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A NOVEL DESIGN OF FINGER VEIN RECOGNITION FOR PERSONAL AUTHENTICATION AND VEHICLE SECURITY

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ABSTRACT

In this paper, a real time embedded finger vein recognition system for personal authentication and vehicle security is proposed. Vein patterns are different for each finger and for each persons and as they are hidden underneath the skin's surface, forgery is extremely difficult these unique aspects of finger vein patterns recognitions set it apart from previous forms of biometrics and have led to its adoption in various security technology, the proposed system is implemented in MATLAB platform and equipped with a novel finger-vein recognition algorithm. The proposed system consists of four module image acquisition module, finger vein matching model, embedded main board and communication module. The image acquisition module is used to collect a finger vein image and is a low cost device. Feature extraction is important for finger vein recognition algorithm and a HAAR classifier is used to extract the features. The finger vein image is matched by calculating the Euclidean distance. Embedded control unit comprises of AT89C51microcontroller and is programmed using Embedded C and has a GSM for alerting a message about the unauthorized person. The proposed system takes only 0.5 seconds to verify one input finger vein sample and the expected error rate (ERR) of 0.06.

Keywords: *Finger Vein Recognition Algorithm, Image Acquisition, Haar Transform, Microcontroller, Gsm.*

1. INTRODUCTION

1.1 Role of Biometric Recognition

This Biometrics are defined as the automated recognition of individuals based on their biological or behavioral characteristics. Common forms of biometrics used for logical and physical access control include fingerprint, facial, iris, retina, speaker (voice), hand geometry, key-stroke, and handwriting recognition. Unique human characteristics are used to identify an individual or to verify an identity[1]. Biometric authentication generally involves the latter-verifying or authenticating a user's claim of identity based on a one-to-one comparison of the presented biometric credential(s) to the registered (enrolled) biometric. The selection of a particular biometric for the specific application involves a weighting of several factors and they are universality, uniqueness, measurability, performance, accuracy, robustness and acceptability. The main objective of this paper is to design a real time embedded finger vein recognition system for personal Identification and vehicle security.

1.2 Role of Embedded Security

Embedded security will be critical for the many next-generation applications and devices, especially when these applications and devices are applied into specific domains of our everyday life from automobiles, hospitals to traffic light controls and flight control for passenger jets, today, security is very much essential in all kind of application activities. Illegal activities are happening in every place today. So government and corporate sections are concentrating mainly on the security levels with their every invention. This will bring privacy all over the world, so in a thought of bringing privacy through security with the development and applications of many embedded techniques, car security system design and analyses are constantly improving [2].

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2. LITERATURE REVIEW

Zhi Liu et al. [1] has proposed finger-vein recognition system for authentication on mobile devices. This system is implemented on a DSP platform and equipped with a novel finger vein recognition algorithm. In this work the system takes only about 0.8 seconds to verify one input finger-vein sample and achieves an equal error rate (EER) of 0.07% on a database of 50 subjects. This proposed system qualified only for authentication on mobile devices.

T. Y. V. BhanuKiranmai et al. [2] has proposed the finger-vein recognition system (FVRS). In this proposed system consist of four hardware modules: radio frequency identification system, image acquisition module, embedded main board, and human machine communication module. RFID module will start the very initial communication between user and device. The image acquisition is used for collecting a finger-vein image for user. The embedded main board is main chapter for security levels, it consists of microcontroller chip, memory (flash) and communication port is executed on FVRS algorithm.

Caixialiu [3] has proposed "study on finger vein feature extraction algorithm", according to the feature of human finger vein image, a finger vein feature extraction method based on improved adaptive niblack threshold segmentation algorithm is proposed. In this method, niblack window parameter and the correction factor, the image is enhanced by adaptive histogram equalization and filtering before feature extraction. This proposed system captures only 200 pixels and 500 pixels of finger vein images.

Ajay Kumar et al. [4] has proposed human identification system simultaneously acquires the finger-vein and low resolution finger print. This system has investigates two new score level combination approaches, holistic and nonlinear fusion, for combining finger vein and finger texture matching scores.

3. SYSTEM ANALYSIS

3.1 Existing Biometric Technology

First, Biometric recognition, or simply biometrics, refers to the use of distinctive anatomical and behavioral characteristics or identifiers for automatic identification of a living person based on physiological or behavioral characteristics for authentication purpose. Among the existing biometric technologies are the face recognition, finger print recognition, finger-geometry, hand geometry, iris recognition, voice recognition, and signature recognition. Biometric method requires the physical presence of the person to be identified. The emphasizes its preference over the traditional method of identifying such as, the use of password, a smartcard etc. Also, it potentially prevents unauthorized admittance to access control system or fraudulent use of ATMs, time & attendance systems, cellular phones, smart card, desktop PCs, workstation, vehicles and computer networks. Biometrics recognition system offers greater security and convenience than traditional methods of personal recognition.

3.2 Proposed Finger Vein Biometric

The finger-vein is a promising biometrics pattern for personal identification in terms of its security and convenience. Compared with other biometric traits, the finger-vein has the advantage. The vein is hidden inside the body and is mostly invisible to human eyes, so it is difficult to forge or steal. The non-invasive and contactless capture of finger-veins ensures both convenience and hygiene for the user, and is thus more acceptable. The finger-vein pattern can only be taken from a live body. Therefore, it is a natural and convincing proof that the subject whose finger-vein is successfully captured is a live. Biometric authentication utilizing vein patterns however is still in its infancy. Vein patterns are the vast network of blood vessels underneath a person's skin. They are unique to each individual and are stable over a long period of time. Due to its uniqueness, stability, and high resistance to criminal tampering, vein pattern recognition offers a more reliable solution for secure biometric authentication systems.

Finger vein authentication technology has several important features that set it apart from other forms of biometrics as a highly secure and convenient means of Human Identification. Resistant to criminal tampering: Because veins are hidden inside the body, there is little risk of forgery or theft. Ease of feature extraction: Finger vein patterns are relatively stable and clearly captured, enabling the use of low-resolution cameras to take vein images for small-size, simple data image processing. Fast authentication speed: One-to-one authentication takes less than one second. Moreover, the authentication device can be compact due to the small size of fingers.

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4. DESIGN AND IMPLEMENTATION

A real time finger-vein recognition system is proposed for authentication on vehicle security. The proposed system consists of four modules and is shown in the Figure 1.

- Image acquisition module
- Finger vein matching module
- Embedded main board module
- Communication module

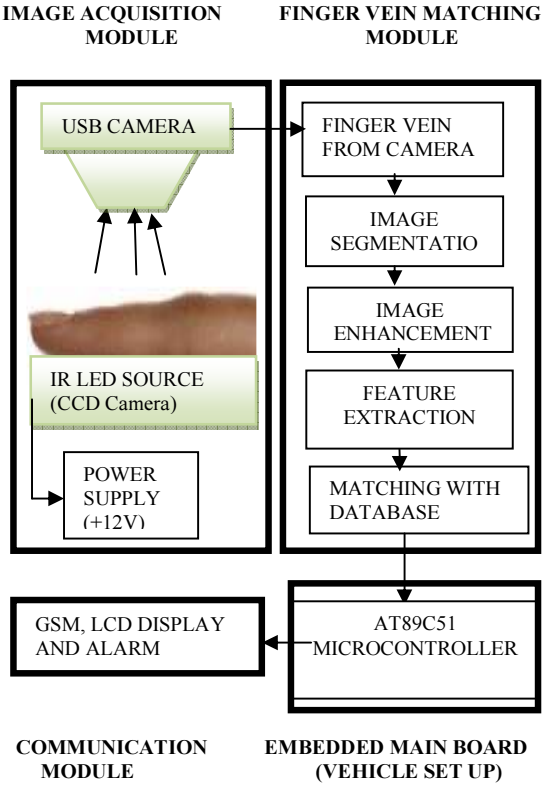


Figure 1. Block diagram of proposed system.

4.1 Image Acquisition Module

Vein patterns, invisible to the naked eye, can be viewed through an image sensor sensitive to infrared light. Infrared light passes through the tissues of the human body and is blocked by pigments such as hemoglobin or melanin. As hemoglobin exists densely in blood vessels, infrared light shining through causes the veins to appear as dark shadow lines in the captured image. In image acquisition module there are two cameras used one is CCD camera and the other is web camera. The CCD IR bullet camera comprises of IR LED source with an array of 36 IR LED's and required 12V DC power supply and has a 6mm lens which supports the IR rays with a maximum penetration distance of 30mm. The LED source is used to pass the IR rays in the finger, to get the finger vein image. The CCD camera used in this work is shown in the Figure 2. and Figure 3. To acquire the image with high quality and another low cost USB web camera is used, and is fixed inside the box which is shown in the Figure 4. This camera has CMOS sensor, 30 fps, and with the video resolution of 640 × 480. These two cameras are arranged as shown in the Figure 5. This image acquistion module is connected with pc through USB cable which is shown in the Figure 6. The finger is inserted in the small hole provided in the low cost image acquistion device to capture the vein image as shown in the Figure 7.The IR rays in the CCD camera, will penetrate the finger and the rays are captured with the help of USB camera fixed in the top of the box. Initially the video image of the vein pattern is displayed in the PC, then the still image of the finger vein is captured from that video. Figure 8. shows the captured finger vein image.

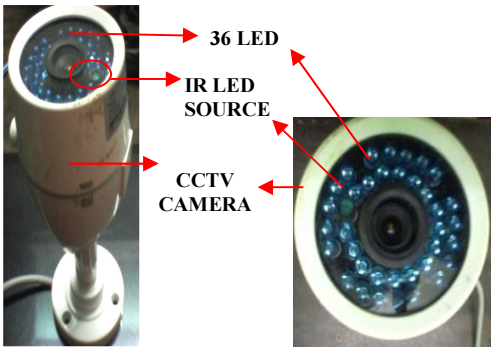
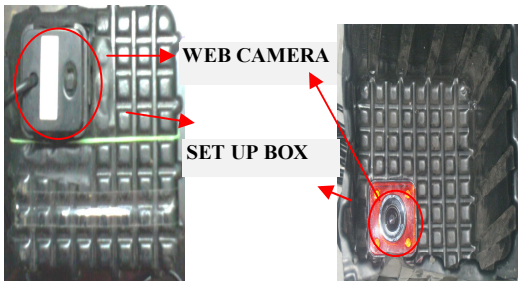


Figure 2. CCD camera. *Figure 3. IR LED source.*



Outer side of the box *Inner side of the box*

Figure 4. Web camera setup box.

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Figure 5. Proposed image acquisition device.

Figure 6. Monitoring the image acqusition.

Figure 7. Detection of finger vein.

Figure 8. Sample finger vein image.

4.2 Finger Vein Matching Module

The Finger vein matching module is used in MATLAB, the MATLAB is used to execute the finger vein recognition algorithm. In the working of real time proposed finger vein recognition algorithm contains two stages.

- The enrollment stage and
- The verification stage

For both stages start with finger vein image processing, which includes region of interest in image segmentation, image enhancement and feature extraction then stored in database [1]. The enrollment stage is to enroll users to the system; first it takes the finger-vein image from the web camera. Image segmentation and enhancement and feature extraction process are done by using image processing technique and the software use here is MATLAB GUI. The verification stages is also get a finger vein image from image acquisition device, image segmentation (ROI), image enhancement, feature extraction and then match with database. The finger vein matching module consists of stages. Input finger vein image, Image segmentation, Image enhancement, Feature extraction and Matching with database.

4.2.1 Image segmentation

Image segmentation is the authorized process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images. Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. The original image is captured with the black unwanted background. Including the background reduced the accuracy of the original image, because the position of finger usually varies across different finger vein images, it is necessary to image segmentation in region of interest (ROI) before feature extraction and matching with database. The bone in the finger joint is articular cartilage. Unlike other bones, it can be easily penetrated by light source. When a finger is irradiating by the uniform light source, the image joint is brighter than the other part and is show in Figure 9.

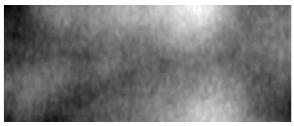

Figure 9. The segmented ROI finger vein image.

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4.2.2 Image enhancement

The segmented finger-vein image is then enhanced to improve its contrast as shown in Figure. 10. The image is resized to 1/4 of the original size, and enlarged back to its original size. Next, the image is resized to into the original size for recognition. Bicubic interpolation is used in this resizing procedure. Finally, histogram equalization is used for enhancing the gray level contrast of the image.

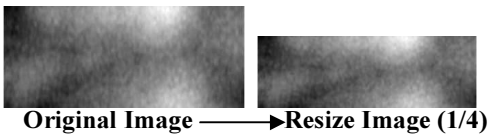

Figure 10. Enhanced finger vein image.

4.2.4 Feature extraction

The feature extraction is the important stage in finger vein recognition algorithm and the finger vein image features are extracted by using HAAR classifier and line detection. The HAAR transform is the simplest of the wavelet transforms. This transform cross-multiplies a function against the HAAR wavelet with various shifts and stretches, like the Fourier transform cross-multiplies a function against a sine wave with two phases and many stretches. The attracting features of the HAAR transform, including fast for implementation and able to analyze the local feature, make it a potential candidate in modern electrical and computer engineering applications, such as signal and image compression. Discrete wavelet transform a wave is an oscillating function of time or space that is periodic. The wave is an infinite length continuous function in time or space. In contrast, wavelets are localized waves. A wavelet is a waveform of an effectively limited duration that has an average value of zero. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilations or contractions (scaling) and translations. The feature extracted finger vein image is shown in the Figure 11.

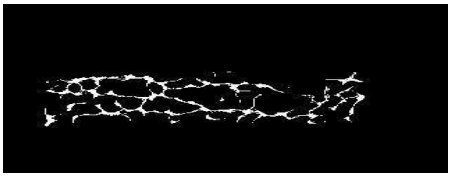

Figure 11. Feature extracted image.

4.2.5 Matching with database

In this work, matching with database is a final and decision making step to get a result from the finger vein recognition algorithm. There are two types of errors in matching results in biometric verification. The first is false rejection, which claims a genuine pair as impostor, and the second is false acceptance, which claims an impostor pair as genuine. These two types of errors are in trade-off relationship. In biometrics, the performance of a system is evaluated by the EER (equal error rate). The EER is the error rate when the FRR (false rejection rate) equals the FAR (false acceptance rate) and is therefore, suitable for measuring the overall performance of biometric systems because the FRR and FAR are treated equally. Here the matching is used for Euclidean distance measures the similarity between two different feature vectors using

$$ED = \sqrt{\sum_{j=0}^{j}(FV_{1,j} - FV_{2,j})^2} \quad (4)$$

Where, ED is Euclidean distance. J is the length of the feature vector, Fvi is the feature vector for individual i

In the verification stage, newly gathered finger vein image is used to apply a preprocessing stages, after that the finger vein image is replaced into the feature extracted image. Finally that extracted image is departing to an authentication stage. This stage will match the newly feature extracted image with the database image, after that matching it will create the match score of each finger vein images in the database. If the match score is greater than of 0.2500 is authorized and lesser than of 0.2500 is not authorized. And the proposed system is implemented in MATLAB GUI.

5. HARDWARE DESCRIPTION

The vehicle set up consist of two modules embedded main board module and communication module. This is very important module for proposed system, developed a vehicle setup for finger vein recognition and as shown in Figure 12.

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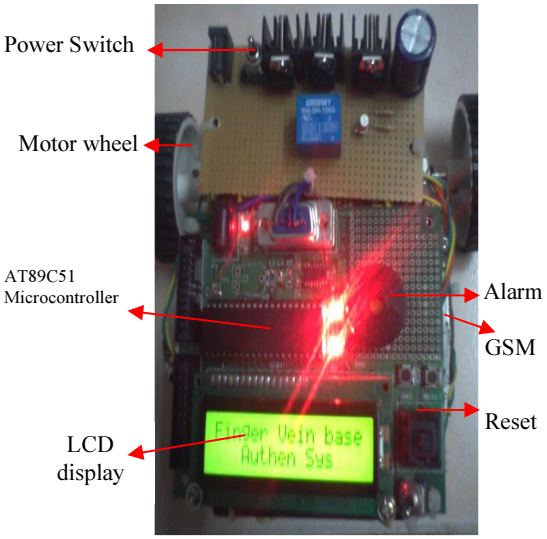

Figure 12. Proposed Vehicle Setup.

5.1 Embedded Main Board Module (AT89C51 microcontroller)

The embedded main board module designed with help of AT89C51 Microcontroller and the controller is embedded with the Embedded C language (Figure 13). The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The AT89C51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vectors two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power-down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset. The LCD pin 4 is interfaced with the microcontroller to the port 1.0 to the pin 1, pin 5 is interfaced with the microcontroller to the port 1.1 to the pin 2, pin 6 is interfaced with the microcontroller to the port 1.2 to the pin 3, pin 7 is interfaced with the microcontroller to the port 2.0 to the pin 21, pin 8 is interfaced with the microcontroller to the port 2.1 to the pin 22, pin 9 is interfaced with the microcontroller to the port 2.2 to the pin 23, pin 10 is interfaced with the microcontroller to the port 2.3 to the pin 24, pin 11 is interfaced with the microcontroller to the port 2.4 to the pin 25, pin 12 is interfaced with the microcontroller to the port 2.5 to the pin 26, pin 13 is interfaced with the microcontroller to the port 2.6 to the pin 27,pin 14 is interfaced with the microcontroller to the port 2.7 to the pin 28. The DC motor (M1) is connected with the microcontroller to the port 0.1/pin38 and M2 is connected with the microcontroller to the port 0.3/pin36 and The receiver pin in GSM is interfaced with the microcontroller to the port 3.0 pin 10 and transmitter pin is connected with the port 3.1 and pin 11. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

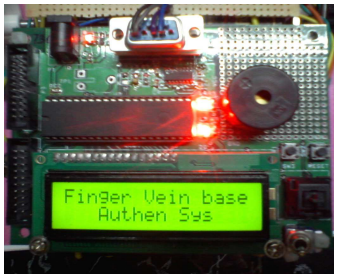

Figure 13. AT89C51 Microcontroller.

5.2 Communication Module (GSM)

The communication module consist of LCD display, alarm and GSM (Global system for mobile). The main purpose of GSM in this work is to alert the authorized vehicle user about the vehicle security. If an unauthorized person is trying to access the car, then an alert message "Access denied" message is sent to the authorized person through GSM (Figure 14), that is to provide a security information about the vehicle. The same message is also displayed in the LCD as shown in Figure 16 and also alarm will produce a beep sound as shown in Figure 15 and LCD display is displaying a message about "unauthorized is accessing a car" as shown in Figure 16. This is a plug and play GSM Modem with a simple to interface serial interface. Use it to send SMS, make and receive calls, and do other GSM operations by controlling it through simple AT commands from microcontroller. It uses the highly popular SIM300 module for all its operations. It comes with a standard RS232 interface which can be used to easily interface the modem to microcontroller and for developing embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. It can also be used in GPRS mode to connect

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to internet and do many applications for data logging and control.

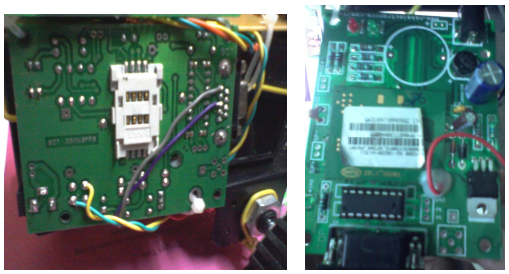

Figure 14. GSM Module

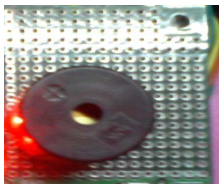

Figure 15. Alarm.

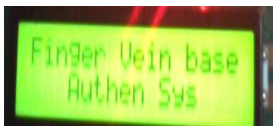

Figure 16. LCD display.

6. SOFTWARE DESCRIPTION

6.1 Matlab

MATLAB is a programming language developed by MathWorks. It started out as a matrix programming language where linear algebra programming was simple. It can be run both under interactive sessions and as a batch job. In this paper finger vein reorganization algorithm is implemented on MATLAB GUI.

6.2 Embedded C

Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations. The AT89C51 microcontroller is programmed with the embedded c, through which it controls the application.

7. RESULTS AND DISCUSSION

The developed work provides the security to the vehicle, by identifying the authorized persons to stat the vehicle. This authentication is provided by the developed finger vein recognition system. The system has basically two main modules in the execution stage. One is creating a database and the other is matching the acquired finger vein image of the person, who is going to access the car. The system is started with the index page. Whenever the start button is pressed then the system starts to execute the process. This index page is created with the help of MATLAB GUI.

7.1 Creating a Database

To identify the authorized person, it is necessary to create a database of group of person's finger vein image. In this work a minimal of 12 image have been taken in to account for maintaining the database. There are four steps for creating the database and are discussed in the following steps.

STEP 1: After pressing the start button in the index page, the next subpage will be opened and has seven buttons for various processes like creating a database, loading a database, capturing the image, segmentation, enhancement, feature extraction and for authenticating. There is one separate button for exit. For capturing the image, create database button needs to be pressed.

STEP 2: The live video will be appeared in the second window and has one specific button to take picture and need to be pressed for the next stage.

STEP 3: The captured image will be appeared in the input axes box.

STEP 4: The next and final stage is an enrollment stage, and is represented as load database button. This stage includes all the processing like segmentation, enhancement and feature extraction. After completing all this process will be loaded in the database.

7.2 Matching the Image

Matching the finger vein image with the database image is the main stage to verify the person's authentication to access the car. This stage is discussed in the following steps.

STEP 1: While pressing the 'capture image button', the live video is appeared in the second window. And that second window also has one specific button to take the picture, and need to be pressed for the next stage.

STEP 2: Newly captured finger vein image will be appeared in the input axes box.

STEP 3: Press the segmentation button, which is used to cut the region of interest on rectangular shape of for the newly captured finger vein image.

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STEP 4: Next press the enhancement button, this will enhance (resize) the newly captured finger vein image (verification stage). The vein is perceptible to the human eye.

STEP 5: Feature extraction for authentication is an important stage, press the feature extraction button it will extracts the newly captured finger vein image features and feature extracted image is display in axes box.

STEP 6: The next and final stage is authentication stage and is represented as authenticate button. Press the authenticate button, this will match the newly feature extracted image with the database image and it will display the matched feature extracted image in the axes box. And also if the finger vein image is matched perfectly with the database image then displays an authorized message in the static box as shown in the Figure 17. The authorized person's details will be displayed in the word document as shown in the Figure 18. The vehicle get started only when the person is a authorized person. The overall prototype of the proposed system is shown in figure 19. The Vehicle access grant message is sent to the authorized person through GSM and the message is shown in the figure 20. If the finger vein image is not matched with the database image then the system displays the message as "unauthorized" in the static box (Figure 21). The access denial message is also sent to the authorized person (Figure 20). The MATLAB will display the mathematical match score (0.2777) of the finger vein image.

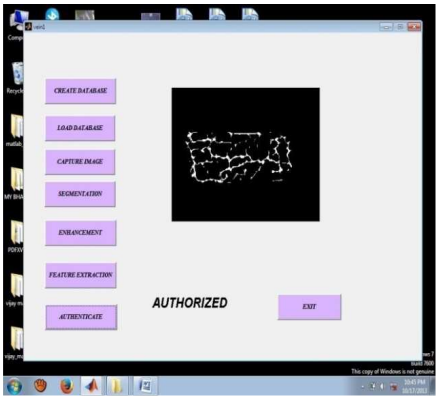

Figure 17. Showing the result for authorized person.

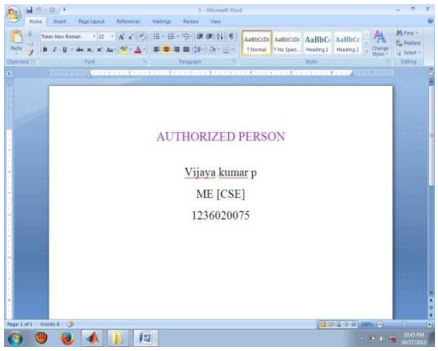

Figure 18. Displaying the authorized person details in word document.

Figure 19. Prototype of the proposed system

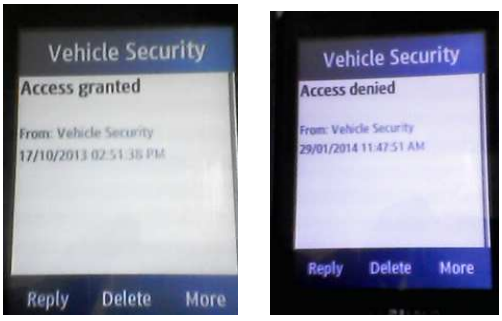

Figure 20. Access Grant and Denial message to the Authorized person

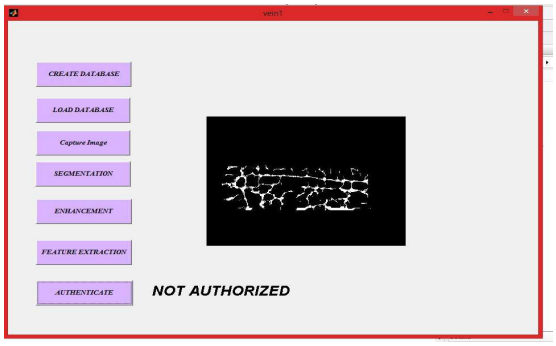

Figure 21. Showing the result for unauthorized person.

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8. CONCLUSION

This paper has been implemented for improving the security and authentication based on biometric system. The developed system includes finger vein matching and controlling the application. The experimental result shows that it takes minimal time that is only 0.5 seconds to verify one input finger vein sample image which is significantly lower than the existing system methods. This system consumes low power and has less computational complexity and hence it is suitable for security applications in vehicle, home, banks and industry etc. In future, this work will be further enhanced by interfacing with DSP platform.

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