Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AN ANFIS BASED PATTERN RECOGNITION SCHEME USING RETINAL VASCULAR TREE – A COMPARISON APPROACH WITH RED-GREEN CHANNELS

[1]G. LALLI, [2]Dr. D. KALAMANI, [3]N. MANIKANDAPRABU.

[1]Assistant Professor (Sl.G.-II), Dept. of CA, Erode Sengunthar Engineering College, TN, India
[2]Associate Professor, Dept. of Mathematics, Kongu Engineering College, TN, India
[3]Lecturer, Dept. of ECE, Senthur Polytechnic College, TN, India
E-Mail ID: lalligovindasamy@gmail.com, manikandaprabube@gmail.com

Mobile Phone: +91 9789909740, +91 9150061808

ABSTRACT

Research Work: This Article focuses the perspective of retinal blood vessel classification and detection in digitized retinal images. The color-based channels like green and red channels extraction processes lead to the enhanced identification of retinal blood vessel through the performance measures using Receiver Operating Characteristics (ROC).

Processes with Methodologies: This proposed system uses the digital images of the databases diaretdb0 and diaretdb1. The retinal vascular structures of these two databases are very precise and perfect. The resized image further involved with two different progressions of color-channel (Red and Green channels particularly) conversion. These extracted features are enhanced with CLAHE (Contrast Limited Adaptive Histogram Equalization) technique. The morphological operations performed for optic disk, noise and border removal. The difference between its' MATLAB based erosion and dilation processes on basis of Canny-Edge Detection technique with Threshold value. These kind of performance measure of the system learned through Receiver Operating Characteristics (ROC) with Sensitivity (Se) and Specificity (Sp) using True Positive (P), True Negative (P^1), False Positive (N) and False Negative (N^1) to be used for determining the 'Authorization' or 'Unauthorization'. The "Count of Pixels" indicates area of blood vessels in respect with Red and Green channels based features are calculated for gaining accuracy of the retinal vascular structure of an image.

Result: The performance measure with ROC is applied for retinal blood vessel identification. This kind of systemic processes may be a new perspective in classification, detection and identification of retinal blood vessels.

Keywords: *Retinal Vascular Structure, ROC, diaretdb0, diaretdb1, Threshold Value, CLAHE, Morphological Operations.*

1. INTRODUCTION:

A biometric system identifies a person through the characteristics of both physical and behavioral features like retina, finger print, iris, face, palm, signature, gait, etc. The biometric trait can be qualified with the characteristic properties such as uniqueness, life-time permanence, qualitative measurement, distinctiveness and universality.

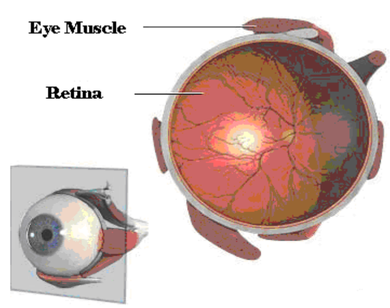


Figure 1. A general View of Retinal

Awareness of the uniqueness of the retinal vascular pattern dates back to 1935 when two ophthalmologists, Drs. Carleton Simon and Isodore

Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Goldstein, while studying eye disease, realized that every eye has its own totally unique pattern of blood vessels. They subsequently published a paper on the use of retinal photographs for identifying people based on blood vessel patterns (Simon and Goldstein, 1935). Later in the 1950s, their conclusions were supported by Dr. Paul Tower in the course of his study of identical twins. He noted that, of any two persons, identical twins would be the most likely to have similar retinal vascular patterns. However, Tower's study showed that of all the factors compared between twins, retinal vascular patterns showed the least similarities (Tower, 1955) [1 -2].

Retina: In the center of the retina is the optic nerve, a circular to oval white area measuring about 2 x 1.5 mm across. From the center of the optic nerve radiates the major blood vessels of the retina. Approximately 17 degrees (4.5-5 mm), or two and half disc diameters to the left of the disc, can be seen the slightly oval-shaped, blood vessel-free reddish spot, the fovea, which is at the center of the area known as the macula by ophthalmologists

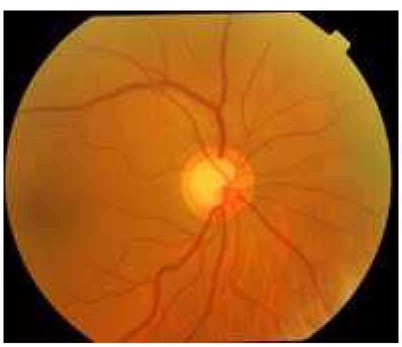


Figure 2. A view of Retina seen through Ophthalmoscope.

There are two sources of blood supply to the mammalian retina: the central retinal artery and the choroidal blood vessels. The choroid receives the greatest blood flow (65-85%) (Henkind et al., 1979) and is vital for the maintainance of the outer retina (particularly the photoreceptors) and the remaining 20-30% flows to the retina through the central retinal artery from the optic nerve head to nourish the inner retinal layers. The central retinal artery has 4 main branches in the human retina. The vessels in Fig.2. emerge from the Optic nerve head and run in a redial fashion curving towards and around the fovea (asterisk in photograph)[3].

Figure *3. Fundus Photograph imaging with the major Nerve Fibers of the retina available in Figure 2..*

2. THE ROPOSED METHODOLOGICAL RETINAL IMAGE PROCESSING:

This proposed system consists of new sequential methodological processes on retinal digitized image. The following flow illustrates the over all image-oriented process sequences.

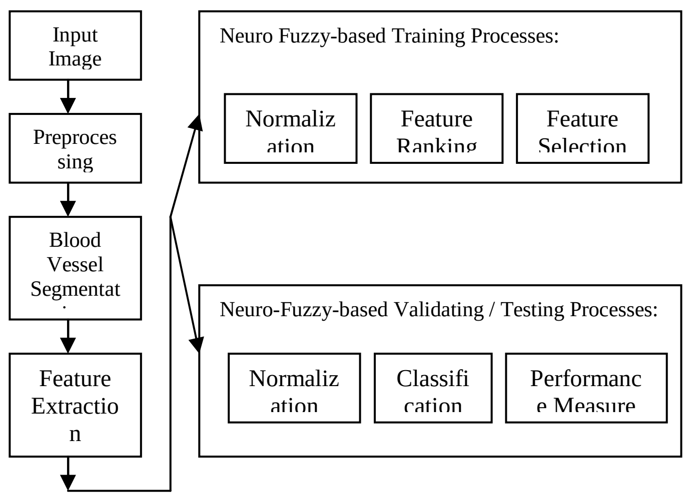


Figure 4. Over all Flow of Image-oriented processing

This system collects more than 219 retinal fundus images from diaretdb0 and 50 retinal fundus images from diaretdb1. An image is resized with 500x500 matrix sized in it's preprocess level. The morphological Segmentation operations are performed on the preprocessed image for it's segmentation. Canny-Edge Detection with Threshold value 0.09 is used for feature extraction of the image. The normalization is done for fixing the feature value in between the fuzzy interval 0 and 1. The neural network based training processes contain the feature ranking and feature selection. The blood vessel count/area is calculated through the Wavelet Transformation for ranking the feature. The Linear Discriminant Analysis (LDA) is used

Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

for feature selection. Similarly, the neural network based validating process have the fuzzy membership function based normalized image values for its' classification and for finding the performance measure. The image is classified with Adaptive Neuro Fuzzy Inference System (ANFIS) with subtractive cluster sequence with rules. There is possible that the system's convergence at certain epoch.

3. METHODOLOGIES USED:

Databases (diaretdb0 and diaretdb1): The Standard Diabetic Retinopathy Database (Calibration Level 0) named **diaretdb0** and Standard Diabetic Retinopathy Database (Calibration Level 1) named **diaretdb1** consist standard images. The database diaretdb0 has 130 color retinal fundus images. All fundus images were acquired using a Zeiss FF450+ fundus camera[4]. The database diaretdb1 has 89 color retinal fundus images. The pixels at 24 bit RGB, captured using a 50◦ field-of-view digital fundus camera[5]. These images are used as our training set of images.

3.1. Image: Green and Red Channels Extraction: The resized fundus image is converted in two different colored features for further image processes. One is Green-color basis, which has the green channel of retinal vascular. Another one is in Red level, in which the extraction of the red channels of retinal vascular only.

3.2. Contrast Limited Adaptive Histogram Equalization (CLAHE): In both way of separate serial processes, the contrast-limited adaptive histogram equalization (CLAHE) is used for enhancing the extracted image. J = adapthisteq(I) enhances the contrast of the grayscale image I by transforming the values using CLAHE. CLAHE operates on small regions in the image, called *tiles*, rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately 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[6].

3.3. Mathematical Morphological Processes:

The operations 'ball' and 'disk' are used with the values r=6 and radius value=6 for disk and border removal respectively. These processes are performed only for obtaining the fibers of retinal blood vessels.

3.4. Median Filter for Noise Removal:

The Median Filtering technique is used for removing the existing noise in the image. In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal.

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing like edge detection on an image. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise[7 – 8]. The median can be used as a measure of location when a distribution is skewed, when end-values are not known, or when one requires reduced importance to be attached to outliers, e.g., because they may be measurement errors.

Formula: MEDIAN = { $(n + 1) / 2$ }th item; n = number of values.

The processes produced the noiseless fine fibers of retinal blood vessels for the authentic processes with the help of retinal vascular structure.

Figure 5 Noise Removal Processes

Fig. Noise Removal in Pixel-based Matrices with Red and Green Channels (Row-wise Process)

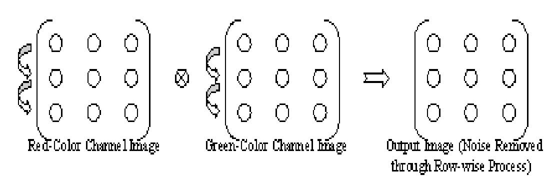
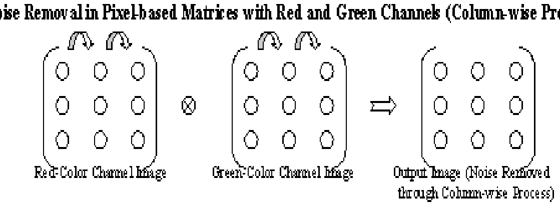


Fig. Noise Removal in Pixel-based Matrices with Red and Green Channels (Column-wise Process)



3.5. Canny Edge Detection:

The standard edge detection algorithm developed by John F. Canny (JFC) in 1986 [9] is

Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

used in this proposed research work. Even though it is quite old algorithm, it has become one of the standard edge detection methods and it is still used in any kind of edge detection based research [10 - 11].

The first step is to filter out any noise in the original image before trying to locate and detect any edges. The Sobel operator uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows).

They are shown below:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

The magnitude, or EDGE STRENGTH, of the gradient is then approximated using the following formula:

$$|G| = |Gx| + |Gy| \quad (1)$$

where, G_X and G_Y are the gradients in the x- and y-directions respectively.

The Manhattan distance measure as shown in Equation (1) is applied to reduce the computational complexity.

The formula for finding the edge direction is done as follows:

$$\text{theta} = \text{invtan}\,(Gy / Gx) \quad (2)$$

The direction of the edges must be determined and stored as shown in Equation (2).

3.6. Blood Vessel Area Calculation:

The original size of the image 1150 x 1500 is resized and used in the form of matrix.

The matrix of image is labeled as a_bloodvessel[500x750]. The below procedure can be used to calculate the area of blood vessels ie. the existence of the number of pixels.

The following codes are used in MATLAB process.

```
for (x=1; x<=500; x++)
    for (y=1; y<=750; y++)
     if (a_bloodvessel[x,y] ==1) then
         area=area+1.
```

3.7. Logical AND Operation:

The 'AND' operation is performed on Contrast features of Red and Green channels which are extracted through the sequential processes such as component extraction, image-feature enhancement and image-feature segmentation processes done on the input image ie. the fundus retinal image with the ophthalmoscope blood vessels components represented in the System flow processes given below in Figure 6. entitled as Systemic Flow of Image Processing.

Table 1. Truth Table for Logical AND Operation:

Truth Table: AND Logic		
Inputs		**Output**
In$_1$	**In$_2$**	**Out**
0 (False)	**0** (False)	**0** (False)
0 (False)	**1** (True)	**0** (False)
1 (True)	**0** (False)	**0** (False)
1 (True)	**1** (True)	**1** (True)

The Logical AND operation can be used to obtain the real common features from the contrast processed features of Red and Green Channels.

Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. SYSTEM FLOW:

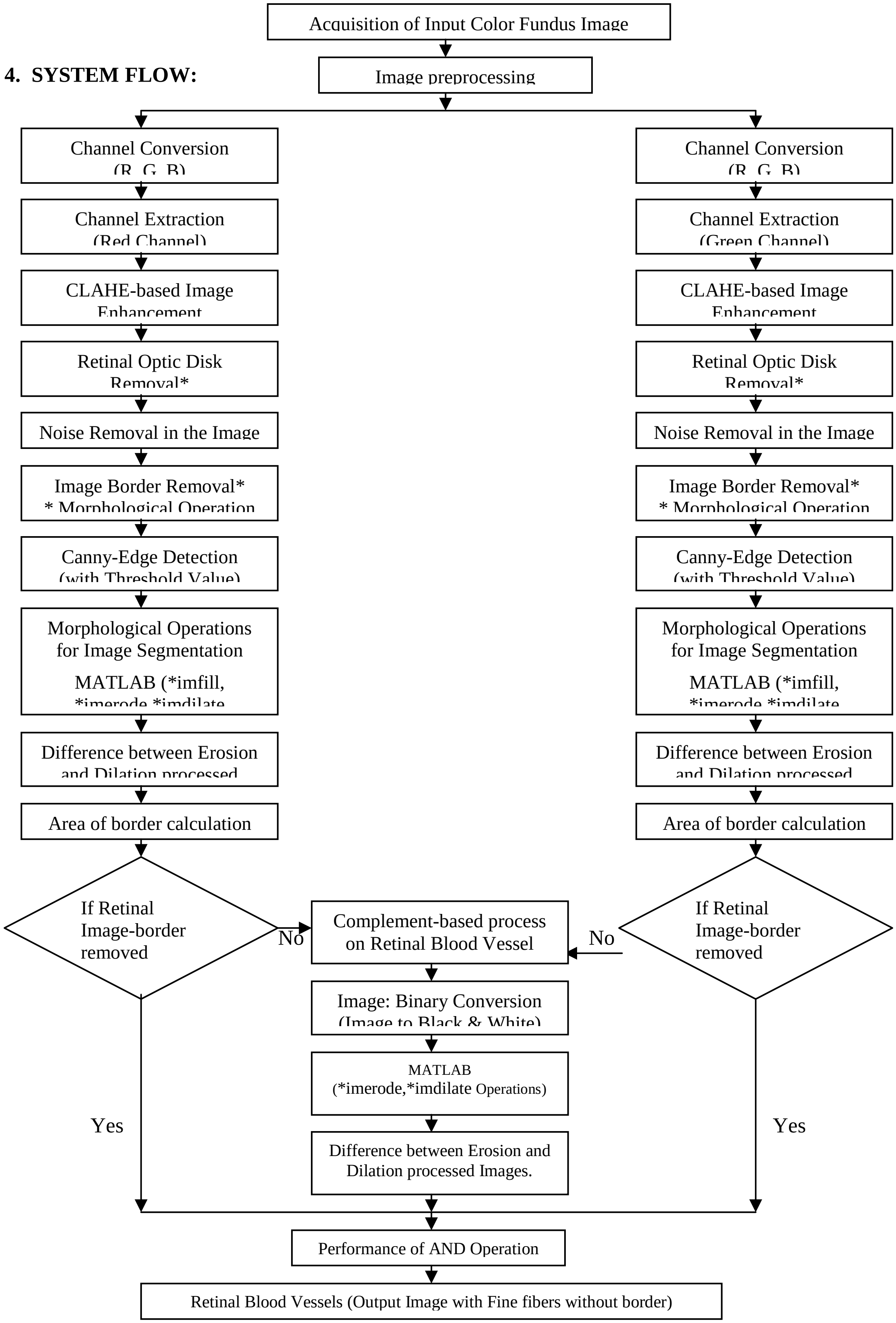


Figure 6. Systemic flow for Image Processing

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5. SYSTEMIC RESULTANT VALUES: IMAGE-BASED IMPLEMENTATION:

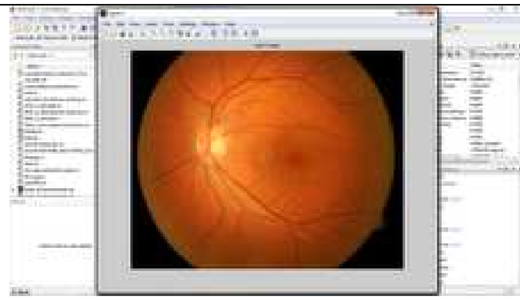
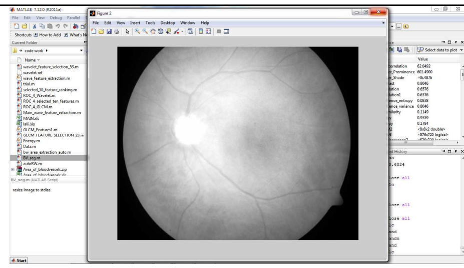
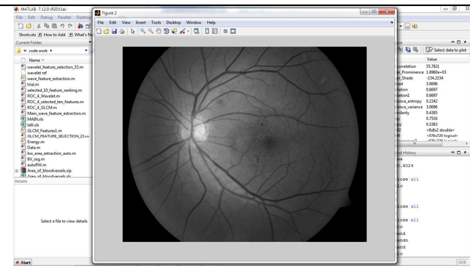
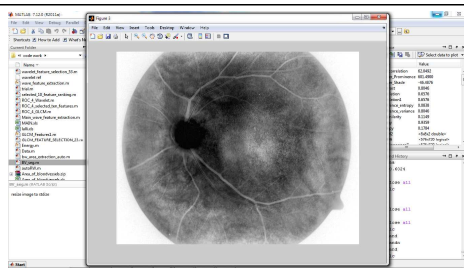
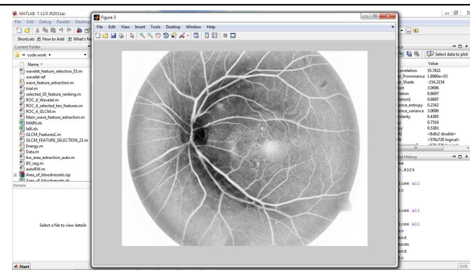
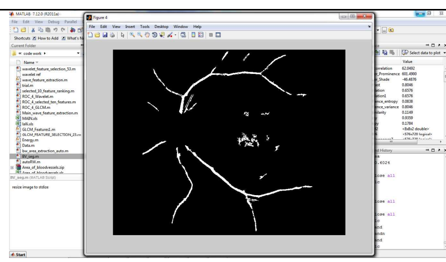
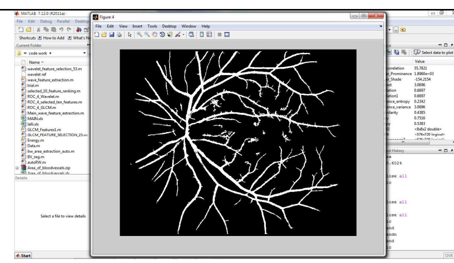
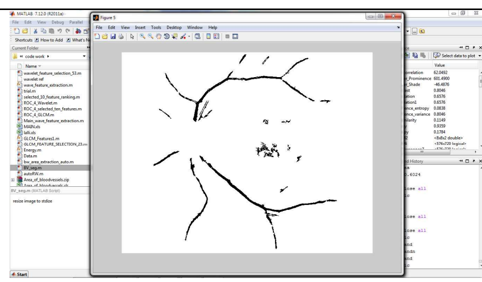
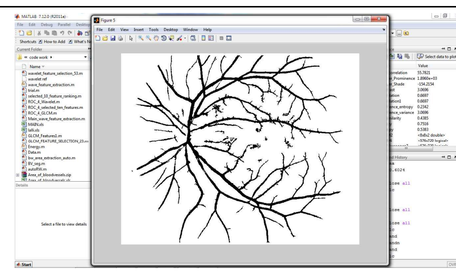
Parameters	Systemic Process – A Sequence of Red and Green Channel Processes	
Step-1: Input Image (Fundus Image of Retina and it's Blood Vessels)		
Features	**Red Channel-based Processes**	**Green Channel-based Processes**
Step-2: Component Extraction		
Step-3: Image Enhancement (Output Image)		
Step-4: Image Segmentation (Segmenting Blood Vessels)		
Step-5: Contrasting Process		

Figure 7. Red-Green Channel Based Systemic Processes Of An Retinal Image

Journal of Theoretical and Applied Information Technology
10th January 2014. Vol. 59 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5.2 Results of Image-based Implementation:

Table 2. Pixels Counts of Red and Green Channels of Images:

Input Image(s)	RED Channel (Count of Pixels)	GREEN Channel (Count of Pixels)	Ground Truth Value
img1	3984	16512	15537
img2	3890	18068	18080
img3	3709	13439	11464
img4	4280	11366	10325
img5	8130	31598	30553
img6	10158	43841	45895
img7	7544	26983	28955
img8	7008	20095	19175
img9	8857	30908	28930
img10	18203	30038	29070

5.3 Graphical Representation of Results of Image-based Implementation:

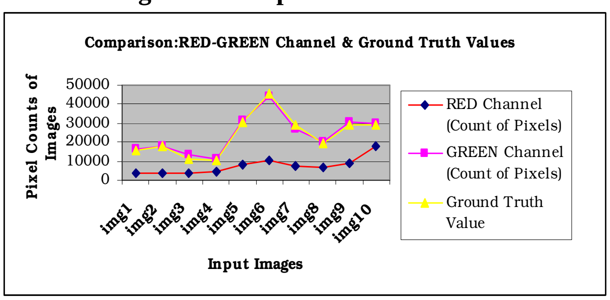


Figure 8. Graphical Representation of Pixels Counts of Red and Green Channels of Images:

6 FUTURE-SYSTEM PERFORMANCE EVALUATION:

Input Image		Desired Value		Decision	
		Positive	Negative		
Actual Value	Positive (True)	P	P^1	*Authrorization*	$P / (P + P^1)$
	Negative (False)	N^1	N	*Unauthorization*	$N / (N^1 + N)$
ROC		*Sensitivity*	*Specificity*	Accuracy = $(P + N) / (P + P^1 + N^1 + N)$	
		$P / (P + N^1)$	$N / (P^1 + N)$		

Figure 9. Performance Measure with ROC

The patterns may be matched in terms of "Sensitivity" and "Specificity" to determine the accuracy as well as for authentication and authorization.

Sensitivity: Test-Matching Process is Positive. The Patterns are matched.

Specificity: Test-Matching Process is Negative. The Patterns are mismatched.

These concepts may be determined according to the following formulae:

Sensitivity (Se) = $P / (P + N^1)$

Specificity (Sp) = $N / (P^1+N)$

Authorization = $P / (P+ P^1)$

Unauthorization = $N / (N^1+N)$

Accuracy = $(P+N) / (P+ P^1+ N^1+N)$

7 CONCLUSION:

The retinal blood vascular structure of a person can be determined by detecting the pattern matching process in between the stored and the current generated images. For the accurate identification of an image, the red and green channel features are implemented and compared through the "Count of Pixels", which represents the area of blood vessels of the processed image. The Green Channel-based blood vessel features are determined for identification with the fine fiber format rather than Red Channel-based blood vessels. The ROC performance related processes with Wavelet Transformation and GLCM are also considered for accurate measurement for feature identification as future research work.

REFERENCES:

[1] De Schaepdrijver, L., Simoens, L. P., Lauwers, H., and DeGesst, J. P. "Retinal vascular patterns in domestic animals". Res. Vet. Sci., 47:34-42, 1989.

[2]Family, F., Masters, B. R., Platt, D. E. "Fractal pattern formation in human retinal vessels". Physica D 38:98-103, 1989.

[3] Helga Kolb, "Simple Anatomy of Retina".

[4] Kauppi, T., Kalesnykiene, V., Kamarainen, J.-K., Lensu, L., Sorri, I., Uusitalo, H., Kälviäinen, H., Pietilä, J., *DIARETDB0: Evaluation Database and Methodology for Diabetic Retinopathy Algorithms*, Technical report

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[5] Kauppi, T., Kalesnykiene, V., Kamarainen, J.-K., Lensu, L., Sorri, I., Raninen A., Voutilainen R., Uusitalo, H., Kälviäinen, H., Pietilä, J., *DIARETDB1 diabetic retinopathy database and evaluation protocol*, Technical report.
[6] Zuiderveld, Karel. "Contrast Limited Adaptive Histograph Equalization." *Graphic Gems IV*. San Diego: Academic Press Professional, 474–485, 1994.
[7] E. Arias-Castro and D.L. Donoho, "Does median filtering truly preserve edges better than linear filtering?", Annals of Statistics, vol. 37, no. 3, pp. 1172–2009.
[8] G.R. Arce, "Nonlinear Signal Processing: A Statistical Approach", Wiley:New Jersey, USA, 2005.
[9] John Canny. A computational approach to edge detection. Pattern Analysis and Machine Intelligence, IEEE Transactions on, PAMI-8(6):679–698, Nov. 1986.
[10] Sergei Azernikov. Sweeping solids on manifolds. In Symposium on Solid and Physical Mod-eling, pages 249–255, 2008.
[11] F. Mai, Y. Hung, H. Zhong, and W. Sze. A hierarchical approach for fast and robust ellipse extraction. Pattern Recognition, 41(8):2512–2524, August 2008.