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# STUDY OF FEATURE EXTRACTION OF RETINAL SCANS

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## ABSTRACT

*In this paper, the retina is discussed as part of the feature of extraction of retinal scans for use in security systems as a means of identification. The design system contains a method of image acquisition and processing of the image. A computer system is also incorporated for matching and verifying the image captured to an already present representation of unique features of the retina that are stored as templates for matching and identification. It should then either allow or deny the user depending on the results of the matching process. This paper shows the development of the step undertaken to process the image to the extraction of the features. The high resolution images are taken through a series of image enhancement process before feature extraction technics are applied and before templates are created for future referencing. The main limitation of this process is attributed to capturing the image from the retina. The image obtained may be of poor quality thus making the unique features of the retina unclear.*

## KEYWORDS:

*Feature extraction, retinal scans*

## 1. Introduction

A wide variety of systems require reliable personal recognition schemes and methods to ascertain and determine the identity of individuals accessing various areas or services. The purpose of these schemes is to ensure the services to be rendered are accessed only by authorized personnel with the necessary clearance. This in-turn prevents unwanted guests. Zones that may utilize biometric acknowledgment plans incorporate secure access to private regions of a structure, PC frameworks to forestall unapproved logins, and government and military offices. Such offices are powerless against security ruptures and would require abnormal state security to check such occurrences (Drozd, Hájek & Drahanský, 2012).

Biometric recognition alludes to the robotized acknowledgment/ID of people

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dependent on their physiological attributes and somewhat likewise social qualities. By utilization of biometrics, it is conceivable to accomplish this abnormal state of security necessities in the offices referenced previously. For this paper, we will focus on the utilization of retinal scans as methods for recognizable proof and the retina as the biometric (Panchal, Bhojani & Panchal 2016; Modarresi, Oveisi & Janbozorgi, 2017).

The retina contains numerous blood vessels which form distinct patterns in the eye. This unique blood vessels patterns form the foundation of the retinal recognition system. "*There are two famous studies that confirmed the unique blood vessel pattern found in the retina*" (Yavuz & Cemal, 2017):

*1. "The first was published in 1935 by Dr. Carleton Simon and Dr. Isodore Goldstein which basically described how every retina has its own unique pattern.*

2. *The second was published in the 1950s by Dr. Paul Tower. He confirmed that each retina in each eye has a different blood vessels pattern and also using photographs he showed that even identical twins have different pattern in their retinas*" (Yavuz & Cemal, 2017).

This was the breakthrough that enabled the retina to be considered as a means of recognition because of the uniqueness it contains. The main limitation of the process of feature extraction of the retinal scans and performance of the retinal scanning process is attributed to capturing the image from the retina. The image obtained may be of poor quality thus making the unique features of the retina unclear (Lam, Yu, Huang & Rubin, 2018). This paper is tasked with developing a system to extract the features in a retinal scan as an aid to identification of different individuals.

## 2. Design methodology

The objective of the paper is to implement a system that extracts the features of a retinal scan to be used as aids in a retinal identification system. The development tool used to extract this features is a software based and MATLAB, which is a high-level language and interactive environment for numerical computation, visualization, and programming. Emphasis is made on the process of image processing and feature extraction and not the process of capturing the retinal scan using a retinal scanner. For the purpose of this paper, images of retinal scans are obtained from a standard international image database to test and verify the various codes in the program. The database used is known as Digital Retinal Image for Vessel Extraction (DRIVE). The details of the design are explained in the subsequent sections.

### *2.1. Image acquisition*

Image acquisition is the process of obtaining an image from a source. This source is usually a hardware source like a digital camera or mobile phone. In this paper, it is the process of obtaining the color image photograph of the retina to be used for feature extraction. The color image is obtained with the help of a specialized hardware source known as retinal image scanner. MATLAB provides image acquisition toolbox which helps the reading in image and preparing it for image pre-processing.

### *2.2. Image pre-processing*

This is the way toward setting up the procured images for image upgrade. Image resizing is the real procedure done. This decreased the extent of the image to empower advanced image handling to be done. It empowers the MATLAB application to show the full image rather than a decreased size of the image as saw before resizing the image is appeared 67 % rather than the typical 100 %.

### *2.3. Image enhancement*

This is a procedure that generally includes evacuating low frequency background noise that may emerge during image securing process, normalizing the intensity of the different pieces of the image, sharpening, filtering and smoothing the image. This procedure features the regions of intrigue. As for this paper, it is the way toward making the image attributes progressively noticeable and featuring the veins of the retina in readiness of the element extraction process. It includes four procedure; Red, Green and Blue color model (RGB) to grayscale change and green channel image choice, histogram adjustment, noise removal and filtering, and image sharpening and smoothening.

*2.3.1. RGB grayscale conversion and green channel image selection*

This is the process of converting the true color image RGB to the grayscale intensity image. This is done by eliminating the hue and saturation information of the image and retaining the luminance of the image. Luminance is described as the amount of light that is emitted from a specific area of the image. The conversion basically gives a scale of the various intensities of the image from the lowest to the highest based on their light each part of the image emits. MATLAB application uses the same technique to perform the conversion. It ranks the various intensities using a scale of 0-255 which means that zero refers to the darkest shade of gray while 255 refers the lightest shade of gray. Green channel selection is using the green channel to perform the image enhancement procedures. This channel is chosen from the three of RGB, because it has the highest intensity as compared to red and blue.

*2.3.2. Histogram equalization*

This is the process of enhancing an image using the image histogram. It enhances the image by transforming the values in an intensity image such that the histogram of the image obtained after the process matches a specified histogram. The specified histogram parameters are defined to allow one to get the output desired.

*2.3.3. Noise removal and filtering*

Digital images are susceptible to a wide range of noise. Noise in images could arise from the process of image acquisition such that the image does not reflect the true intensities of the all pixels. This may be as a result of how the image was transmitted from the acquisition hardware, process of acquisition or even during transmission of the image through electronic media. There are various methods of noise removal; linear filtering, median filtering, and adaptive filtering. For this paper, both adaptive and median filters have been used to remove the noise in the images during the image enhancement process. This is due to their advantages and superiority in terms of quality of the images produced and appearance.

*2.3.4. Image sharpening and smoothing*

This is a process of enhancing that deals with de-blurring an out of a focus image, highlighting edges, improving image contrast and brightening the image.

### *2.4. Feature extraction*

This is the process of obtaining the unique blood vessels from the image using image processing techniques. This is a post processing procedure carried out on the image. It involves morphological structuring, and feature detection.

*2.4.1. Morphological structuring*

Morphology relates to the study of object forms and shapes. Morphological structuring applies mathematical morphology operators by applying structuring elements to binary images. The operators include dilation and erosion. Dilation expands objects by structuring elements, filling holes and connecting disjointed regions while erosion shrinks objects by structuring element, therefore small object are eliminated. Morphological structuring elements are referred to as STREL. The structuring element (SE) is defined by a shape and specified parameters define the shape assumed. The shapes include ball, diamond, disk, line, octagon, rectangle and square. Each of these shapes have various parameters for example the 'disk' shape has parameters such as radius. Skeletonization is a process of reducing distinct features of an image to single smaller lines for easier identification without changing the essential structure of the image. This process is used to get ride if the minute points or small lines that interfere with major continuous blood vessels. It is used to reduce the thick blood vessels into small sizeable lines for easier detection using feature detection technics.

*2.4.2. Feature detection*

For the recognition of the veins, the sides of the lines that structure the vein are utilized to recognize the veins. Since the veins lines are conflicting and have various sharp twist, the features from accelerated segment test (FAST) algorithm is used to detect them and return corner points.

## 3. Simulation results

The results which are shown below are arranged in order of the stages outputs of each step of the design methodology. Each stage shows two different images for comparison purposes.

### *3.1. Image acquisition stage*

Figure no. 1 and Figure no. 2 show the results of the code as highlighted in the design methodology.

*Figure no. 1. Image acquired from 1st retina*

*Figure no. 2. Image acquired from 2nd retina*

### *3.2. Image Pre-Processing Stage*

The image is resized to enable efficient conditions for image enhancement as shown in Figure no. 3 and Figure no. 4.

*Figure no. 3. Image resize of 1st retina by a scale of 0.5*

*Figure no. 4. Image resize of 2nd retina by a scale of 0.5*

### *3.3. Image enhancement stage*

The first step of this process is conversion of the RGB to grayscale image and selection of the green channel enhancement. This is shown in Figure no. 5 and Figure no. 6.

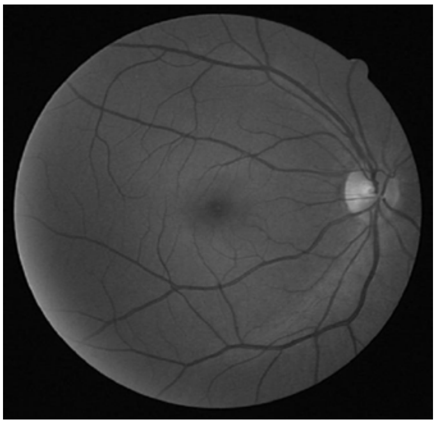

*Figure no. 5. Green channel image 1*

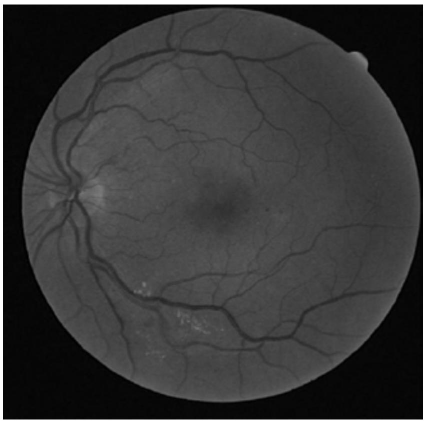

*Figure no. 6. Green channel image 2*

This phase involves histogram equalization as shown in Figure no. 7 and Figure no. 8.

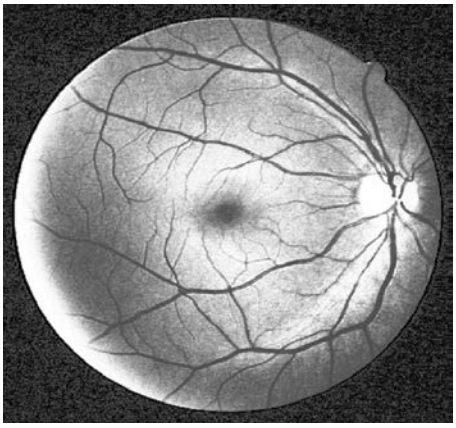

*Figure no. 7. Histogram equalized image 1*

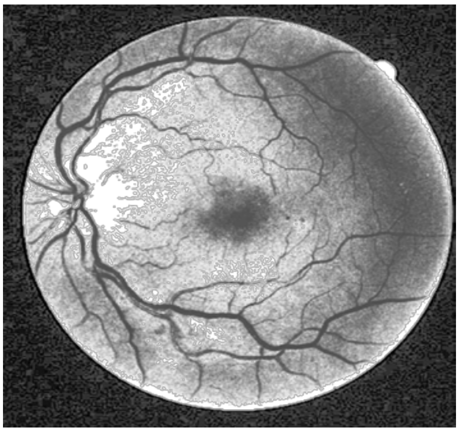

*Figure no. 8. Histogram equalized image 2*

At this stage, the histogram equalized image is sharpened to make edges of the vessels clearer as shown in Figure no. 9 and Figure no. 10.

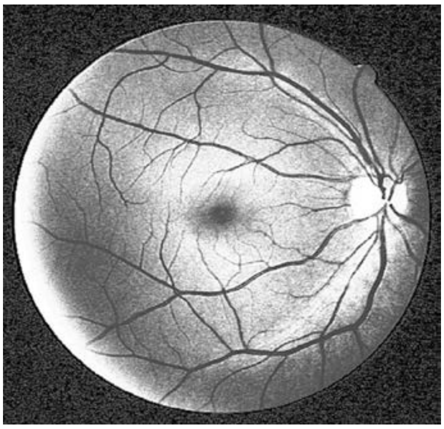

*Figure no. 9. Sharpened image 1*

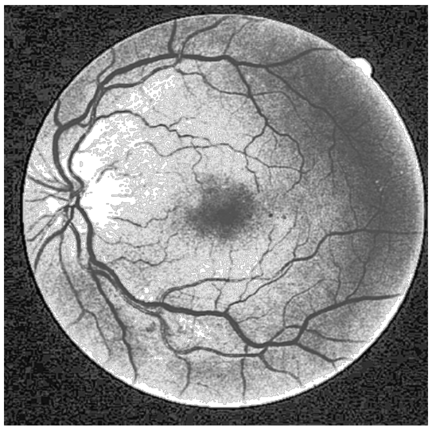

*Figure no. 10. Sharpened image 2*

Adaptive histogram equalization is carried out on the image to increase the intensity of the image as shown in Figure no. 11 and Figure no. 12.

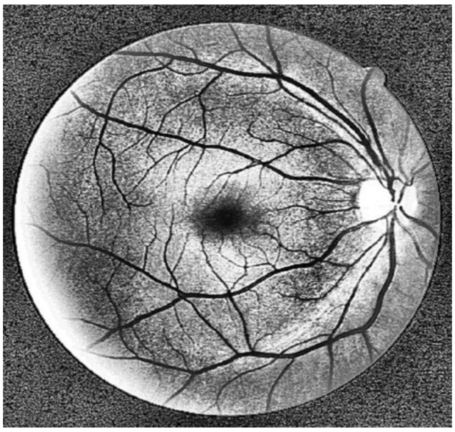

*Figure no. 11. Adaptive histogram equalized image 1*

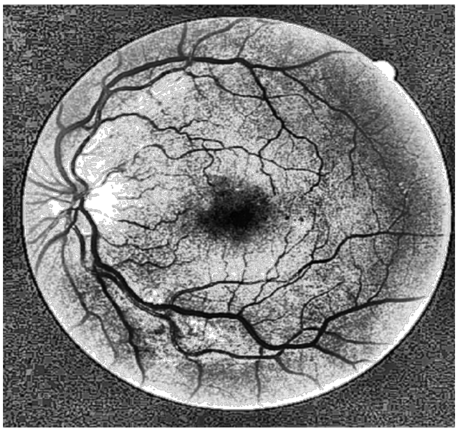

*Figure no. 12. Adaptive histogram equalized image 2*

Noise as a result of image enhancement is removed using filtering methods and wiener method as shown in Figure no. 13 and Figure no. 14.

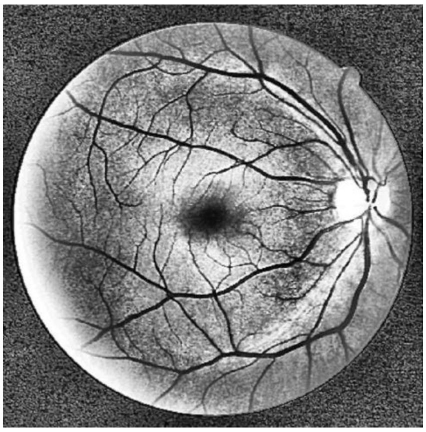

*Figure no. 13. Noise removal in image*

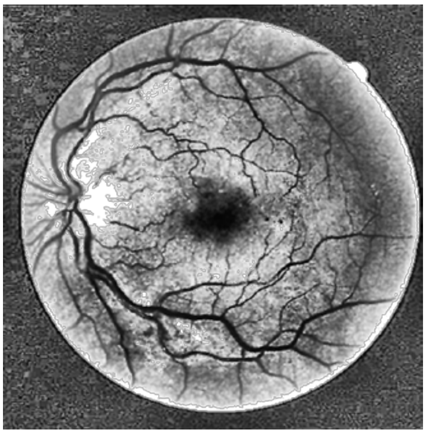

*Figure no. 14. Noise removal in image 2*

Contrast of the image is adjusted to enhance the detail as shown in Figure no. 15 and Figure no. 16.

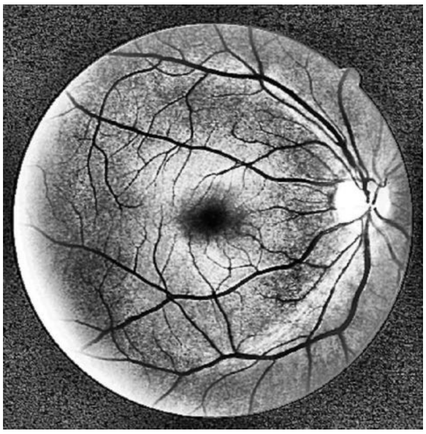

*Figure no. 15. Contrast adjustment in image 1*

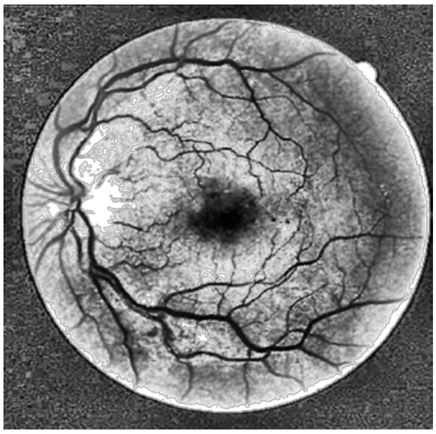

*Figure no. 16. Contrast adjustment in image 2*

Filtering and smoothing is done again to enhance the edges of the image as shown in Figure no. 17 and Figure no. 18.

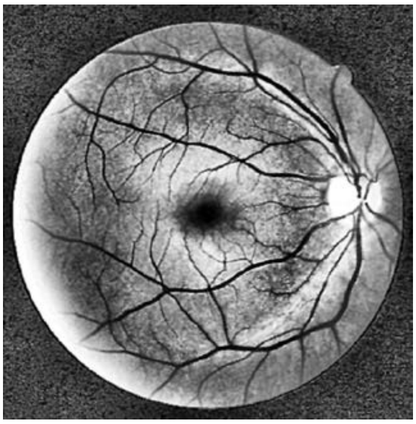

*Figure no. 17. Filtering and smoothing in image 1*

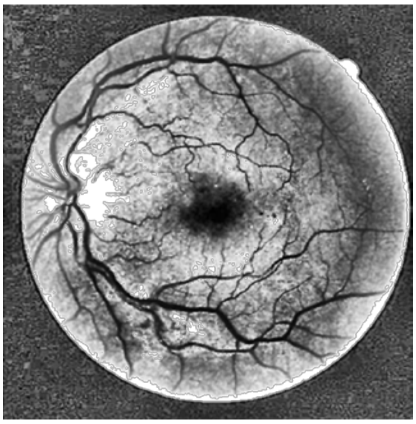

*Figure no. 18. Filtering and smoothing in image 2*

### *3.4. Feature extraction stage*

Thresholding is carried out and the images converted to binary as shown in Figure no. 19 and Figure no. 20.

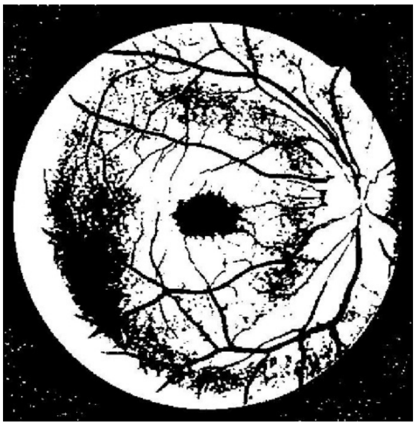

*Figure no. 19. Thresholding and conversion to binary for image 1*

*Figure no. 20. Thresholding and conversion to binary for image 2*

Morphological structuring elements are incorporated, specifically the ‘disk’ operator, as shown in Figure no. 21 and Figure no. 22.

*Figure no. 21. Morphological structuring elements in image 1*

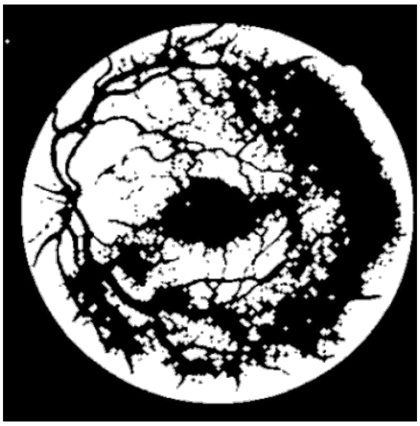

*Figure no. 22. Morphological structuring elements in image 2*

A different technic of morphological structuring known as skeletonization is used to make the extracted vessel paths more distinct as shown in Figure no. 23 and Figure no. 24.

*Figure no. 23. Morphological skeletonization in image 1*

*Figure no. 24. Morphological skeletonization in image 2*

Key feature points of the extracted blood vessels are detected using FAST features detecting tool and the strongest most dominant 500 points shown on the image. This is shown in Figure no. 25 and Figure no. 26.

*Figure no. 25. Feature point detection on image 1*

*Figure no. 26. Feature point detection on image 2*

***3.5. Template creation stage***

The features detected by the FAST feature detector are isolated and plotted on a graph as shown in Figure no. 27 and Figure no. 28. The feature points are used for template creation which is used for matching of images stored in a database and the image acquired.

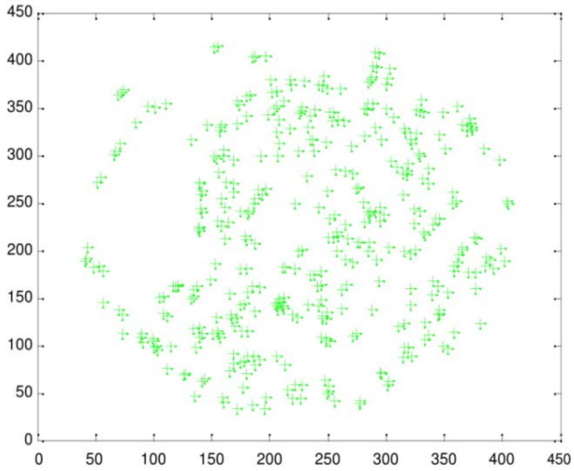


*Figure no. 27. Features points extracted from image 1*

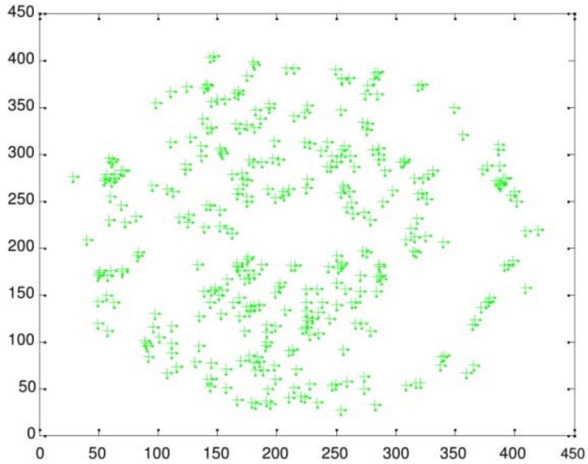


*Figure no. 28. Features points extracted from image 2*

## 4. Conclusion and discussion

In the course of this paper, a number of challenges were encountered during the implementation phase. To implement it efficiently, a retina scanner is required for capturing the retinal scans. Retinal scanners are very expensive as they range from $480 dollars for the basic scanner. This difficulty resulted in other alternatives being devised to make the paper objectives achievable. The limitation of image acquisition was countered by there being standard image databases of retinal images. For this paper, a database known as DRIVE was used to get images that would replace the image acquisition process and therefore enabling the main objective of this paper to be met and the retinal scans used to show the extraction of the blood vessels. The feature extraction of retinal scan has been shown to be unique and therefore gives a high level of safeguarding information. This characteristic enables this method to be incorporated in areas that require high security level such as control rooms of various buildings including airports and Military bases.

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