An Efficient Automatic Attendance System using Fingerprint Verification Technique

Chitresh Saraswat
School of Information Technology,
Indian Institute of Technology,
Kharagpur, India

Amit Kumar
School of Medical Science and Technology,
Indian Institute of Technology,
Kharagpur, India

***Abstract*— The main aim of this paper is to develop an accurate, fast and very efficient automatic attendance system using fingerprint verification technique. We propose a system in which fingerprint verification is done by using extraction of minutiae technique and the system that automates the whole process of taking attendance, Manually which is a laborious and troublesome work and waste a lot of time, with its managing and maintaining the records for a period of time is also a burdensome task. For this purpose we use fingerprint verification system using extraction of minutiae techniques. The experimental result shows that our proposed system is highly efficient in verification of user fingerprint.**

Keywords-fingerprint verification; image processing; minutiae matching; segmentation

I. Introduction

In many institutions and organization the attendance is a very important factor for various purposes and its one of the important criteria that is to follow for students and organization employees. The previous approach in which manually taking and maintains the attendance records was very inconvenient task. After having these issues in mind we develop an automatic attendance system which automates the whole process of taking attendance and maintaining it.

We already know about some commonly used biometric techniques are used for objective identification and verification are like iris recognition, voice identification, facial recognition, fingerprint identification, DNA recognition, hand geometry recognition, signature recognition, and gait recognition [1]. Biometrics techniques are widely used in various areas like building security, forensic science, ATM, criminal identification and passport control [2]. In our proposed automatic attendance system we uses fingerprint recognition technique [3, 4] for obtaining the attendance. The fingerprint recognition is widely used for many other purposes and it is widely popular technique [5]. Fingerprint verification is very convenient and reliable way to verify the person's Identity. It is believed that no two people have identical fingerprint in this world, so the fingerprint verification and identification is most popular way to verify the authenticity or identity of a person wherever the security is a problematic question. The reason for popularity of fingerprint technique is uniqueness of person arises from his behavior; personal characteristics are like, for instance uniqueness, which indicates that each and every fingerprint is unique, different from one other. Universality, that means every person hold the individual characteristics of fingerprint. Permanence, means that fingerprint are permanent, are impossible to change or forgot, and can never be stolen. Collectability means that we can measure fingerprint quantitatively [6].

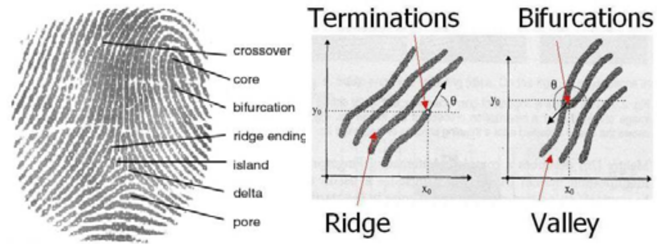
In present scenario, the various uses of fingerprint verification are widespread like authentication to logon machine and others but still majorly for law enforcement applications. There are a lot of expectations that the use of fingerprint recognition will increase which is dependent of some factor involved like small fingerprint capturing devices, fast computing hardware, and awareness on easy to use methods for security [3]. This paper cover the topics on fingerprint verification, algorithm and our proposed system, the details of pre-processing of fingerprint image including enhancement, binarization, segmentation, extracting minutiae from image, post processing and matching, experiment and its result.

A. Fingerprint Recognition

The Fingerprint is the feature pattern of one finger or an impression of friction ridges found on inner surface of finger as shown in figure 1(a). Everyone in this world has his own fingerprint with the permanent uniqueness. A fingerprint is made up of ridges and furrows, which shows good similarities like parallelism and average width [6]. However the research conducting on fingerprint verification and identification shows that we can distinguish fingerprint with the help of minutiae, which are the some abnormal points on the ridges. There are two type of the termination of minutiae, immediate ending of ridges or a point where ridge ends abruptly called ending or termination and the point on the ridge from which other branch drives or a point from where ridge splits into two or more branches is known as bifurcation as shown in figure 1(b).

B. Proposed System

Figure 2 shows our proposed automatic attendance system using fingerprint verification technique. A fingerprint is captured by user interface, which are likely to be an optical, solid state or an ultrasound sensor. Generally, there are two approaches are used for fingerprint verification system among them first one is Minutiae based technique, in which minutiae is represented by ending or termination and bifurcations. Other one is Image based method or matching pattern, which take



(a) **(b)**

Figure 1. (a) The fingerprint image, which describes the important features in fingerprint. (b) Minutiae points (valley is also known as furrow, Termination is also called ridge ending, and Bifurcation is also known as Branch).

account of global feature of any fingerprint image. This method is more useful then the first one as it solve some intractable problem of method one, but this paper talk about the minutiae based representation of fingerprint. The fingerprint verification can be defined as the system that confirm the authenticity of one person by comparing his captured fingerprint templates against the stored templates in database. One to one comparisons are conducted to identify the person authenticity [7, 15]. After this if the authenticity of person is verified then system signal true else false.

II. Preprocessing of Fingerprint Image

The pre-processing of a fingerprint image comprises of procedures like, first the enhancement of image is done by histogram equalization and Fourier transform. After this the process of binarization is done on the enhanced fingerprint image by using locally adaptive method. This binarized fingerprint image is segmented by using threshold or region of interest techniques.

A. Enhancement of Image

Since the fingerprint image are acquired from high quality sensors but the perfection of image quality is questionable. So the enhancement of fingerprint image is done to improve image quality, without even knowing the source of degradation, with this it increase the contrast between ridges and furrows and connect the broken points of ridges. Enhancement of image is first done by histogram equalization, which performed on input image based on calculated probability density function, with the help of which noise is prevented from being amplified and visualization effects are enhanced. After this Fourier transform is applied on image small processing blocks [8, 16] (32 by 32 pixel) according to

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) * \exp\left\{-j2\pi * \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\} \quad (1)$$

where u=0, 1, 2....31, v=0, 1, 2........31.

To enhance the block by its dominant frequency we multiply FFT of block by its magnitude a set of times. The original magnitude FFT = abs(F(u, v)) = |F(u, v)|.

We can get an enhanced block, by using formula

$$g(x,y) = F^{-1}\{F(u,v) * |F(u,v)|^{K}\} \quad (2)$$

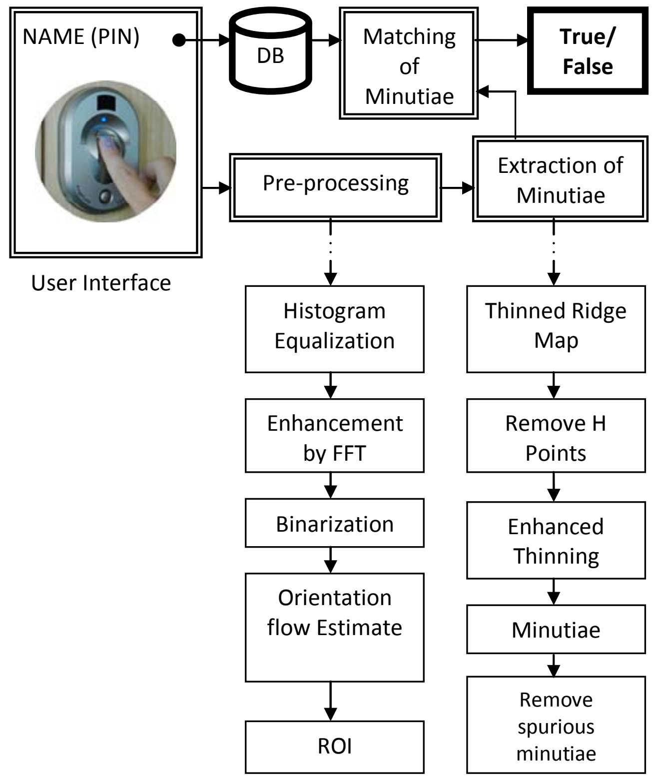


Figure 2. Proposed System: Automatic attendance system architecture representing the stages of preprocessing, extraction of minutiae and matching of minutiae.

where F-1 (F(u, v)) is calculated as:

$$f(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) * \exp\left\{j2\pi * \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\} \quad (3)$$

for x = 0, 1, 2, ..., 31 and y = 0, 1, 2, ..., 31.

B. Binarization of Image

The Binarization of fingerprint image is to convert an image up to 256 gray levels to white and black image. A locally adaptive binarization method is used in which image binarization is done by choose mean intensity value or threshold value and classify all pixels with or above threshold value as white and other pixels as black.

C. Segmentation of Image

Separating the fingerprint area from the background is always useful to avoid extraction of noisy areas of fingerprint [17]. The segmentation of image is to distinguish image object from the background. Only the region of interest is useful for recognition, so image area without effective ridges and furrows are discarded because it does not holds any important information and remaining effective area is sketched out since minutiae in bound region are confusing with the initial minutiae when image were generated. To extract region of interest we use two methodologies, first is block direction estimation and direction variety check [9, 18] and second is extracting by morphological operations. Two morphological operations are chosen "OPEN", which remove expand image with removing of noise and "CLOSE", which shrink image with eliminating small cavities. The interest fingerprint image area is found by subtraction of closed area from opened area.

III. Recognition of Minutiae

The recognition of minutiae is based on the extraction of minutiae in which binary image obtained by binarization process are submitted to fingerprint ridge thinning stage and marking of minutiae.

A. Thinning

Ridge Thinning or thinning is a process of reducing the width of the ridges in fingerprint image to one pixel wide [10, 11, 19]. Can say like this is to eliminate the redundant pixel of ridges till the ridges point is one pixel wide and it should thinned to its central pixel. The minutiae points, which have pixel value one is ending and more than two is bifurcation. Thinning algorithm is classified by iterative and non-iterative algorithms which is a faster approach [10]. The purpose of thinning is to preserve the fingerprint minutiae shape while eliminating extra information and performed because of morphological filtering of segmented image, removal of unwanted branches, and smoothing up the result central path. This algorithm follows the three simple rules are first to remove the unwanted edge points, adding new edge points and shift edge points to the new location. The Algorithm is: The rules [12, 20] are here according to the number of edge point neighbours which an edge point has, and with help of this algorithm erroneous pixels are removed.

STEP 1: An edge point has zero neighbours, then remove the edge point.

STEP 2: An edge point has one neighbour, then start search for the neighbour with maximum edge response to continue the edge, fill the gaps. (A edge can be filled by maximum of three pixel.)

STEP 3: An edge point has two neighbours, and then there are three cases,

- If point is sticking out of an otherwise straight line, then compare its edge response to the corresponding point.
- If the point is adjoining a diagonal edge then remove it.
- Else, the point is valid edge point.

STEP 4: An edge point has more than two neighbours, and then if point is not having any link between multiple edges then thin the edge in logical consistent way.

The figure 3 is showing the Algorithm cases of number of edge point's neighbour.

B. Enhanced Thinning

The fingerprint ridge thinning is to eliminate the redundant pixel of ridge, till the ridges one pixel wide, but this not always happens. There are still some locations where skeleton has two or more pixel width, some extra or erroneous pixel. An extra or erroneous pixel is one with more than four connected neighbour, it can destroy the integrity of bridges and spurs, miss detect and exchange type of minutiae points. So before extraction of minutiae we need to eliminate those extra or erroneous pixels [4], for this purpose we use Enhanced Thinning Algorithm.

We can say for some black node that whether they belong to skeleton or not by examining the kind of their four edges, like node belongs to skeleton if four incoming edges to a node this is known as local maximum. Due to this Pre skeleton is formed, which is when connectivity is not preserved.

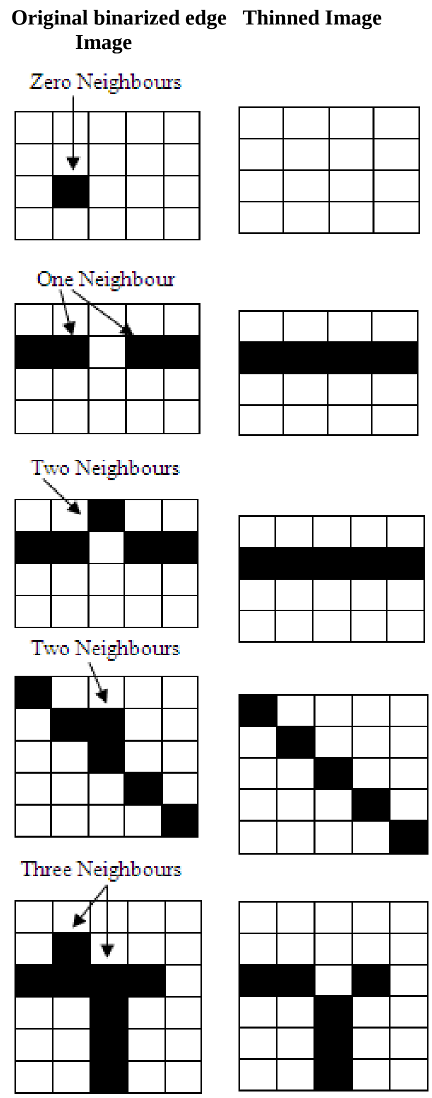


Figure 3. Description of Thinning Algorithm, representing the original binarized images and resultant thinned image.

STEP 1: Labeling of all the nodes with their minimal distance to an edge of image.

STEP 2: Detects all nodes of the pre-skeleton.

STEP 3: To preserve connectivity, find the remaining skeleton nodes.

C. Marking of Minutiae

After Thinning of fingerprint image the important and next step is marking all minutiae points. The maximum number of minutiae detected, increased the probability of accurate results. The crossing number (CN) concept is widely use for this purpose. Together with marking all thinned ridge and fingerprint image are labeled with a unique ID for further process of matching and this labeling is done by using morphological operation BWLABEL [4].

IV. POST PROCESSING OF MINUTIAE

After the pre-processing stage on the binary and skeleton image, we extract almost all minutiae from fingerprint skeleton using various method including Rutovitz crossing numbers [14], due to various noises in fingerprint image it unable to heal the image totally, like false ridge breaks, ridge cross connection and those extraction algorithm produces a large number of spurious minutiae [11] such as break, spur, merge, triangle, multiple break, ladder, lake, island, wrinkle, dot as show in figure 4. So for accurate fingerprint verification post processing stage is very necessary as it helps in differentiating spurious minutiae from genuine ones. As we able to eliminate more unwanted or spurious minutiae chances of getting better matching performance increase with the matching time will decreases.

For various types of false minutiae as in figure 4 shown, dot, spur, lake, island are removed by pre processing algorithms, but bridge, triangle, ladder, wrinkle are not which also known as H-points. If we able to remove H-points of image so we able to eliminate most of spurious minutiae point. The process of eliminating the false minutiae are consist of following steps first extract minutiae set, then remove short breaks, after that removal of spurs if any, then removal of H-points [13] , after that remove close minutiae and border minutiae and we get the true minutiae set.

The elimination process of false minutiae is already started by applying thinning algorithms as shown in Figure 1 (extraction of minutiae steps), by applying the threshold concept and various thinning algorithms we already able to remove the short breaks and spurs. The post processing starts from the next step is removals of H-Points, where H-Points are detected and eliminated. To recognize the H-Points we follow some rules like, the point of intersection should lie between the two ending or two bifurcation points, the distance between bridge midpoint and break midpoint should be in a threshold limit and then we remove minutiae that are very close to each other or the minutiae points which are within the certain distance threshold from image border [14]. After pre-processing, a large percentage of extra or spurious minutiae are deleted and we can treat rest of the minutiae points as genuine and which can be used for fingerprint matching purpose.

V. MATCHING OF MINUTIAE

Matching of minutiae is that when we have two set of minutiae of fingerprint image and using a algorithm we determines whether the give set of minutiae is from the same finger or not. There are some matching techniques as correlation based matching in which two fingerprint images are

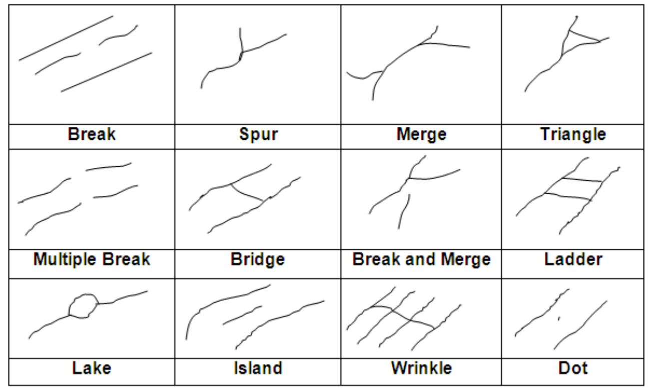


Figure 4. False minutiae structures

superimposed and finding out the correlation between corresponding pixel, Ridge feature based matching in which feature extracted are compared to extracted ridge pattern and the other one is Minutia based matching technique [3] in which minutiae extracted from two fingerprint and stored as sets of point in two dimensional plane. We described this technique here

a) *The stage of Alignment :* In this stage anyone minutiae is choose from each image then calculate the similarity of the two ridges associated with the two referenced minutiae points [9]. If the threshold value is smaller than similarity then transform each set of minutiae to new coordinate system whose origin is at referenced point and x-axis is coincident with the direction of referenced point.

b) *The stage of Matching:* After deriving the set of transformed minutiae points, an algorithm is used for matching the pairs, assuming that minutiae have nearly identical direction and position.

Another algorithm is widely used now a day to accurate, fast and suitable for real time system, in which we use the core point[13] (the point of maximum curvature of concave ridge) for determining the reference point and use round bounding box for matching. This algorithm follows as we denoted the minutiae points and core points that we use fingerprint core to determine the reference point, by which the calculation process is simplified. Firstly we take core as centre of template and input fingerprints and then select a round area around core. After this the referenced minutiae points are converted into polar coordinates and then applying the algorithm for matching. After that use the round circle bounding box, which improve accuracy and simplify the calculating processes. Fingerprint made in different time have some deformation so the minutiae points will change in some direction because this round circle bounding is used.

VI. RESULT AND DISCUSSION

To evaluate the performance of our proposed system we closely experimented on FVC2002 database [21] and evaluated each and every step from enhancement of image, binarization, thinning and enhanced thinning, elimination of false minutiae

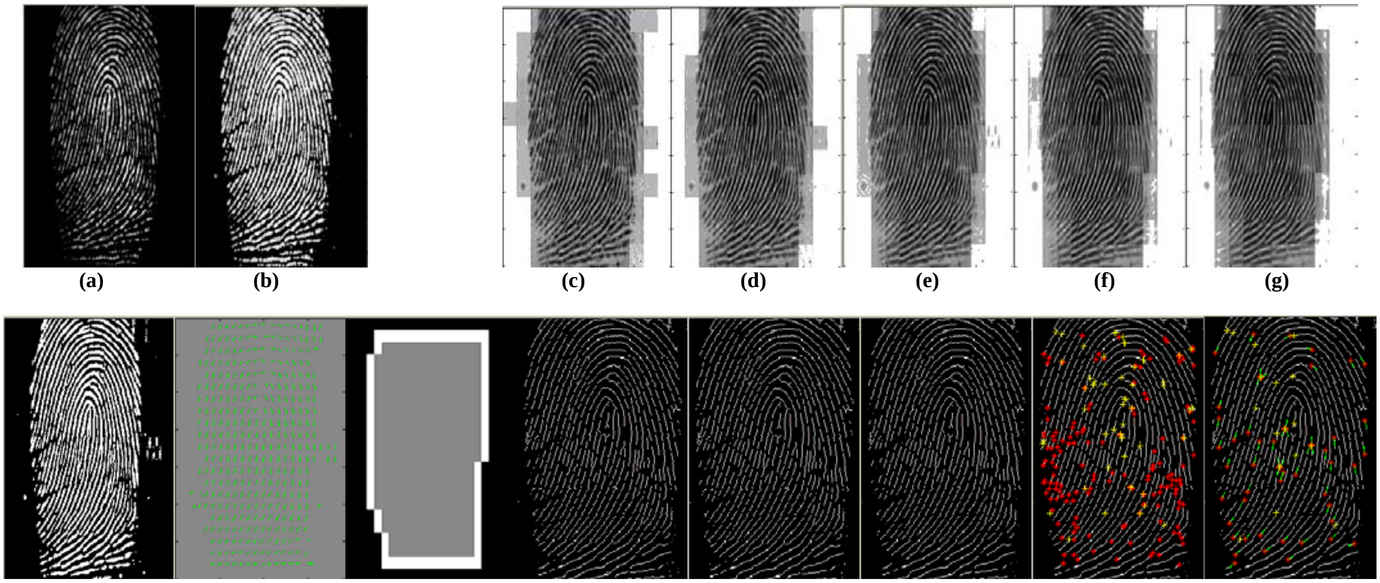


Figure 5. (a) Fingerprint input image, (b) Enhanced by Histogram equalization, (c - g) Enhancement by Fast Fourier Transform: on different value of Factor K = 0.1, 0.3, 0.5, 0.7 and 0.9 respectively, (h) Adaptive binarization of enhanced image (e) K=0.5, (i) Estimation of Orientation flow, (j) Region of interest of fingerprint, (k) Ridge thinned image, (l) Image after removal of H-points, (m) Image after removal of spike, (n) Extracted minutiae, (o) After removal of spurious minutiae.

to matching of extracted minutiae. We emphasis and experiment on the enhancement of fingerprint image, after histogram equalization. When Fourier Transform is applied on the image, small processing box (32 by 32 pixel) on basis of "experimentally determined constant (K)" used in equation (2) of section 2, where we experiment on K = 0.1, 0.3, 0.5, 0.7, 0.9 for getting the best enhanced fingerprint image to go for next stage of binarization and thinning in order to get the good quality enhanced image by which the perfect minutiae extraction can be done in later stages.

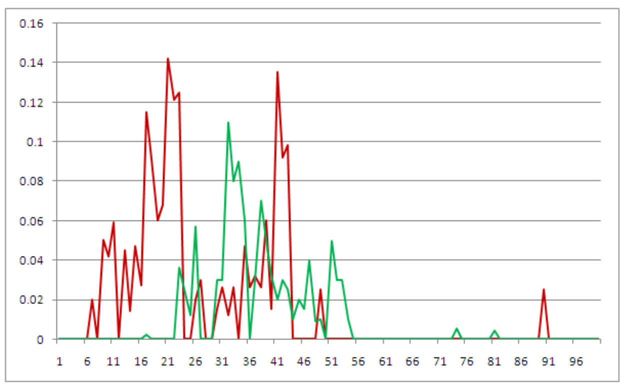
As we can see in the result in figure 5, while increase the value of "K" it improves the appearance of ridges, small holes also filled up but having too much increment in value of "K" results false joining of ridges and ridge ending is merging into bifurcation. So we are getting the best result on value of "K=0.5".

For our result to show the performance of system, where we consider the five images as template from the same user finger. A database consists of 100 templates used for verification. Image in the database is matched with other templates; if it matched then verification is correct else it is rejected. If image matched with template of incorrect fingerprint then it is known as false verification. The verification rate is given as

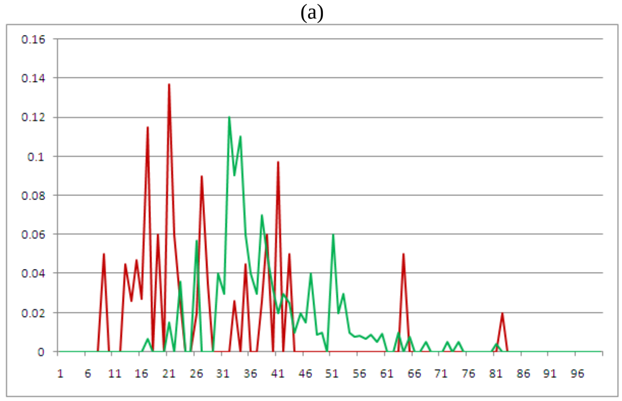
$$\text{Verification rate} = \frac{CV}{CV + FV} \times 100\%$$

where, CV denotes the number of correct verifications and FV is the number of incorrect verifications.

Figure 6 represents the study of distribution of correct and incorrect score on the basis of experimentally determined constant 'k', where the test is performed on the two values of factor k= 0.1 and 0.5. The experimental result shows that for



(a)



(b)

Figure 6. Distribution of correct and incorrect scores on the basis of experimentally determined constant (a) K=0.1, (b) K=0.5, red line represents incorrect score and green line represents correct score.

factor k= 0.1 the average correct match score is 22 and average incorrect score is 40 but in the case of factor k= 0.5 the red curve peaks are mainly located at the left part so the average incorrect score is 27 which is much lower than the previous one and according to the green curve the average correct score is 42. This indicates that the system is capable of differentiate fingerprints at a good correct rate by setting an appropriate value of factor 'k'. The system is capable of easily differentiate vague minutia pairs from genuine minutia pairs that leads to high verification rate and accuracy.

VII. CONCLUSION

This paper introduces the efficient automatic attendance system, by using minutiae based fingerprint technique. We use the methods which are simple, effective and accurate to do the faster execution of enhancement and thinning algorithm of fingerprint image.

In addition, we examine the experimentally determined constant "K" during the enhancement of image with using Fourier Transform, by which we able to differentiate the enhanced quality of image that can lead to the best verification of extracted minutiae of image. The performance evaluation of proposed system is done by using FVC 2000 database (500 images) [21] and the used time taken for verification was very less and verification rate is higher and accuracy is near about 92%.

REFERENCES

[1] Fakhreddine Karray, Jamil Abou Saleh, Mo Nours Arab and Milad Alemzadeh, "Multi Modal Biometric Systems: A State of the Art Survey," Pattern Analysis and Machine Intelligence Laboratory, University of Waterloo, Waterloo, Canada.

[2] Anil K. Jain, Arun Ross and Salil Prabhakar, "An introduction to biometric recognition," Circuits and Systems for Video Technology, IEEE Transactions on Volume 14, Issue 1, Jan. 2004 Page(s):4 – 20.

[3] D. Maltoni, D. Maio, A. K. Jain, S. Prabhaker, "Handbook of Fingerprint Recognition," Springer, New York, 2003.

[4] Manvjeet Kaur, Mukhwinder Singh, Akshay Girdhar, and Parvinder S. Sandhu, "Fingerprint Verification System using Minutiae Extraction Technique," World Academy of Science, Engineering and Technology 46 2008.

[5] H. C. Lee and R. E. Gaensslen, "Advances in Fingerprint Technology," Elsevier Science, New York, ISBN 0-444-01579-5.

[6] "Guide to Fingerprint Recognition" DigitalPersona, Inc. 720 Bay Road Redwood City, CA 94063 USA, http://www.digitalpersona.com

[7] L. O'Gorman, "Overview of fingerprint verification technologies," Elsevier Information Security Technical Report, Vol. 3, No. 1, 1998.

[8] B.G. Sherlock. D.M. Monro. K. Millard., "Fingerprint enhancement by directional Fourier filtering," IEE hoc.-Vis. Image Signal Processing, Vol. 141, No. 2, April 1994.

[9] Lin Hong., "Automatic Personal Identification Using Fingerprints," Ph.D. Thesis, ISBN: 0-599-07596-1, 1998.

[10] E. Hastings, "A Survey of Thinning Methodologies," Pattern analysis and Machine Intelligence, IEEE Transactions, vol. 4, Issue 9, pp. 869 885, 1992.

[11] U. Halici, L. C. Jain, A. Erol, "Introduction to Fingerprint Recognition," Intelligent Biometric Techniques in Fingerprint and Face Recognition, L.C. Jain, U. Halici, I.Hayashi, S.B. Lee, S. Tsutsui (editors), CRC Press, 1999.

[12] S. Pal, "Some Low Level Image Segmentation Methods, Algorithms and their Analysis," Ph.D. Thesis, Department of Computer Science & Engineering, Indian Institute of Technology, Kharagpur 1991.

[13] Ying Jie,YuanYi fang, Zhang Renjie, Song Qifa. "Fingerprint minutiae matching algorithm for real time system." Pattern Recognition 39 (2006) 143 – 146.

[14] Feng Zhao, Xiaoou Tang, "Preprocessing and postprocessing for skeleton-based fingerprint minutiae extraction," Pattern Recognition 40(4): 1270-1281 (2007).

[15] Henry Selvaraj, S. Arivazhagan and L. Ganesan, "Fingerprint Verification Using Wavelet Transform," International Conference on Computational Intelligence and Multimedia Applications, 2003.

[16] Cheong Hee Park and Haesun Park, "Fingerprint classification using fast Fourier transform and nonlinear discriminant analysis," Pattern Recognition 38 (2005) 495 – 503.

[17] Asker M. Bazen and Sabih H. Gerez, "Segmentation of Fingerprint Images," Workshop on Circuits, Systems and Signal Processing, Veldhoven, 2001.

[18] Chaur-Chin Chen and Yaw-Yi Wang, "An AFIS Using Fingerprint Classification," Image and Vision Computing, 2003.

[19] Virginia Espinosa-Dur6, "Fingerprints Thinning Algorithm," IEEE AES Systems Magazine, 2003.

[20] Pradeep M. Patil, Shekar R. Suralkar and Faiyaz B. Sheikh, "Rotation Invariant Thinning Algorithm to Detect Ridge Bifurcations for Fingerprint Identification," IEEE International Conference on Tools with Artificial Intelligence, 2005.

[21] Fingerprint Database (FVC2002). http://bias.csr.unibo.it/fvc2002/

AUTHORS PROFILE

Chitresh Saraswat received the Post Graduation Diploma in Information Technology from Indian Institute of Technology, Kharagpur, India in 2009 and

Bachelor of Technology degree in computer science and Engineering from UPTU Lucknow, India in 2006.He was associated with Tata Consultancy Services Lmtd. Mumbai, India from 2007 to 2008. He is currently working as Intern at School of Medical Science and Technology at IIT Kharagpur. His research interests generally are in biomimetic Intelligence system design, cryptanalysis, human computer interaction and software reliability and testing.

Amit Kumar received the Post Graduation Diploma in Information

Technology from Indian Institute of Technology, Kharagpur, India in 2007 and Bachelor of Technology degree in computer science and Engineering from UPTU Lucknow, India in 2006.He is currently pursuing MS(by Research) in School of Medical Science and Technology at IIT Kharagpur. His research interests generally are in human computer interaction, biomimetic Intelligence system design, machine learning and computer vision.