VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI

A Dissertation Report
On

"RETINA BASED BIOMETRIC RECOGNITION SYSTEM"

Submitted to

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

In partial fulfilment of the requirements for the award of degree of

BACHELOR OF ENGINEERING
IN
COMPUTER SCIENCE ENGINEERING

PROJECT ASSOCIATES

MEGHANA K	**3VC15CS053**
MANJULA G P	**3VC15CS050**
G RAMYA	**3VC15CS027**
VELURU ESWARI	**3VC14CS112**

Under the guidance of
Mr. Puneeth GJ
Assistant Professor,
Department of CSE

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
ACCREDITED BY NATIONAL BOARD OF ACCREDITATION
RAO BAHADUR Y MAHABALESHWARAPPA ENGINEERING COLLEGE
ACCREDITED BY NAAC WITH B++
CANTONMENT, BALLARI-583104, KARNATAKA

2019-20

RAO BAHADUR Y MAHABALESHWARAPPA ENGINEERING COLLEGE

(AFFILIATED TO VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
&APPROVED BY AICTE, NEW DELHI), ACCREDITED BY NAAC WITH B++, BALLARI- 583104, KARNATAKA

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

ACCREDITED BY NATIONAL BOARD OF ACCREDIATION

CERTIFICATE

This is to certify that project work entitled **"RETINA BASED BIOMETRIC RECOGINITION SYSTEM"** is bonafied Work carried out by **MEGHANA K(3VC15CS053), MANJULA GP(3VC15CS050), G RAMYA (3VC15CS027), VELURU ESWARI(3VC14CS112)** of 8th Semester in partial fulfilment for the award of degree of Bachelor of Engineering in Computer **Science &Engineering** of the **Visvesvaraya Technological University,** Belagavi during the year**2019-2020.** It is certified that all corrections / suggestions indicated have been incorporated in the report. The project report has been approved as it satisfies the academic requirement in respect of project work prescribed for the **Bachelor of Engineering Degree.**

Signature of Guide
Mr. Puneeth G J
Assistant Professor,

Dept of CSE

Signature of HOD
Dr T.Hanumantha Reddy
HOD, Dept of CSE,

RYMEC

Signature of Principal
Dr K. Veeresh
RYMEC, Ballari.

Name of Examiners: **Signature with Date**

1. _____
2. _____

ACKNOWLEDGEMENT

I would like to express our regards and acknowledgement to all those who helped in making this seminar possible.

I am grateful to the **Principal Dr. K Veeresh** for providing facilities and untiring zeal, which constantly inspired me towards the attainment of everlasting knowledge throughout the course.

I am deeply indebted to **Dr**. **T Hanumantha Reddy**, **HOD** of Computer Science and Engineering department for the valuable suggestions and constant encouragement provided for the successful completion of the seminar.

I would like to thank our guide, **Mr**. **Puneeth GJ**, Assistant Professor of Computer Science and Engineering department for the constant guidance for the successful completion of project.

Finally, I would like to thank all the staff members of Computer Science and Engineering department for their guidance and support. I am also thankful to my family and friends who continue to give me best support

ABSTRACT

Biometric security has become more important because of the increasing activities of terrorists and hackers. One of the most reliable biometric security systems is retina biometric security system, because no two people have the same retinal pattern. The proposed system consists of four modules viz, retina fundus acquisition, Pre-processing, Detection of bifurcation points and Feature matching. In the pre-processing step retinal blood vessels are enhanced and segmented. From the segmented image bifurcation points are detected, with the help of skeleton process. Using this bifurcation points, it checks similarity with bifurcation points of reference images in database using similarity transformation. The proposed system has extremely lower error rate and quick response.

CO-PO MAPPING

Course Name: Project **Course Code**: 15CSP85 **Batch Number**: A9

Project Title: Retina Based Biometric Recognition System

Staff Name: Mr. Puneeth GJ

Submitted By:

USN	STUDENTNAME
3VC15CS053	MEGHANA K
3VC15CS050	MANJULA G P
3VC15CS027	G. RAMYA
3VC14CS112	VELURU ESWARI

COURSEOUTCOME

CO NO.	COURSE OUTCOMES
C413.A13.1	Understand and analyze the requirements of the end user considering economic, social and environmental factors for providing a feasible solution with strong basics of Computer Science subjects
C413.A13.2	Design, develop and demonstrate feasible solution for the identified problem with good literature survey using modern tools.
C413.A13.3	Prepare well-structured report of the project with plagiarism check and communicate the same in different phases/journals/conferences/project exhibitions.
C413.A13.4	Coordinate and execute the assigned task and evaluate with the team members within in specified time in concern with the project guide

CO-POMAPPING

CO NO.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2
C413. A13. 1	3	3				3	3				3	2		3
C413. A13. 2			3	3	3							2		3
C413. A13. 3								3				2		3
C413. A13. 4									3	3		2		3

TABLE OF CONTENTS

List of Figures

CHAPTER 1

1. INTRODUCTION

In today's world, among various biometric modalities, iris, arguably, is one of the most reliable, universal, measurable, accurate and inimitable. Over the years, it has been established that every iris is unique, particularly in the detailed structure of the front or anterior layer. Not only are the irises of identical twins different, but the iris of the two eyes of the same person are also different. Although specific details of the appearance of an iris vary depending on the level and direction of illumination, it has been claimed that the basic and significant features of iris remain stable and do not change over a long time. Generally, covariates in iris recognition are image quality (i.e. noise, blur), illumination (specular reflection), off angle, occlusion, and resolution. In recent years, several approaches have been developed to advance the state of- art in iris recognition and address these covariates. However, there can be potentially many other covariates in iris recognition which have not yet been identified.

A biometric system is a pattern recognition system that checks the authenticity of a person using biometric measures. There are two types of authentication: - verification (checking the validity of a given identity) and identification (checking if a given pattern is associated with any of the enrolled identities stored in the database).

The retina is an internal protected organ of the body. The human retina consists of blood vessels that form a unique pattern and the pattern does not change through the individual's life. So it is impossible to forge that pattern. Retina based security system works by tracking an image of an individual's retinal blood vessel network and comparing it to a previously authenticated scan of the same individual. The uniqueness and stability of retina guarantees a strong biometric authentication. Also, it is less vulnerable to identity theft.

The primary application for retinal pattern recognition till date has been for physical access entry for high-security facilities such as military installations, nuclear facilities, sophisticated laboratories, etc. It is also used in access control systems at high-security facilities. There are many advantages of retina biometry: - it has a low occurrence of false positives, also offer extremely low (almost 0%) error rates, since no two people have a same retinal pattern it is

highly reliable and it can provide speedy results that are identity of a person can be verified very quickly.

1.1Statement of Problem Area

Area: Image Processing

Problem Statement: Biometric security has become more important because of the increasing activities of terrorism and hackers. Retina recognition technology is continuously growing over years, this technology can resolve the identification of a person's identity, the main purpose of this project is to develop a retina based biometric recognition system for authenticating individuals.

1.2 Previous and current work

1.2.1 Existing system

Although there are some authentic systems based on different biometrics but all of these can easily be forged.

[1] However, several spoof attacks can also be carried against many types biometrics, like fingerprint, face, and iris.

[2] Under spoof attacks replica of the genuine user's fingers are created using some artificial material like silicon or wood glue, etc. to circumvent a system

[3] Sometimes the attackers use an artificial finger, a mask over a face or a contact lens on an eye

[4] As one's signature may alter over a period and it is not as unique as Iris, Face, Fingerprint

[5]. In voice recognition, the main obstacle is speech features are sensitive to background noise. Gait biometric also may vary due to change in body weights. It may not remain fixed for long period of time, owing to major injuries involving leg or brain or due to inebriety.

1.2.2 Disadvantages

- Retina based security framework works by attaching a picture of a person's retinal vein system and contrasting it with a formerly confirmed sweep of a similar person.
- The uniqueness and solidness of retina ensures a solid biometric confirmation.
- Likewise, it is less defenseless against fraud.

1.2.3 Proposed system

The proposed system is Retina based personal identification system using skeletonization and similarity transformation. The system comprised of four modules via, retina fundus acquisition, Pre-processing, Detection of bifurcation points and Feature matching.

Fundus acquisition: Devices used to obtain images of the retina were called fundus cameras, which uses low intensity infrared light to illuminate blood vessel pattern of the retina. Once the retinal image is obtained, the blood vessels are identified through further processing. Then from the complex network of blood vessels distinguishing features are extracted and stored in templates, which are later used in the matching process.

Pre-processing: In this step, it performs blood vessel enhancement and segmentation that helps to extract the retinal blood vessel pattern from fundus image. For this first of all we extract the green channel of the fundus image, because it provides highest contrast. This consists of five stages: Resolution hierarchy creation, Hessian vesselness extraction, back sampling, Hysteresis threshold and Image fusion.

Detection of bifurcation points: Bifurcation are the most reliable and abundant feature in fundus images. The retinal bifurcation points are unique for each person, so they are used for successive process of identification of person. In this paper, it detects bifurcation points with the help of Skeletonization process.

Feature matching: In the matching stage, the reference pattern, p, which is stored in database for the claimed identity is compared to the pattern extracted, p', during the previous stage. Due to the eye movement during the image acquisition stage, it is necessary to align β with α in order to be matched. The movement of the eye in the image acquisition process leads to translation in both axes. So, for same individual, the number of bifurcation points of both patters p and p' are different. So, it is necessary to transform the candidate pattern in order to get a pattern similar to the reference one.

1.2.4 Advantages

- The essential application for retinal example acknowledgment till date has been for physical access section for high-security offices, for example, army bases, atomic offices, modern research centers and so forth.

- It is additionally utilized as a part of access control frameworks at high security offices.

1.3 Objective

- To track an image of an individual's retinal blood vessel network.
- The main objective of this project is to identify a person/individual through their retina.
- To compare tracked retinal blood vessel network with previously authenticated scan of the same individual.

CHAPTER 2

2. SYSTEM FUNCTIONAL SPECIFICATION

2.1 Functions performed

The uniqueness and importance of blood vessels and its pattern in human retina were discovered by two eye specialists, Dr Carleton Simon and Dr Isodore Goldstein while studying on eye diseases back in 1935. They discovered that every eye owns a unique vascular pattern which can be used for personal authentication. Advancing in the same field, Dr Paul Tower studied on the vascular patterns of twins in 1950 and discovered that they are unique even among identical twins. In his study, he showed that retinal vascular patterns the least similar among resemblance factors typical of twins. A few studies have been done on retinal recognition. Main focus was on the accurate extraction of blood vessels. A number of methods have been proposed for blood vessel detection and segmentation for computer aided diagnostic system to detect retinal diseases, but their use for retinal identification is very rare in literature. Landmark based methods for retinal registration were presented in using vessel bifurcations and crossover points as feature points. Another retinal registration method based on location of optic disc was presented by a cross correlation coefficient based retinal identification was done. They first registered the input image and then matching is done by correlating the vascular pattern. Bevilacqua proposed a vascular bifurcation and cross over point-based system for retinal authentication. The comparison was done by means of accumulation matrix. In this paper, we present a new method for secure personal identification based on human retina. The main contribution which we have made during this research is the generation of database for retinal recognition which is very rare and only one database is available online for retinal recognition. The paper includes other contributions as well such as accurate segmentation of vascular pattern, reliable extraction of feature points and formulation of feature vectors for vascular feature points.

Biometrics are used in automated personal recognition and identification systems especially at high security regions. The commonly used biometrics includes fingerprint, iris, and facial and speech recognition. Although there are highly accurate systems based on these biometrics but all of these can easily be forged. Human retina contains vascular pattern which is unique in every individual and can be used in biometric system. Unlike traditionally used biometric systems, vascular pattern of human retina is the most reliable and stable source for biometrics. It is not easy to forge it as it lies at back end of human eye and is not directly

accessible. There is always a confusion regarding iris and retina as they both belong to human eye but their functions and patterns are completely different. Iris is the colored region between the pupil and sclera whereas retina is located at back region of eye. The systems based on iris recognition use iris pattern for uniqueness and identification whereas the foundation of retinal recognition is the pattern of blood vessels present in human retina. Digital retinal images are used in automatic identification systems. They are acquired using digital fundus camera consisting of low power microscope and is used by eye specialists for treatment of retinal diseases. The acquisition of human retina is not as simple as for other biometrics like fingerprints; face, iris etc and the fundus cameras are also very expensive.

2.2 System Data Base preview

Privacy of the application is very important as the application must not reveal the information what it is holding in it. The privacy is very useful for the users and also for the admin to make it work like that.

Overall working of the application must not open-up any kind of errors at the run time so that the application keeps all the data to the server only.

The given application is used on a single standalone system and as the given application is not run online there is not much issue with the security; one needs to protect their own system with some antivirus software which will make the system more resultant and secured.

2.3 User input specifications

The basis of retinal recognition is the vascular pattern which shows uniqueness among different human beings. It is important to extract the complete vascular structure accurately form input retinal image. The first phase of our proposed system is pre-processing in which system extracts the vascular pattern using Gabor wavelet and multi-layered thresholding technique. Pre-processing is also performed to remove noise and extra region from input fundus image

The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system. The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and

keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things:

- What data should be given as input?
- How the data should be arranged or coded?
- The dialog to guide the operating personnel in providing input.
- Methods for preparing input validations and steps to follow when error occur.

1. Input Design is the process of converting a user-oriented description of the input into a computer-based system. This design is important to avoid errors in the data input process and show the correct direction to the management for getting correct information from the computerized system.

2. It is achieved by creating user-friendly screens for the data entry to handle large volume of data. The goal of designing input is to make data entry easier and to be free from errors. The data entry screen is designed in such a way that all the data manipulates can be performed. It also provides record viewing facilities.

3. When the data is entered it will check for its validity. Data can be entered with the help of screens. Appropriate messages are provided as when needed so that the user will not be in maize of instant. Thus the objective of input design is to create an input layout that is easy to follow.

2.4 User output specifications

Feature vectors for different retinal images are saved in database. The last stage identifies the input retinal image by matching the feature vectors of query image with the ones stored in database. The proposed system calculates a Feature Distance (F D) by calculating Mahalanobis distance between feature vectors of all feature points in query image and templates stored in database. The matching phase finally computes a score value which represents that how similar two retinal images are when compared with each other. This value is computed by counting the number of feature vectors from database matched with the query image feature vectors on the basis of F D.

A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and

direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making.

1. Designing computer output should proceed in an organized, well thought out manner; the right output must be developed while ensuring that each output element is designed so that people will find the system can use easily and effectively. When analysis design computer output, they should Identify the specific output that is needed to meet the requirements.

2. Select methods for presenting information.

3. Create document, report, or other formats that contain information produced by the system.

The output form of an information system should accomplish one or more of the following objectives.

- Convey information about past activities, current status or projections of the
- Future.
- Signal important events, opportunities, problems, or warnings.
- Trigger an action.
- Confirm an action.

2.5 Internal and External Limitations

The person recognition system based on biometrics require thorough testing and validation. There are only a few publicly available databases for retinal recognition as compared to fingerprint or facial recognition. VARIA is the only database that is truly formed for retinal recognition systems. It includes 233 retinal images of 139 different persons with a resolution of 768 × 584. To further evaluate the proposed retina identification system, we designed our own database with the help of armed forces institute of ophthalmology (AFIO), Pakistan and we named it as Retinal Identification Database.

- False Acceptance Rate (FAR) is the rate of individuals which are incorrectly accepted. It measures the number of cases in which input vector is matched to a non-matching vector present in the database.
- False Rejection Rate (FRR) is the rate of individuals which are incorrectly rejected. It measures the number of cases in which input vector is not matched to actual vector present in the database.

- Receiver Operating Characteristic (ROC) is a curve which shows the relation between FAR and FRR and using ROC we can tradeoff between these two parameters. ROC curves are used to compute the area under the curve (AUC).
- Equal Error Rate (EER) is the rate at which both FAR and FRR have same values. The value of the EER can be easily obtained from the ROC curve. In general, the device with the lowest EER is most accurate.
- Recognition Rate (RR) is computed by running the system on test data and it is the number of persons which are correctly classified.

CHAPTER 3

3. SYSTEM DESIGN

3.1 System Architecture

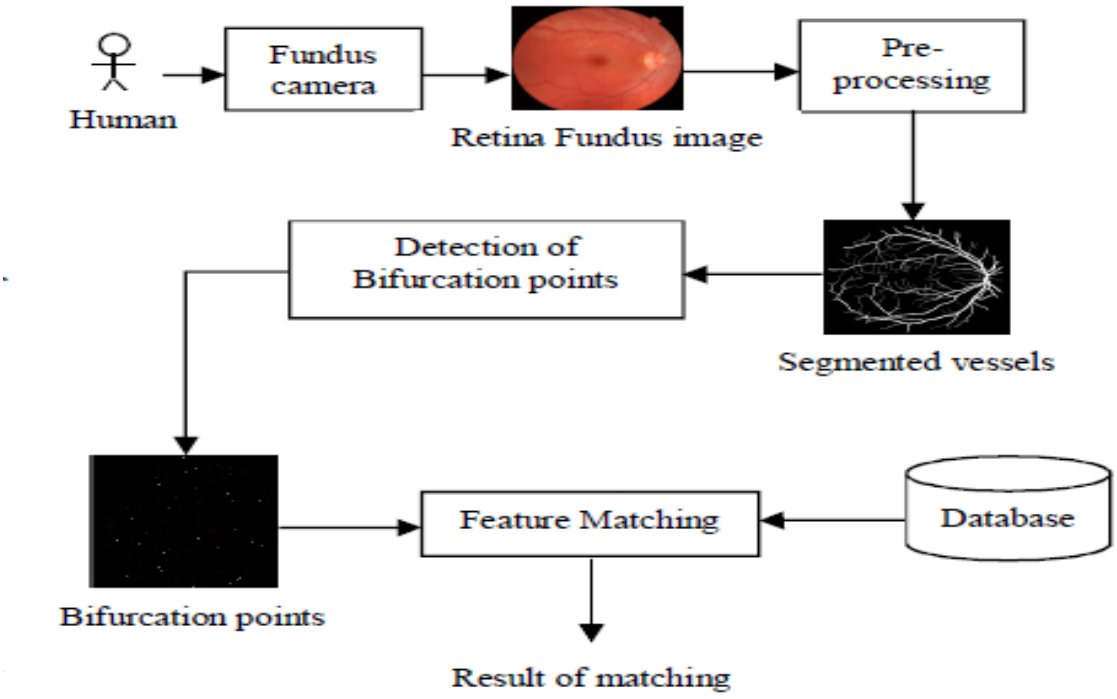

Fig 3.1: System Architecture

- The proposed system is Retina based personal identification system using skeletonization and similarity transformation. The system comprised of four modules viz, retina fundus acquisition, Pre-processing, Detection of bifurcation points and Feature matching.

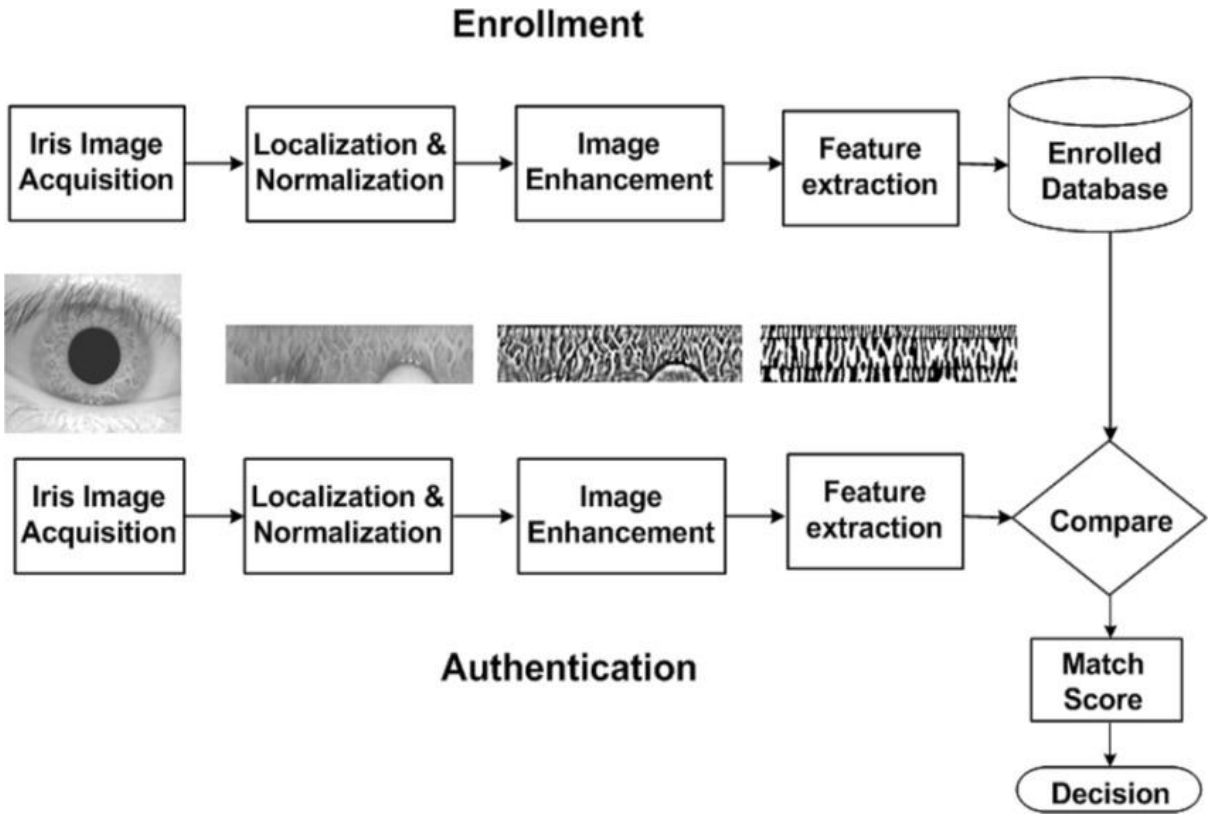

Fig 3.1.1: System authentication process

3.2 Use case Diagram

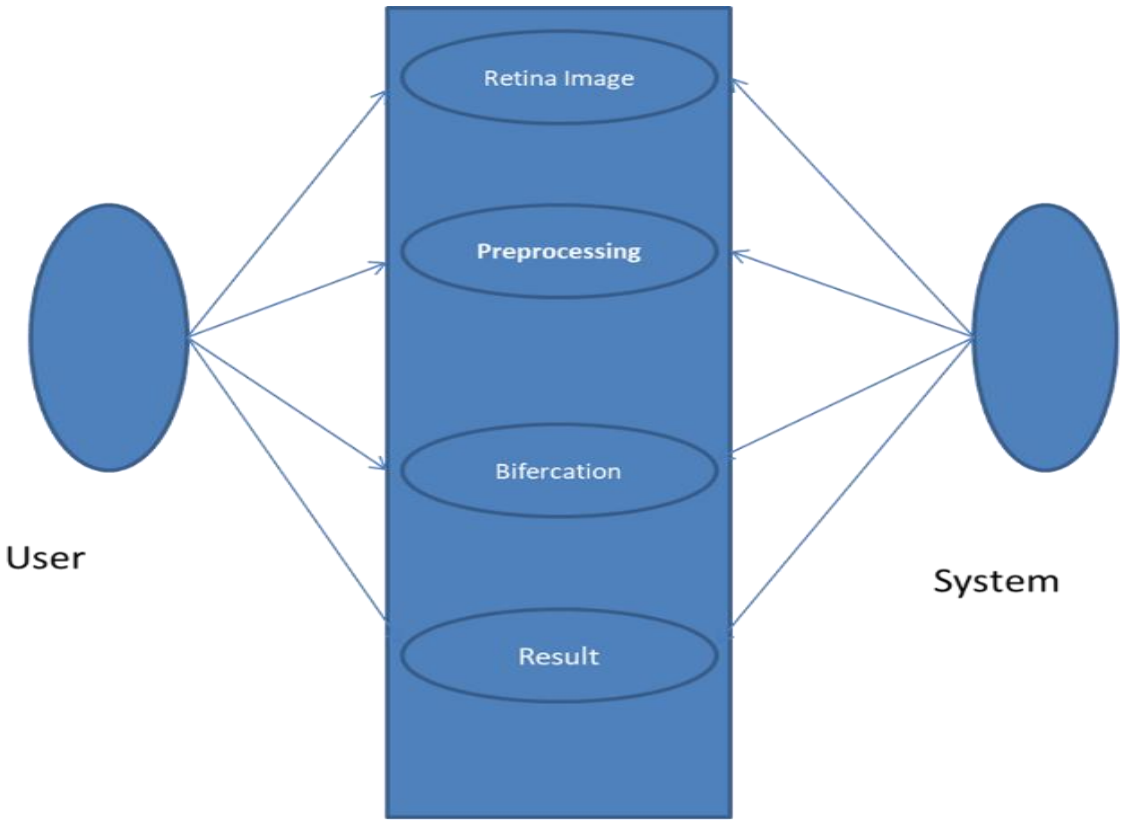

Fig 3.2: Use case diagram

- The above diagram gives the different modules how it is connected to the system perspective is given, as one can see all the modules are connected to the main admin system which will carry out all the functionality with easy.

3.3 System Sequence Diagram

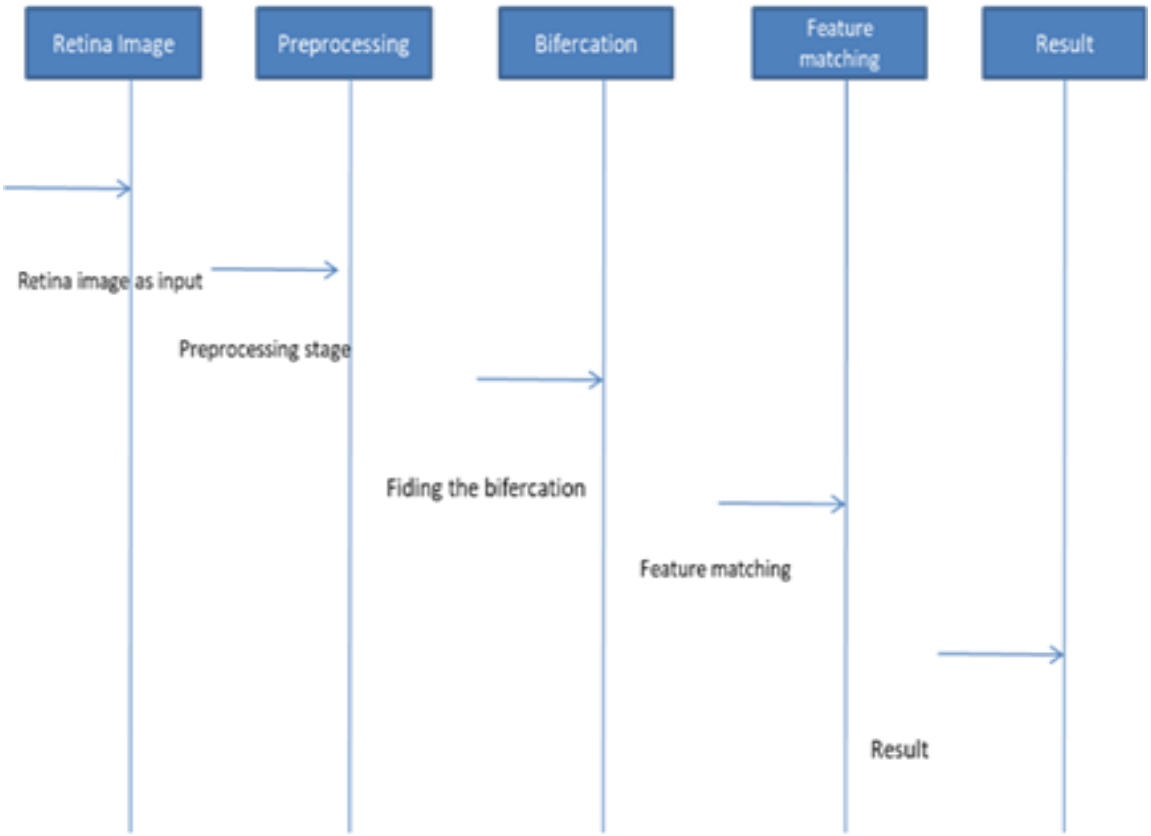

Fig 3.3: System Sequence diagram

- The above figure explains the procedural designs of the events which is carried out in the application, initially the retina image is taking as a input, which will be preprocessed and segmented image is feature extracted and finally the matching or not matching is found out.

3.5 Algorithm Specification

The mldivide Algorithm

The mldivide operator employs different solvers to handle different kinds of coefficient matrices. The various cases are diagnosed automatically by examining the coefficient matrix. For more information, see the “Algorithms” section of the mldivide reference page.

General Solution

The general solution to a system of linear equations Ax = b describes all Possible solutions. You can find the general solution by:

1 Solving the corresponding homogeneous system Ax = 0. Do this using the null command, by typing null (A). This returns a basis for the solution Space to Ax = 0. Any solution is a linear combination of basis vectors.

2 Finding a particular solution to the non-homogeneous system Ax = b.

Singular Coefficient Matrix:

A square matrix A is singular if it does not have linearly independent columns. If A is singular, the solution to Ax = b either does not exist, or is not unique. The backslash operator, A\b, issues a warning if A is nearly singular and raises an error condition if it detects exact singularity.

Over determined Systems

This example shows how overdetermined systems are often encountered in various kinds of curve fitting to experimental data. A quantity, y, is measured at several different values of time, t, to produce the following observations. You can enter the data and view it in a table with the following statements.

A rectangular matrix A is rank deficient if it does not have linearly Independent columns. If A is rank deficient, the least-squares solution to AX = B is not unique. The backslash operator, A\B, issues a warning if A is rank deficient and produces a least-squares solution if the system has no solution and a basic solution if the system has infinitely many solutions.

Underdetermined Systems

This example shows how the solution to underdetermined systems is not unique. Underdetermined linear systems involve more unknowns than equations. The matrix left division operation in MATLAB finds a basic solution, which has at most m nonzero components for an m-by-n coefficient matrix.

Using Multithreaded Computation with Systems of Linear

Equations

MATLAB software supports multithreaded computation for a number of linear algebra and element-wise numerical functions. These functions automatically execute on multiple threads. For a function or expression to execute faster on multiple CPUs, a number of conditions must be true:

1 The function performs operations that easily partition into sections that execute concurrently. These sections must be able to execute with little communication between processes. They should require few sequential operations.

2 The data size is large enough so that any advantages of concurrent execution outweigh the time required to partition the data and manage separate execution threads. For example, most functions speed up only when the array contains several thousand elements or more.

3 The operation is not memory-bound; processing time is not dominated by memory access time. As a general rule, complicated functions speed up more than simple functions. inv, lscov, linsolve, and mldivide show significant increase in speed on large double-precision arrays (on order of 10,000 elements or more) when multithreading is enabled.

Iterative Methods for Solving Systems of Linear Equations

If the coefficient matrix A is large and sparse, factorization methods are generally not efficient. Iterative methods generate a series of approximate solutions. MATLAB provides several iterative methods to handle large, sparse input matrices.

3.6 Equipment Configuration

Hardware Requirements

Processor : Core2 Dueo processor is essential

System : 1.1 GHz speed is needed

Ram : 1GBRam Required

Hard Disk : 20GB Hard disk

Software Requirements

Operating System : Windows

Programming : Matlab-tool

3.7 Implementation Languages

Matlab

MATLAB stands for Matrix Laboratory. According to The Math works, its producer, it is a "technical computing environment". We will take the more mundane view that it is a programming language.

This section covers much of the language, but by no means all. We aspire to at the least to promote a reasonable proficiency in reading procedures that we will write in the language but choose to address this material to those who wish to use our procedures and write their own programs.

Case Sensitivity

MATLAB variable names are normally case-sensitive. Thus, variable C is different from variable c. A variable name can have up to 19 characters, including letters, numbers and underscores. While it is tempting to use names such as Fund Returns it is safer to choose instead fund returns or to use the convention from the C language of capitalizing only second and subsequent words, as in fund Returns. In any event, a\Adopt a simple set of naming conventions so that you won't write one version of a name in one place and another later. If you do so, you may get lucky (e.g. the system will complain that you have asked for the value of an undefined variable) or you may not (e.g. you will assign the new value to a newly-created variable instead of the old one desired). In programming languages there are always tradeoffs. You don't have to declare variables in advance in MATLAB. This avoids a great deal of effort, but it allows nasty, difficult-to-detect errors to creep into your programs.

Matlab is a program that was originally designed to simplify the implementation of numerical linear algebra routines. It has since grown into something much bigger, and it is used to implement numerical algorithms for a wide range of applications. The basic language used is very similar to standard linear algebra notation, but there are a few extensions that will likely cause you some problems at first.

The goal of the tutorials here is to provide a simple overview and introduction to matlab. The tutorials are broken up into some of the basic topics. The first includes a few examples of how Matlab makes it easy to create and manipulate vectors. The tutorials move from the simple examples and lead to more complicated examples.

Guide

Open GUI Layout Editor

Syntax

Guide

Guide ('filename.fig')

Guide ('full path')

Guide (Handle List)

Description

Guide initiates the GUI design environment (GUIDE) tools that allow you to create or edit GUIs interactively.

Guide opens the GUIDE Quick Start dialog where you can choose to open a previously created GUI or create a new one using one of the provided templates.

Guide ('filename.fig') opens the FIG-file named filename.fig for editing if it is on the MATLAB path.

Guide ('full path') opens the FIG-file at full path even if it is not on the MATLAB path.

Guide (Handle List) opens the content of each of the figures in Handle List in a separate copy of the GUIDE design environment.

Matlab

A basic introduction on how to define and manipulate vectors in Matlab. This is the most basic way that numbers are stored and accessed in Matlab.

Matrices

An introduction on how to define and manipulate matrices. We demonstrate how to create matrices and how to access parts of a matrix.

Vector operations

Here we bring together elements of the first two tutorials. The real power of matlab is that the basic operations defined in linear algebra can be carried out with similar notation and a minimal number of programming steps.

Loops

We introduce the basic loop construct used in Matlab. We show how to define a for loop and provide an example of a how it can be used to solve a problem.

Plots

A general overview of the basic plotting commands is given. This is a very basic overview given to demonstrate some of the ways data can be plotted.

Executable Files

An introduction is given on how to define files that contain command that Matlab can execute as if they had been typed in at the command prompt.

Subroutines

An introduction to subroutines is given. This is a more general way to provide an executable file in which generic arguments are passed back and forth through the command line.

If statements

The basic control structure in Matlab is the "if" statement which allows for conditional execution of certain parts of a code. This is useful when you have to check conditions before deciding what actions should be taken.

Data Files

Matlab allows a number of ways to access data files for use in a session. The different ways to save all of the data, a particular matrix, and C style read write statements is examined. Also, the diary command is examined to demonstrate how a text copy of a session can be saved.

Matrix Operators

Expressions use familiar arithmetic operators and precedence rules.

+ Addition

- Subtraction

* Multiplication

/ Division

\ Left division

^ Power

‘Complex conjugate transpose

( ) Specify evaluation order

Array Operators

When they are taken away from the world of linear algebra, matrices become two-dimensional numeric arrays. Arithmetic operations on arrays are the same for arrays and matrices, but that multiplicative operations are different. MATLAB uses a dot, or decimal point, as part of the notation for multiplicative array operations.

The list of operators includes

+ Addition

- Subtraction

. * Element-by-element multiplication

. / Element-by-element division

.\ Element-by-element left division

. ^ Element-by-element power

.' Unconjugated array transpose

If the Dürer magic square is multiplied by itself with array multiplication. At the result is an array containing the squares of the integers from 1 to 16, in an unusual order.

Building Tables

Array operations are useful for building tables. Suppose n is the column vector

Functions

MATLAB provides a large number of standard elementary mathematical functions, including abs, sqrt, exp, and sin. Taking the square root or algorithm of a negative number is not an error; the appropriate complex result is produced automatically. MATLAB also provides many more advanced mathematical functions, including Bessel and gamma functions. Most of these functions accept complex arguments. For a list of the elementary mathematical functions, type help.

For a list of more advanced mathematical and matrix functions, type help some of the functions, like sqrt and sin, are built in. Built-in functions are part of the MATLAB core so they are very efficient, but the computational details are not readily accessible. Other functions are implemented in the MATLAB programming language, so their computational details are accessible. There are some differences between built-in functions and other functions.

For example, for built-in functions, you cannot see the code. For other functions, you can see the code and even modify it if you want. Several special functions provide values of useful constants.

Infinity is generated by dividing a nonzero value by zero, or by evaluating well defined mathematical expressions that overflow, that is, exceed real max. Not-a-number is generated by trying to evaluate expressions like 0/0 or Inf-Inf that do not have well defined mathematical values.

Command Line Editing

Various arrow and control keys on your keyboard allow you to recall, edit, and reuse statements you have typed earlier. For example, suppose you mistakenly enter rho = (1 + sqrt (5))/2 you have misspelled sqrt. MATLAB responds with Undefined function 'sqrt' for input arguments of type 'double'. Instead of retyping the entire line, simply press the ↑ key. The statement you typed is redisplayed. Use the ← key to move **t**he cursor over and insert the missing r. Repeated use of the ↑ key recalls earlier lines. Typing a few characters and then pressing the ↑ key finds a previous line that begins with those characters. You can also copy previously executed statements from the Command History.

Concatenation

Concatenation is the process of joining small matrices to make bigger ones. In fact, you made your first matrix by concatenating its individual elements. The pair of square brackets, [], is the concatenation operator. For an example, start with the 4-by-4 magic square, A, and form

B = [A A+32; A+48 A+16]

The result is an 8-by-8 matrix, obtained by joining the four sub matrices:

Logical Subscripting

The logical vectors created from logical and relational operations can be used to reference sub arrays. Suppose X is an ordinary matrix and L is a matrix of the same size that is the result of some logical operation. Then X (L) specifies the elements of X where the elements of L are nonzero.

This kind of subscripting can be done in one step by specifying the logical operation as the subscripting expression.

Suppose you have the following set of data:

x = [2.1 1.7 1.6 1.5 NaN 1.9 1.8 1.5 5.1 1.8 1.4 2.2 1.6 1.8];

The NaN is a marker for a missing observation, such as a failure to respond to an item on a questionnaire. To remove the missing data with logical indexing, use is finite(x), which is true for all finite numerical values.

The find Function

The find function determines the indices of array elements that meet a given logical condition. In its simplest form, find returns a column vector of indices. Transpose that vector to obtain a row vector of indices. For example, start again with Dürer's magic square.

Multidimensional Arrays

Multidimensional arrays in the MATLAB environment are arrays with more than two subscripts. One way of creating a multidimensional array is by calling zeros, ones, rand, or randn with more than two arguments.

For example, R = randn (3, 4, 5); creates a 3-by-4-by-5 array with a total of 3*4*5 = 60 normally distributed random elements. A three-dimensional array might represent three-dimensional physical data; say the temperature in a room, sampled on a rectangular grid. Or it might represent a sequence of matrices, A (k), or samples of a time-dependent matrix, A(t). In these latter cases, the (i, j) the element of the kth matrix, or the tkth matrix, is denoted by A (i, j, k).

MATLAB and Dürer's versions of the magic square of order 4 differ by an interchange of two columns. Many different magic squares can be generated by interchanging columns.

Cell Arrays

Cell arrays in MATLAB are multidimensional arrays whose elements are copies of other arrays. A cell array of empty matrices can be created with the cell functions. But, more often, cell arrays are created by enclosing a miscellaneous collection of things in curly braces, {}. The curly braces are also used with subscripts to access the contents of various cells. For example,

C = {A sum (A) prod (prod (A))}

Produces a 1-by-3 cell array. The three cells contain the magic square, the

Row vector of column sums, and the product of all its elements. When C is displayed, you see. This is because the first two cells are too large to print in this limited space, but the third cell contains only a single number, 16! So there is room to print it.

Here are two important points to remember. First, to retrieve the contents of one of the cells use subscripts in curly braces. For example, C {1} retrieves the magic square and C {3} is 16! Second, cell arrays contain copies of other arrays, not pointers to those arrays. If you subsequently change A, nothing happens to C.

You can use three-dimensional arrays to store a sequence of matrices of the same size. Cell arrays can be used to store a sequence of matrices of different sizes.

Dynamic Field Names

The most common way to access the data in a structure is by specifying the name of the field that you want to reference. Another means of accessing structure data is to use dynamic field names. These names express the field as a variable expression that MATLAB evaluates at run time. The dot-parentheses syntax shown here makes expression a dynamic field name:

StructName. (Expression)

Index into this field using the standard MATLAB indexing syntax. For example, to evaluate expression into a field name and obtain the values of that field at columns 1 through 25 of row 7, use structName. (Expression) (7, 1:25)

Dynamic Field Names Example.

The avg score function shown below computes an average test score, retrieving information from the test scores structure using dynamic field names: function avg = avgscore (test scores, student, first, last) for k = first: last scores(k) = test scores. (student). week(k);

Creating Matrices

The MATLAB environment uses the term matrix to indicate a variable Containing real or complex numbers arranged in a two-dimensional grid. An array is, more generally, a vector, matrix, or higher dimensional grid of numbers. All arrays in MATLAB are rectangular, in the sense that the Component vectors along any dimension are all the same length.

Symbolic Math Toolbox™ software extends the capabilities of MATLAB

Software to matrices of mathematical expressions. MATLAB has dozens of functions that create different kinds of matrices. There are two functions you can use to create a pair of 3-by-3 example. Matrices for use throughout this chapter. The first example is symmetric:

Identity Matrix

Generally accepted mathematical notation uses the capital letter I to denote identity matrices, matrices of various sizes with ones on the main diagonal and zeros elsewhere. These matrices have the property that AI = A and IA = A whenever the dimensions are compatible. The original version of MATLAB could not use I for this purpose because it did not distinguish between uppercase and lowercase letters and i already served as a subscript and as the complex unit. So, an English language pun was introduced.

Using Multithreaded Computation with Linear Algebra

Functions

MATLAB software supports multithreaded computation for a number of linear algebra and element-wise numerical functions. These functions automatically execute on multiple threads. For a function or expression to execute faster on multiple CPUs, a number of conditions must be true:

1.The function performs operations that easily partition into sections that execute concurrently. These sections must be able to execute with little communication between processes. They should require few sequential operations.

2 The data size is large enough so that any advantages of concurrent execution outweigh the time required to partition the data and manage separate execution threads. For example, most functions speed up only when the array contains than several thousand elements or more.

2 The operation is not memory-bound; processing time is not dominated by memory access time. As a general rule, complex functions speed up more than simple functions. The matrix multiply (X*Y) and matrix power (x^p) operators show significant increase in speed on large double-precision arrays (on order of 10,000 elements). The matrix analysis functions det, rcond, hess, and expm also show significant increase in speed on large double-precision arrays.

CHAPTER 4

4. SYSTEM VERIFICATION

4.1 Functions to test

4.1.1 Unit Testing

This testing is done by making the system to undergo the test condition by providing the individual values one by one and validating the results from the output. The system must give full results and expected values it must return. Validation is done extensive with full input test cases.

Test Objectives:

- The validate condition with all input values must be done
- No content should be present without a real reason.

Features to be tested

- check that the units are of the correct arrangement
- The coding and all should be genious we should not steal the code from other sites

4.1.2 Integration Testing

This test is done to make the integration process happens correct or not, following is the reason why integration testing is taken place.

This is more of incremental testing cases where each module is tested by providing a set of input values.

1. Then from the lowest module of the values it will be incremented to the next level.
2. The integration testing has to satisfy to the highest to make the application more accurate.

4.1.3 Functional test

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input: identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures: interfacing systems or procedures must be invoked.

4.1.4 Acceptance Testing

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

4.2 Description of System Testing

4.2.1 System Testing

The system testing makes test that the entire system is working correctly or not. This is very important as the overall working of full system is done here. The system testing is done by the expert tester which requires the testing to be done vigorously.

1. White Box Testing

This sort of testing guarantees that

- All autonomous ways have been practiced in any event once
- All coherent choices have been practiced on their actual and bogus sides
- All circles are executed at their limits and inside their operational limits
- All inner information structures have been practiced to guarantee their legitimacy.

To follow the idea of white box testing we have tried each structure. we have made autonomously to confirm that Data stream is right, all conditions are practiced to check their legitimacy, all circles are executed on their limits.

2. Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests,

must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box. You cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

3. Essential Path Testing

Built up strategy of stream chart with Cyclomatic multifaceted nature was utilized to determine experiments for all the capacities. The fundamental strides in inferring experiments were: Utilize the plan of the code and draw journalist stream chart.

Decide the Cyclomatic multifaceted nature of resultant stream chart, utilizing equation:

V (G) =F-O+2 or

V (G) =Q+1 or

V (G) =Number of Regions

Where V (G) is Cyclomatic multifaceted nature,

F is the quantity of edges,

O is the quantity of stream diagram hubs,

Q is the quantity of predicate hubs.

Decide the premise of set of directly autonomous ways.

The safety of the application is very useful to maintain as this is one of the main attributes to make the application successful.

Background Security can be separated into four related issues:

- Privacy
- Overall working
- Safety
- Discretion

CHAPTER 5

5. RESULTS

5.1 Snapshots

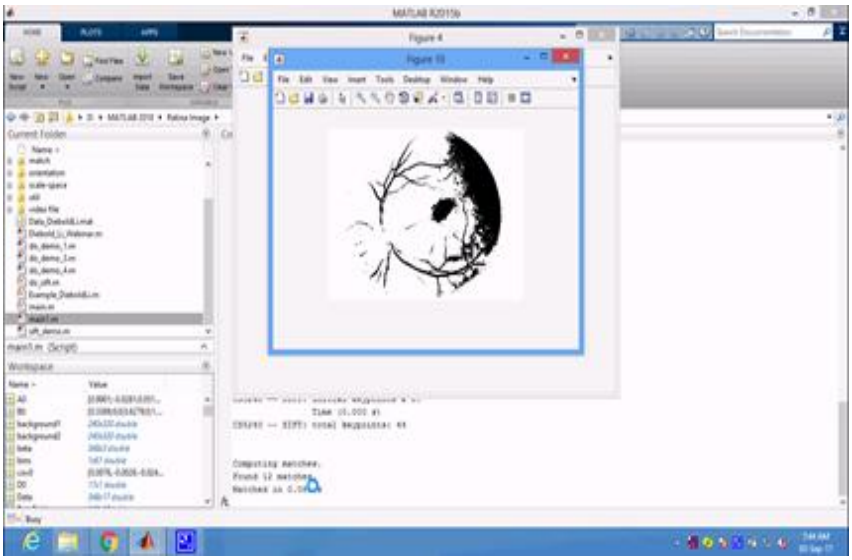

Fig 5.1: Main screen of the application

The above screen shot is the main screen which will be opened once the application is executed.

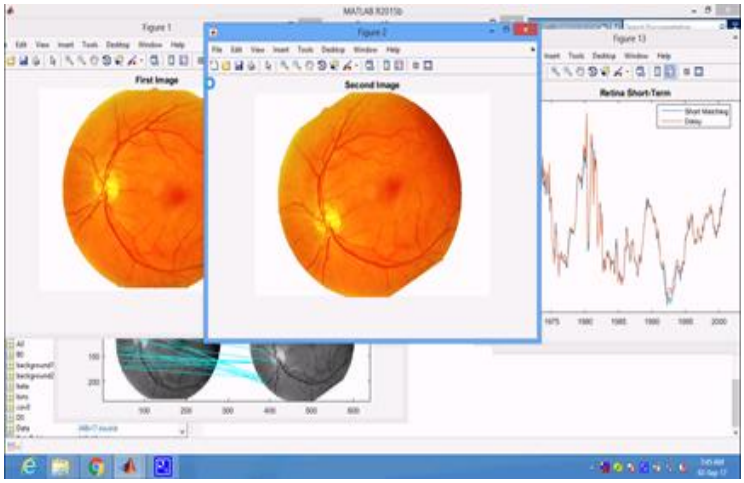

Fig 5.2: Fundus acquisition stage

The above snapshot gives the 2 images, one is the main images which are compared with the second images, both images graph and other feature is extracted once the pre-processing is carried out. There is a high accuracy of finding the matching of the images.

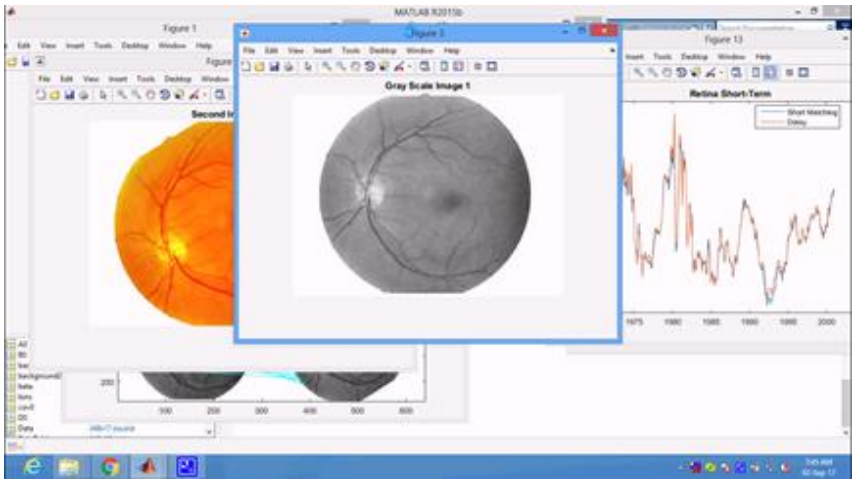

Fig 5.3: Pre-processing stage

The above screen shot gives the gray scale of the image1 which is done at the time of pre-processing step, once this step is done, the pre-processing of the image2 also carried out.

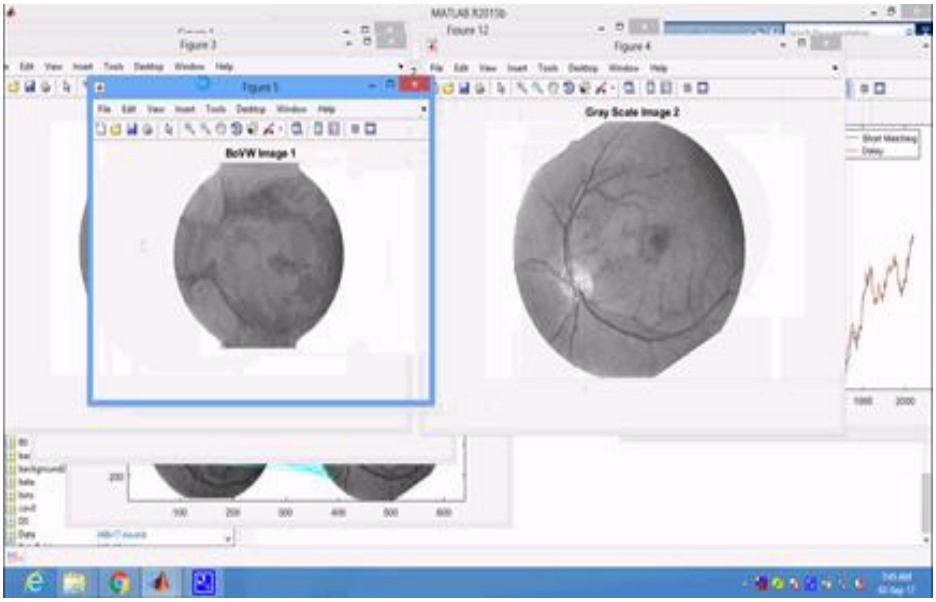

Fig 5.4: Converting of gray scale image into black and white format

The gray scale image is now converted into the black and white format for the exact feature extraction after the pre-processing step is done.

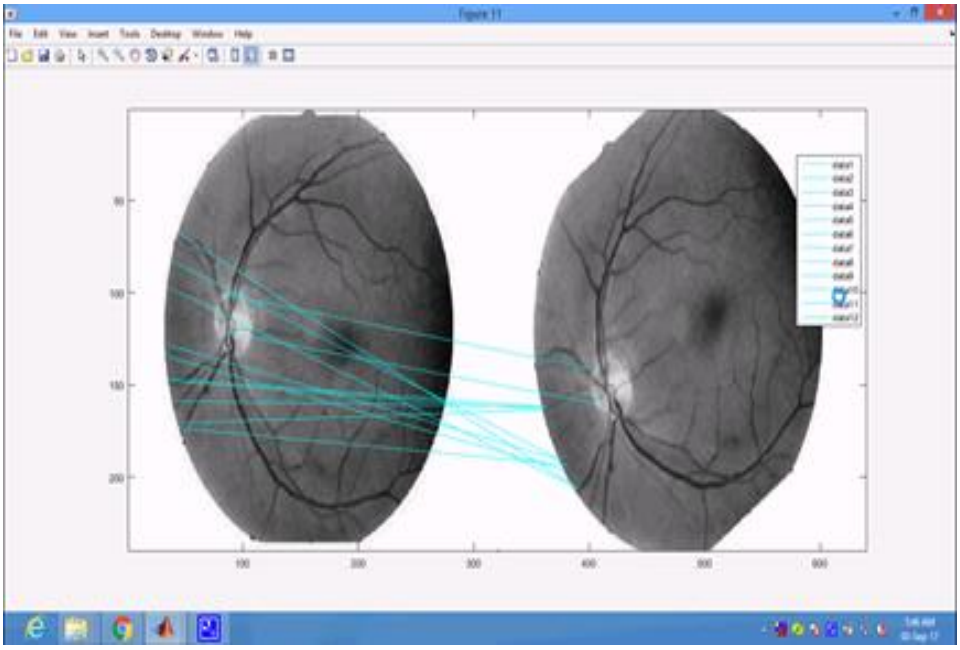

Fig 5.5: Feature matching stage

The above screenshot is giving the 2 images which we are matching here, the two retina images after the processing and segmentation, now the feature extraction process is initiated which will make the process to finalize the matching step.

Fig 5.6: Retina long-term graph

The above graph is the final graph representation of the both the graph, from the graph one can understand the matching functionality of the 2 images. The above graph is the retina time i.e. long-term graph is shown.

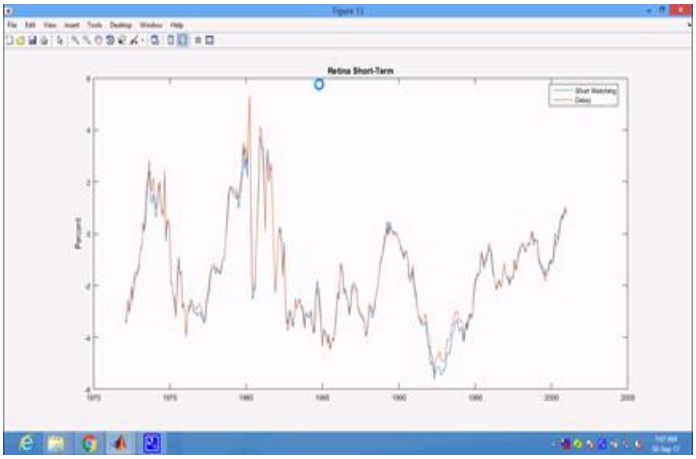

Fig 5.7: Retina short term graph

The above graph is another type of the graph of the 2 retina images. This is called as retina short term graph and short matching and delay is calculated here. The process involves this step after the pre-processing and feature extraction is done.

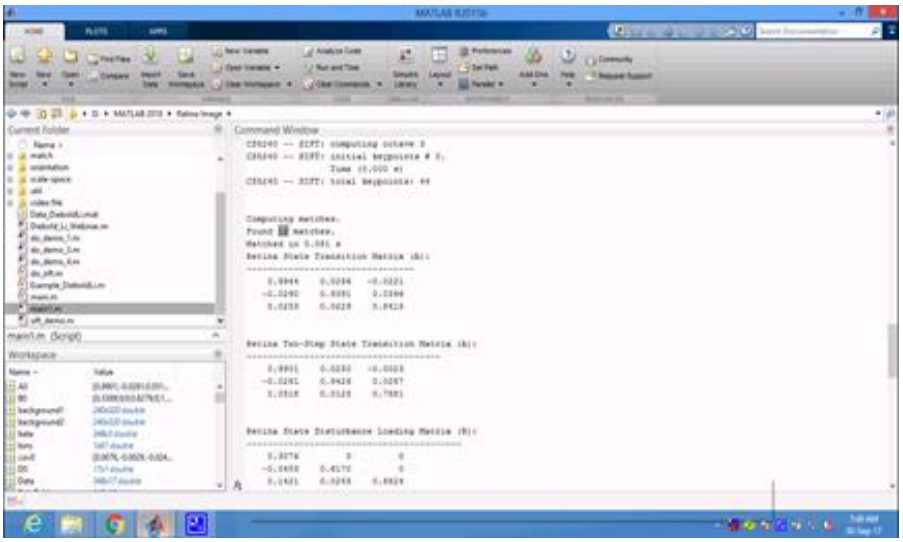

Fig 5.8: Final output of time taken

The output gives the time taken for each type of the operation to be processed. And retina values of the 2 images which has been submitted for the sake of processing. This will give the number of matched in this case it is given as 12 and also the time taken for the matching process to be done.

CHAPTER 6

6. Conclusion

The given Retina based individual recognizable proof framework utilizing skeletonization and comparability change, is a straightforward and productive framework for distinguishing legitimacy of individuals. The utilization of hessian-based vessel division technique removes the total retinal vessel tree from fundus picture. Accordingly, we can remove all highlights. Skeletonization develops the skeletal structure of retinal vessels. From the aftereffect of skeletonization, the pixel order technique identifies all bifurcation focuses in the image. These recognized bifurcation focuses are utilized as highlights in coordinating stage. In the coordinating stage, the obtained design is coordinated with the reference one put away in database of the framework. Here, the level of comparability is measured utilizing closeness metric. Consequently, the proposed framework can create an exact outcome. Likewise, it offers amazingly low blunder rate. The framework requires less calculation time. It is a basic and productive strategy for checking confirmation of client.

CHAPTER 7

7. REFERENCES

[1] Robust Vessel Segmentation in Fundus Images, A. Budai, R. Bock, A. Maier, J. Hornegger, International Journal of Biomedical Imaging Volume 2013

[2] A Combined Method to Detect Retinal Fundus Features V-Bevilacqua S. Cambo-L. Cariello (Italy)

[3] Retinal Verification with a Feature Points-Based Biometric Pattern, M. Ortega, M. G. Penedo, J- Rouco, N-Barreira, and M. J-Carreira, Hindawi Publishing Corporation EURASIP Journal on Advances in Signal Processing Volume 2009,

[4] Alejandro F. Frang-Wiro J-Niessen, et al. "Multiscale-vessel improvement sifting," Medical Image Computing and P-C Assisted Intervation-MICCAI'98. 1998, 1496:130:137.

[5] Digital picture handling, third release, Rafael C Gonzales and Richard E-Woods.

[6] Retinal Fundus Biometric Analysis for Personal Identifications, Vitoantonio Bevilacqua, Lucia Cariello 2008.

[7] Retinal Fundus Features Hybrid Detection in light of a Genetic Algorithm, Vitoantonio Bevilacqua, 70125 Bari, Italy

[8] J. Daugman, "How iris recognition works," *IEEE Trans. Circuits Syst.Video Technol.*, vol. 14, no. 1, pp. 21–30, Jan. 2004.

[9] J. Daugman, "Probing the uniqueness and randomness of IrisCodes: Results from 200 billion iris pair comparisons," *Proc. IEEE*, vol. 94, no. 11, pp. 1927–1935, Nov. 2006

[10] *Unique Identification Authority of India*. [Online]. Available: http://uidai.gov.in, accessed Nov. 1, 2015.

[11] K. R. Nobel, "The state of the art in algorithms, fast identification solutions and forensic applications," MorphoTrust USA, Billerica, MA, USA, Tech. Rep., Jan. 2013. [Online]. Available: http://www.planetbiometrics.com/article-details/i/1446/.

[12] P. E. Peterson *et al.*, "Latent prints: A perspective on the state of the science," *Forensic Sci. Commun.*, vol. 11, no. 4, pp. 1–9, 2009

[13] C. Champod, "Edmond Locard—Numerical standards and 'probable' identifications," *J. Forensic Identification.*, vol. 45, no. 2, pp. 136–163,1995

[14] K. McGinn, S. Tarin, and K. W. Bowyer, "Identity verification using iris images: Performance of human examiners," in *Proc. IEEE 6thInt. Conf. Biometrics, Theory, Appl., Syst. (BTAS)*, Sep./Oct. 2013,pp. 1–6.

[15] H. Proenca, "Iris recognition: On the segmentation of degraded images acquired in the visible wavelength," *IEEE Trans. Pattern Anal. Mach.Intell.*, vol. 32, no. 8, pp. 1502–1516, Aug. 2010.

[16] H. Proenca, S. Filipe, R. Santos, J. Oliveira, and L. A. Alexandre, "TheUBIRIS.v2: A database of visible wavelength iris images captured on the-move and at-a-distance," *IEEE Trans. Pattern Anal. Mach. Intell.*,vol. 32, no. 8, pp. 1529–1535, Aug. 2010.

[17] Z. Sun, L. Wang, and T. Tan, "Ordinal feature selection for iris and palm print recognition," *IEEE Trans. Image Process.*, vol. 23, no. 9, pp. 3922–3934, Sep. 2014.

[18] M. S. Sunder and A. Ross, "Iris image retrieval based onmacro-features," in *Proc. 20th Int. Conf. Pattern Recognit.*, 2010, pp. 1318–1321.

[19] J. De Mira and J. Mayer, "Image feature extraction for application of biometric identification of iris—A morphological approach, "in *Proc. Brazilian Symp. Comput.Graph. image Process.*, 2003, pp. 391–398

[20] F. Shen, "A visually interpretable iris recognition system with crypt features,"Ph.D. dissertation, Dept. Computer. Sci. Eng., Univ. Notre Dame, Notre Dame, IN, USA, 2014.

[21] F. Shen and P. J. Flynn, "Using crypts as iris minutiae," *Proc. SPIE*, vol. 8712, p. 87120B, May 2013.

[22] F. Shen and P. J. Flynn, "Iris matching by crypts and anti-crypts," in*Proc. IEEE Conf. Technol. Homeland Secure.*, Nov. 2012, pp. 208–213.

[23] F. Shen and P. J. Flynn, "Are iris crypts useful in identity recognition? "in *Proc. IEEE 6th Int. Conf. Biometrics, Theory, Appl., Syst.*, Sep./Oct. 2013, pp.

[24] F. Shen and P. J. Flynn, "Iris crypts: Multi-scale detection and shape-based matching," in *Proc. IEEE Winter Conf. Appl. Computer. Vis.*, Mar. 2014, pp. 977–983

[25] J. Chen, C. W. Harvey, M. S. Alber, and D. Z. Chen, “A matchingmodel based on earth mover’s distance for tracking Myxococcusxanthus,” in *Proc. Med. Image Comput. Comput.-Assist. Intervene.*, 2014, pp. 113–120.

[26] J. Chen, F. Shen, D. Z. Chen, and P. J. Flynn, “Iris recognition-based features,” in *Proc. IEEE Int. Conf. Identity, Secure.* onhuman-interpretable *Behavior Anal. (ISBA)*, Mar. 2015, pp. 1–6.

[27] *CASIA Iris Image Database*. [Online]. Available: http://biometrics.idealtest.org/, accessed Nov. 14, 2015.