIDORE(Base11)	30	46	11	13	70.00	30.00
5.2	MESSIDORE(Base12)	31	31	10	28	69.00	31.00
5.3	MESSIDORE(Base13)	36	30	10	27	62.00	38.00
5.4	MESSIDORE(Base14)	39	24	04	33	61.00	39.00
5.5	MESSIDORE(Base21)	40	18	16	26	60.00	40.00
5.6	MESSIDORE(Base22)	42	17	22	19	58.00	42.00
5.7	MESSIDORE(Base23)	31	31	06	32	69.00	31.00
5.8	MESSIDORE(Base24)	45	17	13	25	55.00	45.00

5.9	MESSIDORE(Base31)	41	10	27	22	59.00	41.00
5.10	MESSIDORE(Base32)	33	19	19	29	67.00	33.00
5.11	MESSIDORE(Base33)	30	20	26	24	70.00	30.00
5.12	MESSIDORE(Base34)	37	15	09	39	63.00	37.00

5.4 Fuzzy C-Means Classification applies on MESSIDORE (Base 31 to 34) Data Base

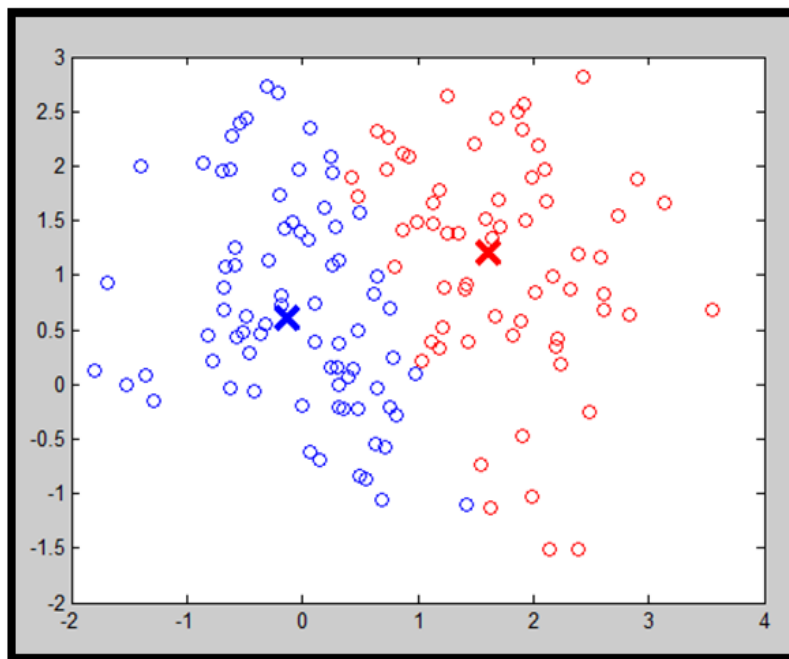


Fig.5.4 C-Means Classification applies on MESSIDORE Data Base

5.5 K-Means Classification applies on MESSIDORE Data Base:

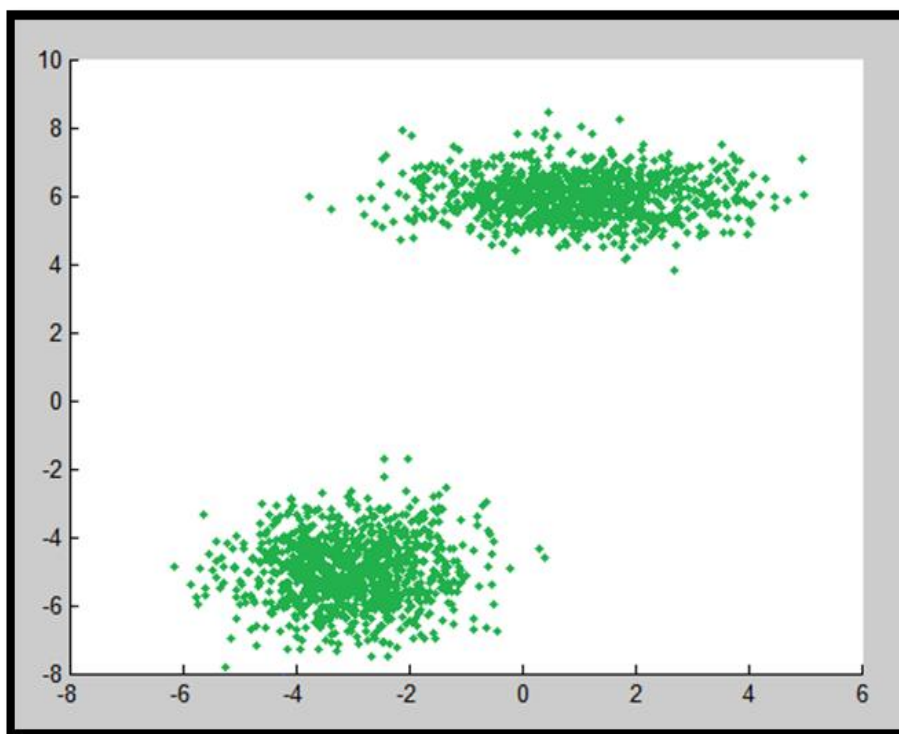


Fig.5.5 K-Means Classification applies on MESSIDORE Data Base

5.6 K-Means Clustering applies on MESSIDORE (Base 31 to 34) Data Base:

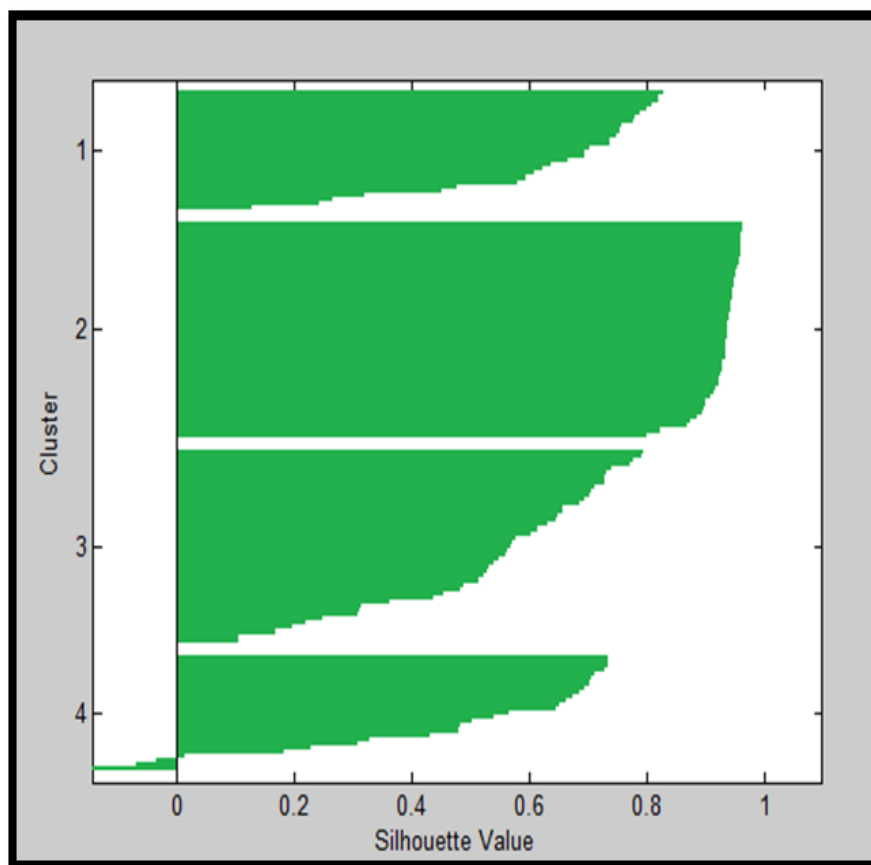


Fig.5.6 K-Means Clustering applies on MESSIDORE Data Base

## VI. CONCLUSIONS

Here we have concluded that like CDR (cup to disc ratio), RDR (rim to disc ratio), IOP (Intra ocular pressure) is also very important factor in Glaucoma diagnosis procedure. For this experiment we have used morphological method for feature extraction and median filter with other supporting methods used for image preprocessing and image enhancement procedure and we get sufficient results through this experiment as we have mentioned in above resultant tables.

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