International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-4, April 2014

An Embedded Real Time Finger Vein Recognition System for ATM

Mr. Shobhit Mishra, Mr. Mathew Oommen, Mr.Sunilkumar

***Abstract*— As a newly emergent biometric technology, finger-vein recognition has attracted more attentions in personal identification. Generally, finger-vein images have low contrast and uneven illumination due to finger-vein imaging manner and finger-shape variation. So, finger-vein enhancement is indispensable for reliable finger-vein network extraction.In consideration of emerging requirements for information protection, biometrics, which uses human physiological or behavioural features for personal identification, has been extensively studied as a solution to security issues. However, most existing biometric systems have high complexity in time or space or both, and are thus not suitable for ATM. In this paper, we propose a real-time embedded finger-vein recognition system for authentication on Automated Teller Machine (ATM). The system is implemented on a DSP platform and equipped with a novel finger-vein recognition algorithm. Experimental results showthat the proposed method is capable of enhancing finger vein images effectively and reliably.**

***Index Terms*— Finger Vein Recognition; biometrics; ATM; DSP; Personal Identification; Biometric**

I. Introduction

combinations were studied in order to define a final setup Biometric technique is used as a hedge against identity theft in our digital age. It becomes more and more important because it is more reliable than traditional methods such as passwords. Traditional biometric techniques contain fingers, faces and iris. Compared to them, vein recognition is a new member Private information is traditionally provided by using passwords or Personal Identification Numbers (PINs), which are easy to implement but is vulnerable to the risk of exposure and being forgotten. Biometrics, which uses human physiological or behavioral features for personal identification, has attracted more and more attention and is becoming one of the most popular and promising alternatives to the traditional password or PIN based authentication techniques. Moreover, some multimedia content in consumer electronic appliances can be secured by biometrics. There is a long list of available biometric patterns, and many such systems have been developed and implemented, including those for the face, iris, fingerprint, palm print, hand shape, voice, signature, and gait. Notwithstanding this great and increasing variety of biometrics patterns, no biometric has yet been developed that is perfectly reliable or secure. For example, fingerprints and palm prints are usually frayed; voice, signatures, hand shapes and iris images are easily forged; face of the biometric family. The finger-vein is a promising biometric pattern for personal identification in terms of its security and convenience.

Compared with other biometric traits, the finger-vein has the following advantages. 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 alive. We designed a special device for acquiring high quality finger-vein images and propose a DSP based embedded platform to implement the finger-vein recognition system in the present study to achieve better recognition performance and reduce computational cost. The target of this project was the design and development of a finger vein identification system that could be used by a limited number of users in a networked environment. The work realized was divided in two parts, the study and development of the finger vein recognition process and the networked solution.

In general, it is recognized that it is a great challenge to design a finger vein identification systems that achieves certain level of performance. For this propose different extraction methods and combinations were studied in order to define a final setup that is contained and explained in this paper.

This paper also proposes a new finger vein pattern recognition method based on geometrical parameters of the finger vein pattern, which is to acquire the values of the maximum and minimum distance between two lines of cross section scans of the finger vein pattern.

It will study also the use of different methods and the combination of results to generate a final matching score using a Support Vector Machine (SVM). It will present the modeling used to characterize and determine the performance of different methods in order to decide a final system setup, based in Kernel Density Estimation (KDE). Finally, this paper presents the developed networked solution. It will present a server-client structure using free SQL Database servers tools (MySQL Server).

II. OVERVIEW OF SYSTEMS

The proposed system consists of three hardware modules image acquisition module, DSP mainboard, GSM module and human machine communication module. The structure

Manuscript received March 28, 2014.

Mr. Shobhit Mishra, Department of ECE, Hindustan Institute of Technology and Science, Hindustan University, OMR Padur, Chennai-603103, India

Mr. Mathew Oommen, Department of ECE, Hindustan Institute of Technology and Science, Hindustan University, OMR Padur, Chennai-603103, India

Mr..Sunilkumar., Assistant Professor, Department of ECE, Hindustan Institute of Technology and Science, Hindustan University, OMR Padur, Chennai-603103, India

diagram of the system is shown in Fig. 1. The image acquisition module is used to collect finger-vein images. The DSP mainboard including the DSP chip, memory (flash), and communication port is used to execute the finger-vein recognition algorithm and communicate with the peripheral device. The human machine communication module (LED or keyboard) is used to display recognition results and receive inputs from users.

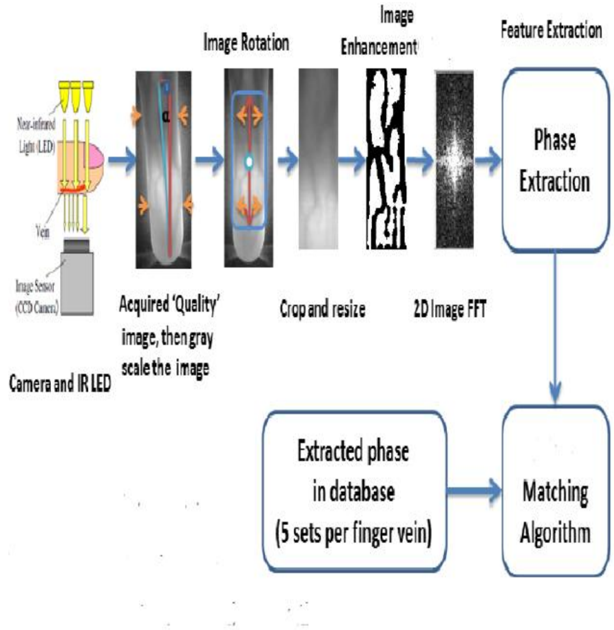


Fig 1- overview of system

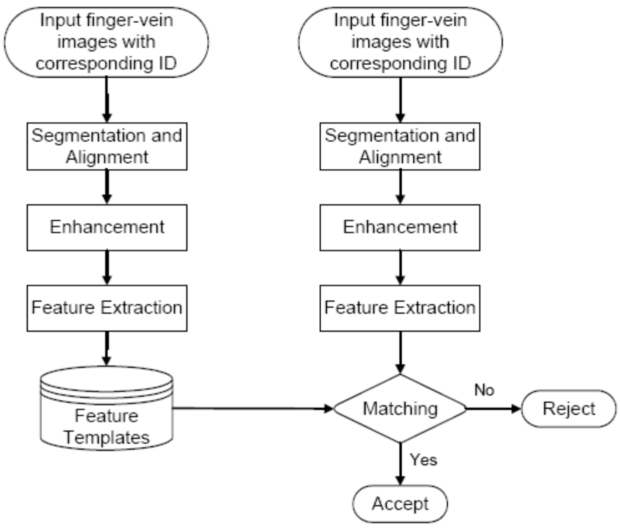
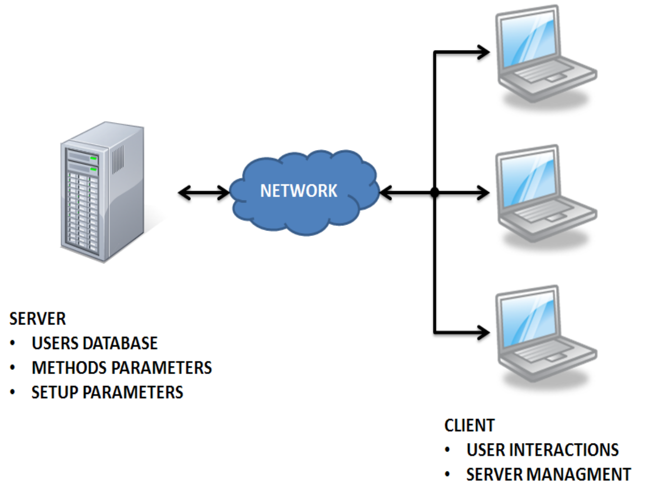


Figure 2- The Flow Chat of Proposed Algorithm

The proposed finger-vein recognition algorithm contains two stages: the enrolment stage and the verification stage. Both stages start with finger-vein image pre-processing, which includes detection of the region of interest (ROI), image segmentation, alignment, and enhancement. For the enrolment stage, after the pre-processing and the feature extraction step, the finger-vein template database is built. For the verification stage, the input finger-vein image is matched with the corresponding template after its features are extracted. Fig. 2 shows the flow chart of the proposed algorithm. Some different methods may have been proposed for finger-vein matching.The solution proposed has been developed as a distributable system with a common database that may be updated and accessed by different clients from local or non-local networked locations. The solution relies in a data server that can be remotely accessed to acquire the registered users of the system and a GUI Client program that manages the user interactions: identification and registration; and operations: delete/modify users, benchmarking and setup. In this paper has been designed a server-client system were the computing tasks are realized in the client.



III. IMAGE ACQUISITION

The main body property used to acquire the images required for finger vein identification is the fact that blood vessels are opaque to Near-Infrared light and at the same time, bones and flesh aren't, delivering a different degree of shadowing at a picture taken in this wave length. A finger vein identification system will target such property through the use of a Near-Infrared (NIR) illumination system that targets to create the required lighting conditions to create an input frame for a Near-Infrared sensor from the light that pass through the user fingers and defines a pattern in the input image. The device used for this project, shown at Figure 1, consists into an array of Near-Infrared (NIR) light illuminators regulated by a COM interface that serves the propose as NIR light source, a NIR camera that serves the propose of capturing the light that passes through the user's finger and create an image that can be processed by a computer and some physical support for the users to place the finger.

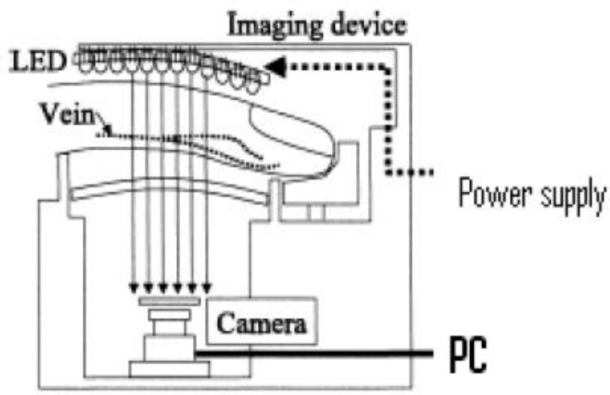


Fig 3- Finger Vein Scanner

The illuminators are located at the top-front part of the finger and the camera is located at the base of device heading up. The illuminators have a design fault and haven't been located homogeneously at the top of the device, given a stronger lighting level at the front of the device.
The camera acquisition resolution is setup at 320x240 pixels. However, given the distance between the camera and the finger, the region of interest for the system has a resolution of 210x131 pixels, this count as a 35.8% of the source picture resolution.
The device only has two supports for the front and back of the finger respectively without support for the hand. This have proven to provoke that different pictures are likely to have problems with rotation and different levels of curvature of the fingers given the high degree of freedom the users have to place the finger.

IV. PROPOSED ALGORITHM

This process can be dived in two blocks, the first one: *image acquisition* and the second one: *vein segmentation and feature extraction*. The target of the first block it's to acquire a clear picture from the finger and the second block target it's to generate a pattern as clear as possible and obtain representative features from it that can beused in the identification process. The identification or authentication process will require a stage of feature extraction and matching.

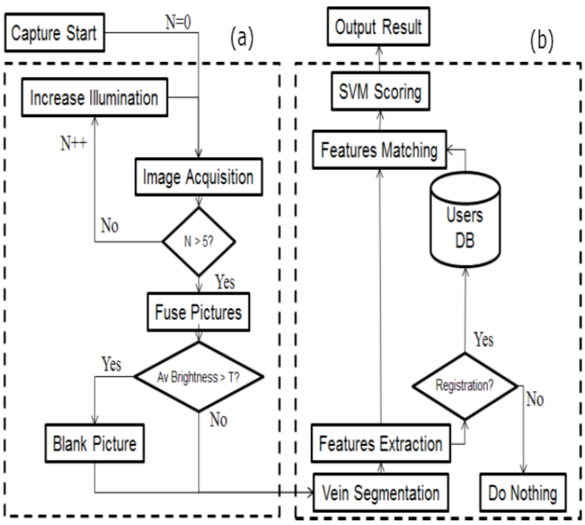


Figure 4- a) Image Acquisition Block; b)Vein segmentation, Feature Extraction and Matching Block

A. *Image Acquisition Block*

We are using an infrared camera that captures the image that flows from a led array from the top of the device trough the user's finger to the camera. The amount of light that will be delivered to the sensor will vary according the user's finger thickness. In order to obtain a good image for data acquisition at the first block it's required to capture several different pictures at different illumination levels and fuse the different pictures using a pixel per pixel averaging using the Equation 2

$$A(x,y) = \left(\frac{I_1(x,y)^{\frac{3}{4}} + I_2(x,y)^{\frac{3}{4}} + \cdots + I_{N-1}(x,y)^{\frac{3}{4}}}{N} \right)^{\frac{4}{3}} \quad \forall x,y$$

Where x and y, are the coordinates of the pixel and N the number of images used for fusing. different users will have fingers with different thickness, the global illumination level of the picture is checked and used to adjust the exposition time of the camera in order to try to get pictures that have similar levelsof luminosity and improve the vein visibility, once more, trying to avoid the saturation of the camera near the illuminators area.

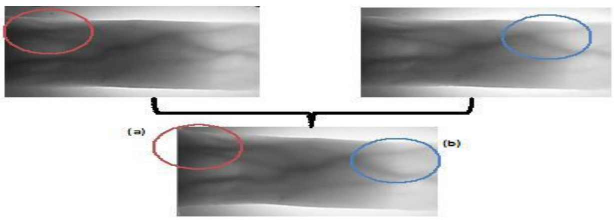


Figure 3- a) Smoother vein pattern near the darkest part of the picture. b) Smoother transition from dark part of the finger to a more illuminated region.

With this procedure, it's is possible to overcome some of the device design faults and at the same time as shown in the Fig 3, the final picture has a more recognizable finger vein pattern and less noise than neither the lowest or highest exposition time.

B. *Finger Vein Segmentation*

The position of a finger vein near the border of the finger is hidden by the increase of luminosity derivate from the decrease of the finger height. In our case, this phenomenon is used to avoid the separation of the last finger vein detected and the finger side detected. Adding the finger side information increases the pattern complexity and also the system properties.

$$C(y) = P(y) \frac{\sum_{q=-W/2}^{W/2} P(q) T_r(H-1>y+q>0)}{\sum_{q=-W/2}^{W/2} T_r(H-1>y+q>0)}$$

In equation, *H* is the height of the picture, *W* it's an odd value to use as window size (35 was used for the above graphs and study) for a local average filtering, *Tr(b)*, is a logical function that given the expression b is true the value it's 1, 0 otherwise and P(y) it's the function of the profile value of the image.

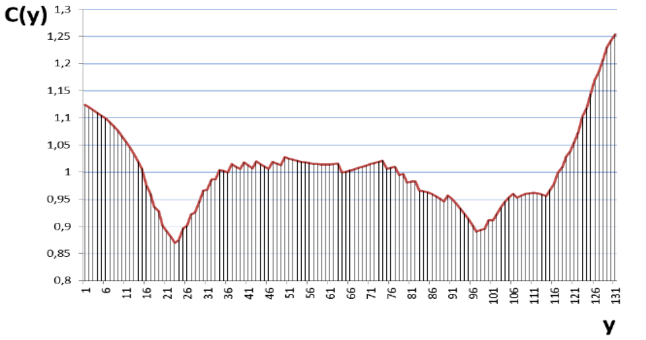


Figure -C(y), Cross-sectional profile of finger-vein image

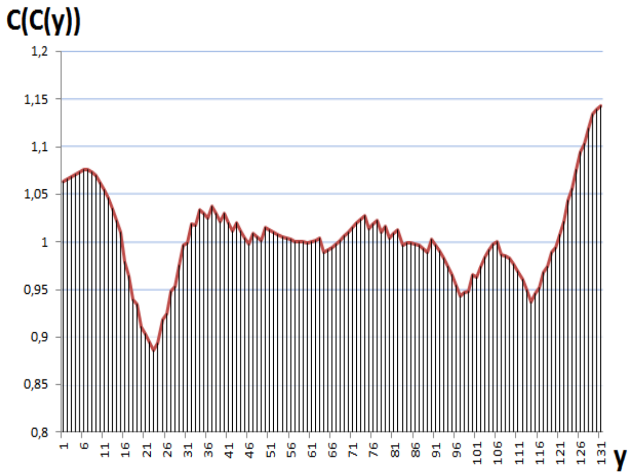


Figure 5 -C(C(y)), Cross-sectional profile of finger-vein image

There are some issues related to the acquisition of the final image by this method, such as single isolated points around the main detected pattern. In order to avoid such irregularities a smooth Gaussian filter is applied to the finger vein pattern to reduce the segmentation noise.

Once obtained the finger vein segmentation (Figure 7b), it's required to apply a thinning algorithm to reduce the width of the pattern to a single pixel width line. This project uses an 8-kernel matrix algorithm for such a task. Fig 6 shows the 8 kernels used.

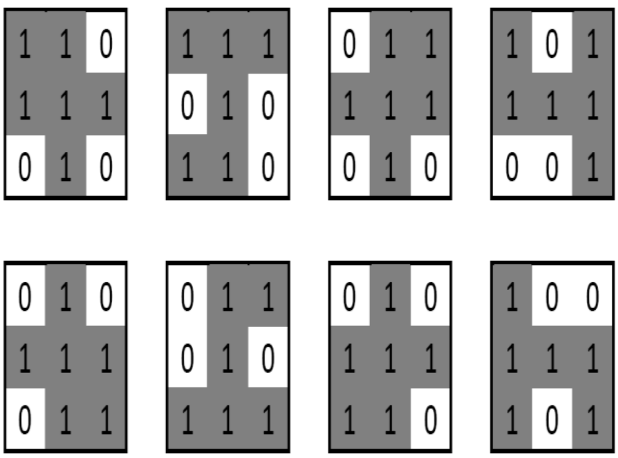


Figure - The 8 Kernels used in the thinning algorithm

In the smoothed vein pattern, the introduction of the finger side as one more vein fused with the top and bottom finger vein, increases the number of lines detected and the complexity of the final vein pattern. This aid in the identification of a given vein pattern and at the same time decreases the correlation between finger vein patterns from different fingers. It also helps to avoid the problem related with fingers with almost un-detectable vein patterns.

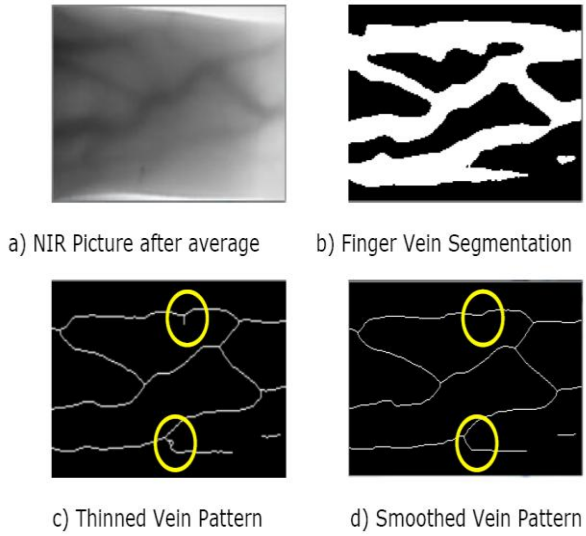


Figure 6 - Example of the finger vein segmentation and thinning process. Circles mark the location of irregularities before and after the smoothing of the vein pattern.

In this case, the finger geometry becomes the finger vein pattern used for identification proposes. It also has the advantage that the rotation of the finger commonly hides the vein closer to the finger side.

C. Features Extraction and Matching Algorithms

In this project three different kinds of data from the finger vein pattern were selected as feature points and the fusion between them in order to obtain a final result.

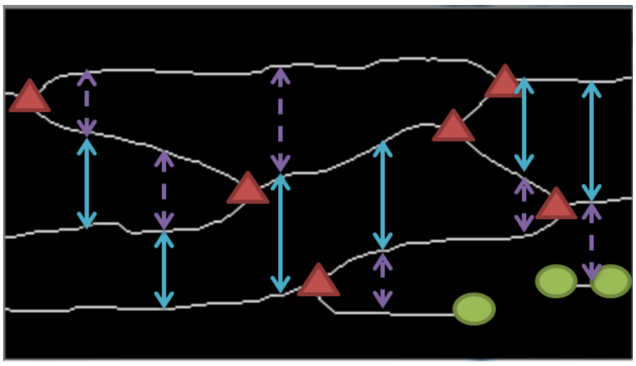


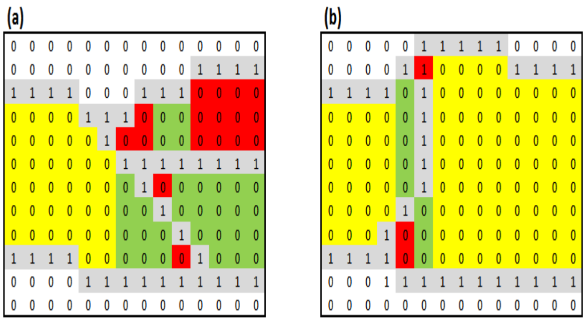
Figure 7 - Example of feature points extracted: a) Triangle: Cross point b) Circle: End Point c) Continuous Arrow: maximum distance value d) Discontinued Arrow: minimum distance value

a) Maximum Minimum Distance (MMD) method

This procedure is a novelty proposed in this thesis. It consist into realize a cross section scanning of a finger vein pattern from left to right recording the maximum and minimum distance found into two feature vectors Applying this method to the vector of maximum distance and the vector of minimum distance it is possible to obtain two different results. Since the noise that the thinning process adds to the maximum and minimum distance vector it's not highly correlated both vectors add information to the system. A simplified example of this calculation for both vectors is shown in the fig. It's possible to observe, that both values can differ.

$$AVS(\vec{x},\vec{y}) = \frac{\sum_{\forall i} T_r((x_i,y_i) \neq (0,0))(\min(x_i,y_i)/\max(x_i,y_i))}{\sum_{\forall i}\{T_r((x_i,y_i) \neq (0,0))\}}$$

Where *Tr(b)*, is a function such that if logical expression b is true the value it's 1, 0 otherwise; $\vec{x}$ and $\vec{y}$ are two vectors of the same length and x_i and y_i the values. The AVS function proposed ranges between 0 and 1, where 1 it's a full match and 0 it's a total mismatch.



Min	6	6	6	6	6	5	1	2	1	1	3	3	3	3
Max	6	6	6	6	6	5	4	3	2	2	3	4	4	4

Min	6	6	6	5	2	1	9	9	9	9	8	8	8	8
Max	6	6	6	5	5	3	9	9	9	9	8	8	8	8

Min	6	6	6	6	6	5	1	2	1	1	3	3	3	3
Min	6	6	6	5	2	1	9	9	9	9	8	8	8	8
	1	1	1	0,833	0,333	0,2	0,111	0,222	0,111	0,111	0,375	0,375	0,375	0,375
												AVS	0,459	

Max	6	6	6	6	6	5	4	3	2	2	3	4	4	4
Max	6	6	6	5	5	3	9	9	9	9	8	8	8	8
	1	1	1	0,833	0,833	0,6	0,444	0,333	0,222	0,222	0,375	0,5	0,5	0,5
												AVS	0,597	

Figure 8: Example of minimum and maximum distance vector and the calculation of the AVS at each. Yellow marked the value used for both maximum and minimum, green the value used for the maximum and red the value for the minimum.

D. Score-Level Fusion Based on SVM

An SVM classifier requires the acquisition of data for training proposes of the system and cross validation data. The training data is used as reference by the classifier to define the boundaries of the classification problem. Given that the classifier will use the training data as reference, it is not possible to test the classification performance using the training data. The data used to test the classification setup is called cross validation data, and it's propose is to define the final performance of the system. The input data for each SVM were setup as follow:

- HD SVM uses the calculated distance for end and cross points (2 values).
- FD SVM uses the calculated distance of the FD method (1 value).
- MMD SVM uses the calculated distance by applying the AVS to minimum and maximum distance vectors (2 values).
- Multimodal FD+MMD SVM uses the values used for FD and MMD SVM machines (3 values)
- Multimodal HD+FD+MMD uses the values defined for all the other SVM (5 values).

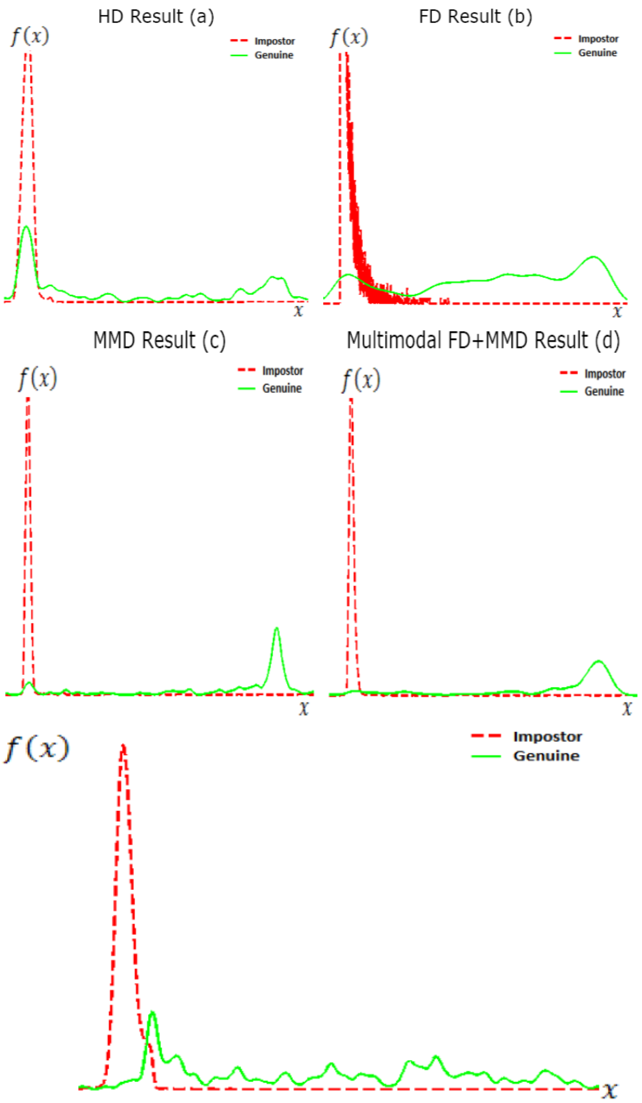


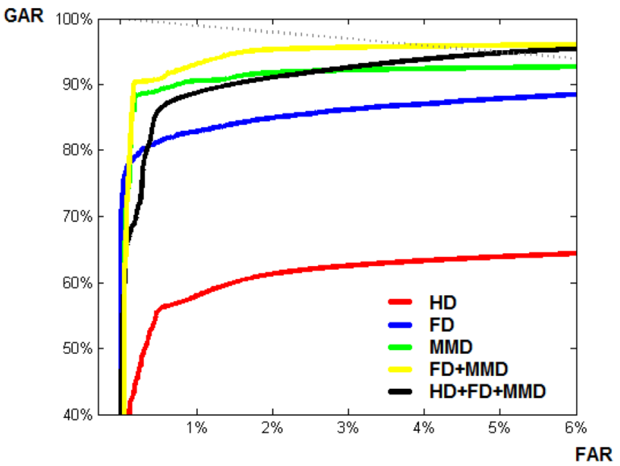
Figure 9: Probability density functions of each proposed SVM

V. EXPERIMENTAL RESULT

In order to calculate the Genuine Acceptance Rate (GAR) and False Acceptance Rate (FAR), it's possible to use the PDF calculated using the KDE method. The final GAR and FAR for a given decision threshold can be calculated as shown in Equations

$$FAR_M(x) = \int_{-\infty}^{x} far_M(x)dx$$

$$GAR_M(x) = 1 - \int_{-\infty}^{x} gar_M(x)dx$$



Where M is the chosen method and $gar_m$and far_m are the PDF of GAR and FAR of such method. However, given that the threshold defines non valid matches, the final probability for GAR needs to be subtracted from 1. Once the training data and parameters of the SVM have been choose, it is possible to use it as a method to score the similarity. It's required for the methods that have more than one value and especially useful for the multimodal systems. The next step will be to compare the output data from the matching of the 225 samples reserved for cross-validation.

Method	GAR	FAR	EER
HD	65%	0.5%	28%
FD	87%	0.5%	9.7%
MMD	93%	0.5%	7.1%
Multimodal FD+MMD	96%	0.5%	5.1%
Multimodal HD+FD+MMD	84%	0.5%	5.3%

Figure-Comparative values of the different methods studied

In order to calculate the new False Acceptation Rate (FAR) and Genuine Acceptance Rate (GAR), it's required to rely into combinatory systems study. The final probability for FAR and GAR can be calculated as shown in Equation

$$FAR_{MN} = \int_{-\infty}^{x} (1 - \sum_{i=0}^{N-1} (1 - far_{M0}(x))^{3-i} far_{M0}(x)^{i}) dx$$

$$GAR_{MN} = \int_{-\infty}^{x} (1 - \sum_{i=0}^{N-1} (gar_{M0}(x))^{3-i} (1 - gar_{M0}(x))^{i}) dx$$

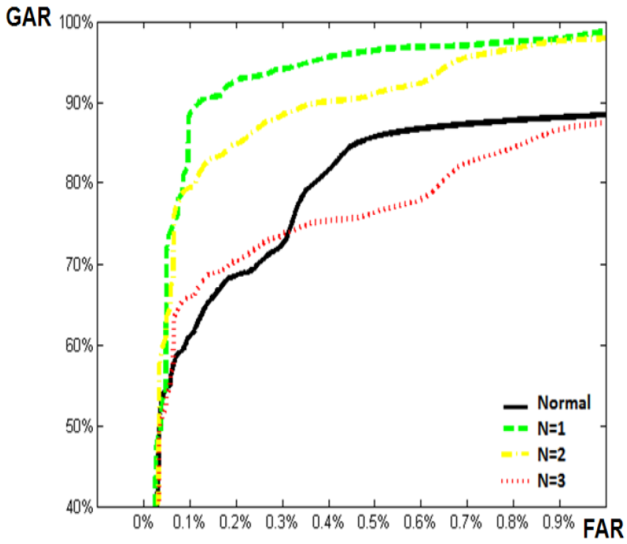


Figure 10: ROC curves for the different possible values of N with FD+MMD multimodal method.

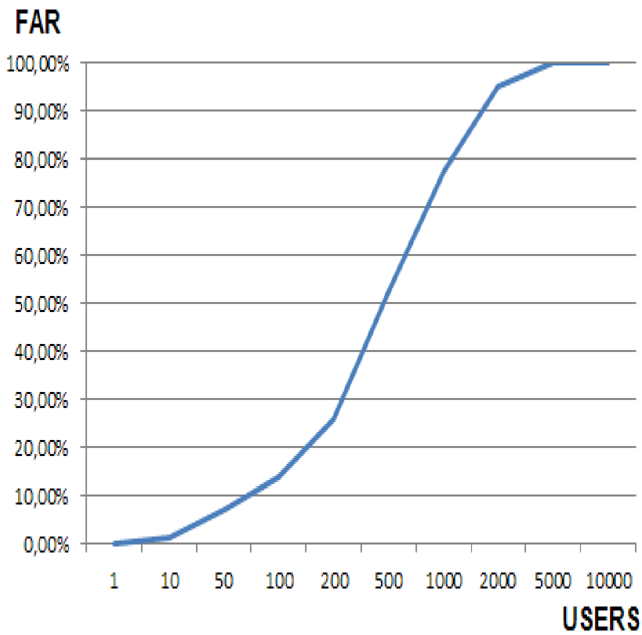


Figure 12: FAR of an Identification System that has method setup with a 0.15% One-To-One FAR.

VI. CONCLUSION

This paper study the possibilities and performance of different methods and setup of a finger vein identification system and propose a networked implementation of a finger vein identification system. It has been explained the process to extract the finger vein pattern from an input Near Infrared camera and the required steps to make it something reliable for a finger vein identification system. This paper has shown how it is possible to improve the problems related to a non-homogenous illumination of the finger from an array of illuminators. However, it would be recommendable for future device designs to avoid such design faults. During the experimentation with the finger vein segmentation and extraction, as well as matching process, was possible to identify the effects related to rotations and different curvature levels of the finger. It would be recommendable for future designs to reduce the distance between the illuminators and the camera and consequently, reduce the height of the device, reducing the degrees of freedom of a given user at the time to introduce the finger. It has studied and defined the properties of different methods and scoring setups in order to define the final parameters of our proposed solution.

It is also shown that methods with low levels of accuracy can be used to define a multimodal system with an increased accuracy but, at the same time, it has been proved that the minimum FAR required by the system can suffer a great penalty if one of the combined systems and the combination of more than one sample per user can greatly improve the performance of the system.

It has also been proposed a distributed setup using networked solution to provide the authentication information to different devices at remote locations.

REFERNCE

[1] K. Jain, S. Pankanti, S. Prabhakar, H. Lin, and A. Ross, "Biometrics: a grand challenge", *Proceedings of the 17th International Conference on Pattern Recognition (ICPR)*, vol. 2, pp. 935-942, 2004.

[2] P. Corcoran and A. Cucos, "Techniques for securing multimedia content in consumer electronic appliances using biometric signatures," *IEEE Transactions on Consumer Electronics*, vol 51, no. 2, pp. 545-551, May 2005.

[3] Y. Kim, J. Yoo, and K. Choi, "A motion and similarity-based fake detection method for biometric face recognition systems," *IEEE Transactions on Consumer Electronics*, vol.57, no.2, pp.756-762, May 2011.

[4] D. Wang , J. Li, and G. Memik, "User identification based on finger vein patterns for consumer electronics devices", *IEEE Transactions on Consumer Electronics*, vol. 56, no. 2, pp. 799-804, 2010.

[5] H. Lee, S. Lee, T. Kim, and HyokyungBahn, "Secure user identification for consumer electronics devices," *IEEE Transactions on Consumer Electronics*, vol.54, no.4, pp.1798-1802, Nov. 2008.

[6] D. Mulyono and S. J. Horng, "A study of finger vein biometric for personal identification", *Proceedings of the International Symposium Biometrics and Security Technologies*, pp. 134-141, 2008.

[7] Z. Liu, Y. Yin, H. Wang, S. Song, and Q. Li ,"Finger vein recognition with manifold learning", *Journal of Network and Computer Applications,* vol.33, no.3, pp. 275-282, 2010.

[8] Jiang Hong, GuoShuxu, Li Xueyan, QianXiaohua: "Vein Pattern Extraction Based on the Position-Gray-Profile Curve", 978-1-4244-4131-0/09/$25.00 ©2009 IEEE

[9] Byung Jung Kang, Kang Ryoung Park: "Multimodal biometric authentification based on the fusion of figer vein and finger geometry", Optical Engineering Letters 090501-1, September 2009, vol 48(9).

[10] SeptimiuCrisan, Ioan Gavril Tarnovan, Titus Eduard Crisan: "Radiation optimization and image processing algorithms in the identification of hand vein patterns", Computer Standarts& Interfaces 32, 2010, pp 130-140

Mr. Shobhit Mishra, is doing his M. Tech Embedded systems in the Department of ECE, Hindustan Institute of Technology and Science, Chennai. He did his B.Techin Electronics and Instrumentation atMaharana Institute of Professional Studies, Kanpur (Uttar Pradesh Technical University) in 2012.

Mr. Mathew Oommen, is doing his M. Tech Electronics & Communication in the Department of ECE, Hindustan Institute of Technology and Science, Chennai. He did his B.E in Electronics and Communication at Jawaharlal Nehru Technological University, Hyderabad in 2012.