A NOVEL MODIFICATION OF SURF ALGORITHM FOR FINGERPRINT MATCHING

KADHIM H. KUBAN[1], WASAN M. JWAID[2]

[1] Professor at Computer Science Dept., College of Education for Pure Sciences, Thi-Qar University, Thi-Qar, IRAQ

[2]MSc Student, Marshes Research Centre, Thi-Qar University, Thi-Qar, IRAQ

E-mail: [1] khalibraheemi@utq.edu.iq, [2] walhamdany@utq.edu.iq

ABSTRACT

Fingerprint detection and recognition process is a critical task in many biometric systems. Hence, the accuracy of detection and matching fingerprint plays an important role in many research works. Many fingerprints sample are degraded through such other transformations. Therefore, there is a need to find a method that able to detect and match fingerprints sample over all other circumstances and give high accuracy rate. There are two approaches are commonly used, minutiae based and image based approach, minutia approach faced several problems when fingerprint samples are degraded or rotated which lead to poor performance result, image-based approach is seem that its very robust against such other degradation issues. In this paper, we proposed a novel modification to one of the most robust algorithms that used to extract the interest points, called SURF. These points also called feature are later used for matching process after eliminating outlier sets. The proposed system is tested on FVC2002 DB1, and FVC2004 DB2 according to set of performance evaluation metrics such as FAR, FRR, SMR, EER and accuracy, which shows our proposed system can successfully find matching between one fingerprint and other one (1:1) matching, as well as (1:M) matching when more than one fingerprint images may have related to the query image.

Keywords: *Fingerprint, Minutiae, Image Pattern, Descriptor Points, SURF, Matching Score.*

1. INTRODUCTION

Fingerprint recognition system refers to the identification method that used for identification and verification issues. Fingerprint system employee a model that compute the matching score between two or more fingerprints that belongs to certain user or many users in database, where the similarity score between fingerprint samples that belong to similar user should be high rather than other users [1]. Fingerprint matching process is a difficult pattern recognition task due to the image quality degradation issues. Fingerprint image contains too low features and finally fingerprint matching score is totally depending on the acquisition manner [2]. Hence, current fingerprint matching techniques can be classified into two approaches based on feature extraction process which are: Minutiae-based approach and image-based approach [3]. Minutiae approach is based on the minutiae points which are represented in the fingerprint image by their coordinates. Therefore, this approach is depending heavily on the pre-processing steps [4]. So, when the tested fingerprint images are rotated, degraded or contain small overlapping area. This approach faces several problems in matching process due to the change in minutiae coordinate locations, and fingerprint minutiae can be matched to any minutiae of other fingerprint. Another issue also can be addressed here is, minutiae-based approach is used many pre-processing and enhancement steps like, ridge segmentation and thinning, directional filtering, minutiae extraction and purification, where these processes are highly computationally and expensive, and the accuracy of this approach is affected by the quality of images [3,5]. So, there is a need to find a technique that robust against image quality degradation. Image-based approach typically extracts the features from fingerprint images directly with few pre-processing steps when compared to the previous approach. By using image-based approach many techniques can be adopts to achieve high performance when degradation issues are existing in images samples [6]. Also by use this approach, the accuracy and matching score among fingerprint samples can be improved by adopts appropriate techniques such as robust local descriptors. Below, Table 1, illustrates the comparison between the previous mention approaches [2, 7].

Journal of Theoretical and Applied Information Technology
31st March 2018. Vol.96. No 6
© 2005 – ongoing JATIT & LLS
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

TABLE 1. Comparison Between Fingerprint Recognition Systems

T	Image-Based Approach	Minutiae-Based Approach
1	Robust to fingerprint image quality	Heavily depends on fingerprint image quality
2	Features are directly extracted from raw images itself	Required pre-processing techniques priori.
3	This approach is not popular as compared to minutiae approach	This approach is very popular than image-based approach
4	Able to handle such image degradation issues	Do not able to handle image degradation issues
5	Used for Fingerprint samples that do not have good quality	Used for fingerprint samples that have good quality
6	Time consuming is low when compared to minutiae approach	Computationally complex and expensive than image-based approach
7	Able to achieve high accuracy in low quality images.	Not able to achieve high accuracy in low quality images.

Based on previous issues in fingerprint matching and recognition systems as shown in the above table (Table 1), the efficient way is by extracting the key features from fingerprint image itself, where in this case two type of features can be extracted which are: global features and local features. Global features also called (global descriptors) describe the image as whole [8]. Global features typically used in object detection, object classification and image retrieval, which include shape descriptor, texture features and contour representation. Histogram Oriented Gradient (HOG), Shape Matrices and Invariant Moment are examples of global descriptors. Local features describe the image patches (interest points in image such as blob or corner) of an object. Local descriptors commonly used for object recognition (identification) [9]. Someone may have confused between object detection and recognition (identification) concepts. Typically, there is a large difference between these concepts where the object detection refers to the process of finding the existing of something (object) for example find an airplane is existing in image or video. While, object recognition (identification) refers to finding (recognize) an object in an image, such as recognize person in that image. SIFT, SURF, BRISK, FREAK, MSER and LBP are some examples of local feature descriptors. To achieve high accuracy in object recognition (identification) system, the desired system should be robust against such other degradation or transformation issues, in other words recognition system should be invariant to scaling, rotation or pliable distortion on fingerprint surface. The following table (Table 2) illustrates the common characteristics among the most famous local descriptors algorithms used in object recognition systems [10, 11].

TABLE 2. Comparison Between Variant Local Descriptor Algorithms

Detector	Invariance			Speed
	Scale	Rotation	Illumination	
SIFT	Yes	Yes	Partial	++
SURF	Yes	Yes	Yes	++
FREAK	Yes	Yes	No	+++
BRISK	Yes	Yes	No	+++
LBP	No	Yes	Yes	+++
HOG	No	No	No	++

According to the previous table (Table 2), we can notice that among all feature descriptor algorithms, SURF (Speeded Up Robust Feature) is the best well known feature descriptors algorithm, which can be used to detect the matching between two images or recognize a particular object while other objects are existing on the given image [12]. Hence, this paper illustrated a novel modification on SURF algorithm by modified a list of proposed metrics which are illustrated as follow: the first metric is proposed to calculate the average of matching features and the goal of this metric is to avoid compare fingerprint images that do not possess an appropriate number of features. Second metric is using to calculate distance ratio, third metric used to calculate the average of distance ration, fourth metric is calculating the ratio of second and third metric to gives an indicator about the candidate matching and finally the fifth metric calculate the percentage of matching and based on this value our proposed system either accepted or rejected the tested fingerprint sample, the details of our proposed metrics are explained in section five (5 - steps involved proposed technique). Based on the goal of this paper, where fingerprint samples are given on selected databases, where two databases (FVC 2002

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and FVC 2004) are used in evaluation and validation section. This paper is organized as follow: section one, includes an introduction to fingerprint matching (recognition) system. Section two, illustrates the most related work for our desired goal. Section three, illustrates an overview of existing issues in current fingerprint systems. Section four, shows an overview about the existing technique. Section five, involves the details steps of the proposed methodology. Section six, Implementing our proposed system upon selected dataset. Section seven, Performance evaluation metrics are calculated, and finally, conclusion and future work.

2. RELATED WORK

Now a day's image-based fingerprint matching and recognition approach has significantly attracted by many researchers, and essential number of research papers has showed in their related works sections [12, 13, 14, 15 and 16], the using of image-based approach has more reliable than minutiae based approach. In this section, the literature review of current image-based fingerprint matching and recognition aspects are presented based on using local descriptors techniques. In 2007, Wang et all [16], they used Support Vector Machine (SVM) classifier to calculate singularity information and coefficients of the given orientation model, where the singular points and orientation patterns are used for fingerprints matching. In 2009, Kant and Nath [17], they extracted singular delta points from fingerprints then only single print of person used for comparison manner. In 2010, Sanjekar and Dhabe [18], introduced a modified approach by using Haar wavelet transformation to decompose the given fingerprint samples up to three levels then extracting wavelet statistical features from decomposed images, then use distance vector to find the proximity among the given dataset. In 2014, Kumar et all [2], adopts extract local descriptors from region of interest (ROI) after pre-processing the given samples, then using such proximity measure (Euclidian distance, Histogram intersection, Chi-square distance and Support vector machine) to infer the matching score. In 2015, Zhong and Peng [9], used SIFT algorithm and Local Sensitive Hashing (LSH) approach for fingerprint matching and retrieving, where the extracted fixed length features are used in database indexing based on using multi-template image feature fusion technology. In 2015, Saini et all [3], used SURF algorithm for fingerprint recognition process by calculating the percentage of distance between fingerprint query image and the whole samples in database. In 2016, Dubey et all [19], they combine SURF and PHOG methods to enhanced the accuracy of matching performance. In our proposed model, image-based approach is considered to avoid the previous issues that discussed in introduction part and related work section, where in table 1. SURF algorithm is used to extract robust local features from the given fingerprints due to its consider very fast and robust against invariant circumstances when compare with others (table 2), then proposed proximity measures are used to eliminate error matching features based on using proximity measures, after that correct matching features are used to calculate matching score using our proposed formula and based on matching threshold, we can infer if the tested fingerprints are matching or not. This property is never used previously when compared our system with such other related system, where many systems either compared twice candidate or find only the first matching sample, so in proposed system we extended this property to satisfy most of user requirements which cannot be provided through the use of traditional systems. Finally, FVC 2002 and FVC 2004 databases are used to evaluating the performance of our proposed system and methodology by using the following metrics FAR, FRR, EER, SMR, and Accuracy.

3. EXISTING SYSTEMS ISSUES AND CHALLENGES

One of the most critical issue in fingerprint recognition systems is the lack of the system against variant image quality degradation. The accuracy of fingerprint system is totally depending on the image quality, where several factors are effected on image acquisition technique [3, 20]. There are two factors are affected on fingerprint image acquisition quality which are: sensor factors and skin factors. Sensor factors such as noise, dirtiness and variant size which may be annexed to image through the acquisition process and then produced poor quality fingerprint images, then degrading the performance of proposed system. Skin factors for example wetness, dirtiness, dryness, precarious or permanently cuts and contusions where some of these factors cannot be avoids, thus differently we expected poor performance results [21]. Therefore, it's very important property for fingerprint recognition system to estimate the given fingerprint image and reject the degraded images. Advance recognition system can adjust such pre-processing steps to enhanced an image to improve its quality to ensure

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the efficiency of the system is become better [22]. Another challenges are depending on the adopting technique, whereas mention previously, most of existing system are designed based on minutiae approach. These systems are facing a problem when tested images are partially rotated or overlapped by other objects. The problem in minutiae-based systems is these systems are working based on the co-ordinates patterns of minutiae points, then when image is rotated with respect to enrolled changes or when the scaling of an image is partially changed the extracted minutiae co-ordinates are changes also, hence produced very poor matching result. So, we can summarize the issues of minutiae-based approach based on the following cases [23, 24]:

3.1 Rotated Fingerprint

Rotated or partially rotated fingerprint image as shown in the figure 1, when minutiae-based approach is used, it's difficult to find matching of two images due to the minutiae points co-ordinates are changed.

Figure 1 Normal and Rotated Fingerprint Images

3.2 Missing (Wrapped) Fingerprint Parts

Minutiae-based approach also fails when part of fingerprint image is missing or wrapped as shown in Figure 2, due it's difficult to match minutiae points in missing part, hence the result of matching is poor in this case.

Figure 2 Missing or Partially Wrapped Fingerprint Parts.

4. PROPOSED TECHNIQUE

To handle the previous issues that existing in most fingerprint recognition systems, we proposed to use robust local feature extractor and descriptor algorithm based on using image-based approach. Among variant local descriptor algorithms such as SIFT, BRISK, FREAK, MSER etc., SURF (Speeded Up Robust Feature) have been reported the most distinctive and robust algorithm against scale, illumination and partially occlusion cases. The key idea of SURF algorithm is to detect and extract points also called (interest points) to be scale and rotation invariant features. There are three steps behind the theoretical background of SURF algorithm which are: detection, extraction and matching steps. In first step, interest points could be detected in the give fingerprint image by used Determinant of Hessian Matrix (DOH). Hessian matrix determination can decide whether a point can be chosen as an interest point or not. Hence, for the given image that involve number of pixels in squalor form, Hessian matrix at point (x) in an image I and scale (σ = 1.2) is calculated based on Eq.1 [25]:

$$(x\ \sigma) = \begin{bmatrix} Lxx(x,\sigma) & Lxy(x,\sigma) \\ Lyx(x,\sigma) & Lyy(x,\sigma) \end{bmatrix} \quad (1)$$

Where:

$$Lxx(x,\sigma) = I(x) * \frac{\partial^2 y}{\partial x^2}\, g(\sigma) \quad (2)$$

$$Lxy(x,\sigma) = I(x) * \frac{\partial^2 y}{\partial x^2}\, g(\sigma) \quad (3)$$

and g(σ) is the second is the second derivative of the Gaussian at scale (σ).

The following figure (figure 3), shows discretized Gaussian derivatives in both x and y directions.

SURF algorithm used an integral image to maximize the speed of calculating the average intensity within a given image. using an Integral image in Hessian matrix approximation which can reduce the time of computation effectively [26]. Instead of calculate the approximations for Gaussian second order derivatives of an Integral image at different scales values (σ)s, SURF apply scale space analysis of an Image to find interest points that is invariant to scale change by using box

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

filters in Pyramid mode as shown in the following figure (figure 4) [25].

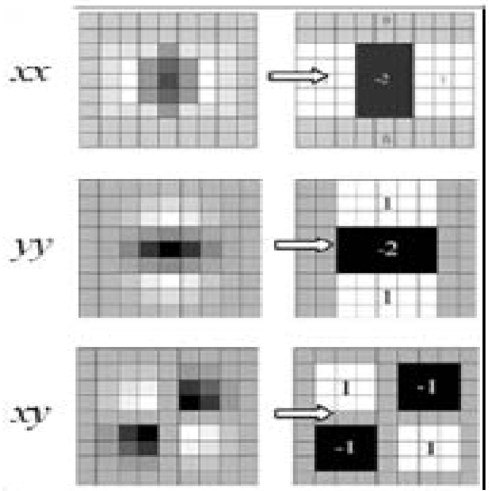

Figure 3 Gaussian Second Order Derivatives of an Image at Point x with Coordinates (x, y)

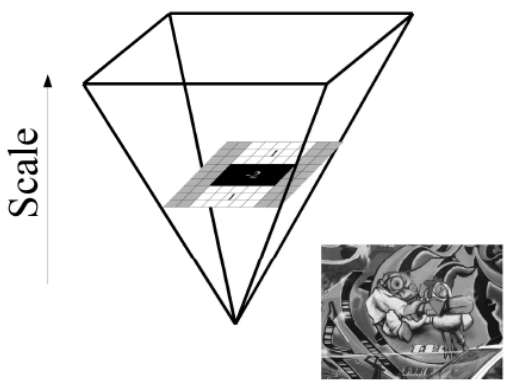

Figure 4 Scale Space Analysis of an Image Using Box Filters.

Scale Space of an image is divided into number of levels called octaves, an octave represents a series of filter response maps obtained by convolving the same input image with a filter of increasing size. Each octave is subdivided into a constant number of scale levels. The number of scale levels parameter controls the number of filters used per octave. At least three levels are required to analyze the data in a single octave, these levels correspond directly to the desired sampling of the scale variable (σ). The box filter starts off with a (9×9) size filter as an initial scale layer and scale value is an S=1.2 which corresponding to the approximated Gaussian derivative with scale value σ=1.2, and so on for the remaining filter sizes. The following figure (figure 5) shows the filter sizes and octaves at different scale levels [25].

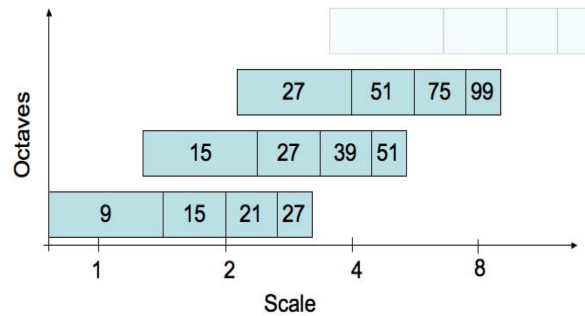

Figure 5 Filter Sizes and Octaves at Different Scale Levels

When the approximation of Hessian matrix determinant is obtained at each layer, non-maxima suppression (NMS) is applied in 3×3×3 neighborhood to localize the interest points over the scales of an image. NMS can be defined as the process of find the candidates of interest points within certain neighborhood around the pixel (x). in other words, every pixel in scale space it compared to its 26 neighbors in both upper and lower scales, at this step we get set of interest points that has minimum strength which determined by threshold value as well as local maxima and minima in that scale space. Determinant of interest point must be weighted to obtain a good approximation and also to reject interest points that having low contrast or points lying on edges or being close to edges by using the following equation Eq.4 [25, 31]:

$$Det(H^{SURF}_{Approx}) = D_{xx}D_{yy} - (W\,D_{xy})^2 \quad (4)$$

Where W can be kept to = 0.9.

Once interest points have been localized both in space and scale. Next step is called extraction step. Extraction step also called Feature descriptor, which aim to construct a descriptor for every detected pixel in the given image, from the neighborhood information by using vector space representation. Feature description steps involves two stages; the first one is determining an orientation for every pixel (feature) by convolving the pixel in its neighborhood with the horizontal and the vertical Haar wavelet filters. Thus, this step also called orientation assignment step, due to the pixels (point) may existing in different orientation

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in different images, the following figure (figure 6) shows the orientation of horizontal and vertical Haar wavelet filters [30].

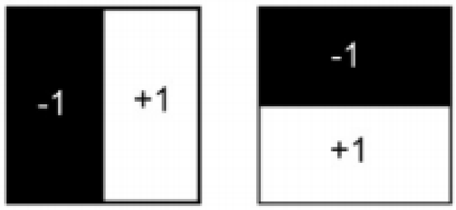

Figure 6 Horizontal and Vertical Haar Wavelet

In order to be the detected points are invariant to rotation, Haar wavelet responses are calculated in both x and y direction in circular neighborhood of radius (6σ) around the interest point, where (σ) is the scale at which the point is detected. The dominant orientation is estimated by calculating the sum of all responses within a sliding orientation window and longest vector is chosen as the dominant orientation. Second stage involves construct an interest point descriptor. Now, to extract a descriptor for every selected point, a square region (size 20σ) centered around the interest point and oriented along with the orientation that selected in previous stage, then the region is split into smaller 4 ×4 sub-regions and Haar wavelet responses in x and y direction at 5 x 5 regularly spaced sample points are calculated and summed up in each region ,by use this values a four dimensional feature vector per 4 ×4 regions which yield a vector $V = (\sum d_x, \sum d_y, \sum |d_x|, \sum |d_y|)$ with 64 dimensions, when the sign of entries is considered then the vector produced with 128 dimensions as shown in the following figure (figure 7) [25, 31].

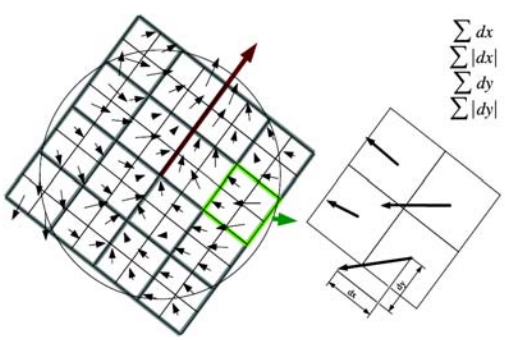

Figure 7 Feature Descriptor at Interest Point

Final step in SURF algorithm, is matching step, which includes calculate pairwise distance (Euclidian distance) among feature vectors of the given two tested images, then if the overall pairwise distance value greater than distance threshold then these feature vectors are added to index matching pairs, otherwise features are discarded, in other meaning, feature vector 1 of first tested image, is match feature vector 2 of second tested image, If and only if the distance is less than Euclidian distance threshold. Additional constraints are applied when the distance from the nearest neighbor feature vector, where typically is set a values fall within range (0:0.9) [2, 27].

5. STEPS INVOLVED IN PROPOSED TECHNIQUE

In our proposed methodology, we need a sound measure that able to handle the issues of finding the proximity among feature vectors also called (descriptors) overall wining set, and this value has discriminative power to give a decision regarding to complete the next processes or not. Typically, measure the distance among feature vectors for the two candidate images, may produce correct matching features in index matching pairs, but actually these features are not similar due to some of these feature vectors may involve parts of similar object texture thus looking as similar when considered only Euclidian distance threshold. Therefore, we suppose N is the number of matched features (vectors) based on Euclidian distance, then by define the minimum distance metric between two matched points is MIN_DIST, then for the given N matched feature number, we define the average of minimum distances (AVGMIN) by using following equation Eq.5 as follow:

$$AVG_{MIN} = \frac{1}{N}\sum_{i=1}^{N} MIN\_DIST \quad (5)$$

After that, we calculate the ratio of distances of (K-Nearest Neighbor, where K in our proposed system is =2). Thus, for the feature vector 1 in first tested image if the closest neighbors in second tested images are (neighbor1, neighbor2) and the distance values for both vectors are: V1 and V2 then the distance ration (DIST Ratio) can be defined by using equation Eq.6:

$$Dist_{Ratio} = \frac{V1}{V2} \quad (6)$$

Then, for the whole matched feature points N, we calculate the average of distance ratio (AVG Ratio) by using the following equation Eq.7:

$$AVG_{Ratio} = \frac{1}{N}\sum_{i=1}^{N} Dist_{Ratio} \quad (7)$$

Now, for the given matching features N, we calculate the matching percentage for the given feature sets, if the matching percentage is exceeding the pre-defined threshold where in proposed system is set to (15), then features are in image 1 are match features in image 2 otherwise features are discarded. Matching percentage can be calculated as in the following equation Eq.8:

$$Match_{Ratio} = \frac{[AVG_{NNN} + AVG_{Ratio}]}{2} \quad (8)$$

Now, the question is: Are all the points are correctly matched, may there are points that do not fit plan. The solution of this issue is by using RANSAC algorithm (Random Sample Consensus), which is used to eliminate the outlier points (error matching features). The key idea behind RANSAC algorithm is: its try to find a model where the that data points are fitted to the model (inlier features) and eliminate non fitted points (outlier features).

Proposed system adopt another metric to eliminate also error matching features by proposed a metric called Similarity or matching Percentage (P) and can be defined by using the equation Eq.9:

$$P = \frac{|CF|}{|TF|} \quad (9)$$

Where, CF is Correct matching features after applying RANSAC algorithm (inliers) [28, 29], and TF is the Total matching feature number in index matching pair matrix, in proposed system P is not fixed and its reflect the exist matching score between the given two input images, the following figure (figure 8) shows the block diagram of the proposed system.

As shown in the proposed system figure, image enhancement step is used to make the fingerprint image is clearer for forthcoming operations. When fingerprint image acquired from sensors or other visual medians, image is not actually with its better quality [20]. Thus, image enhancement used for increasing contrast among ridges and furrows and also for connecting the false broken points.

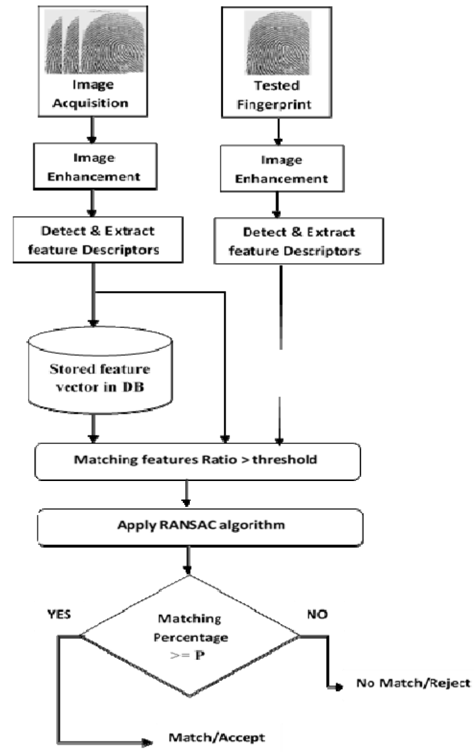

Figure 8 Block Diagram of Proposed System

6. EXPERIMENTAL RESULTS

Proposed fingerprint matching simulation has done by using Matlab 2015a. Main GUI interface for input the selected image from image dataset and the entered test image can be shown in the figure 9, where the mainframe is accepted two types of matching strategy which are: (1:1) matching and (1:M) matching. Hence, in first case the fingerprint acquired from one person is compared with all the fingerprints which store in database. While second case, typically used in the process of seeking the criminals. In experimental result section, the performance of proposed system has been implemented and evaluated by selecting FVC 2002 and FVC 2004 datasets where DB1 has selected from every dataset, where every Database involves (8) fingerprints samples impressions for (10) fingers, then totally we have (160) fingerprint samples. The proposed system involves the following development steps:

6.1 Reading Fingerprints (1:1) Matching

A. First, both the tested samples would be tested to calculate the matching score between them. Thus, we call the first sample is reference template and the second fingerprint image is tested image.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Hence, in the beginning, proposed system adopts Image enhancement process after converted image into Grayscale image, then find interest points locations for both images and select strongest points by using SURF algorithm, figure 9 shows the strongest points for both reference and test images.

Figure 9 Detect and Select Strongest Points in Both Fingerprint Images

B. Next step involves using our modified system to give a decision about tested fingerprint. In this step, features (points) that selected from both samples are compared to others by measure their proximity using Euclidian distance to build index pairs matching matrix, where the feature vectors in first sample are checking against features in second samples, these features may involve error matching features which is called also (outliers) as shown in the following figure 10.

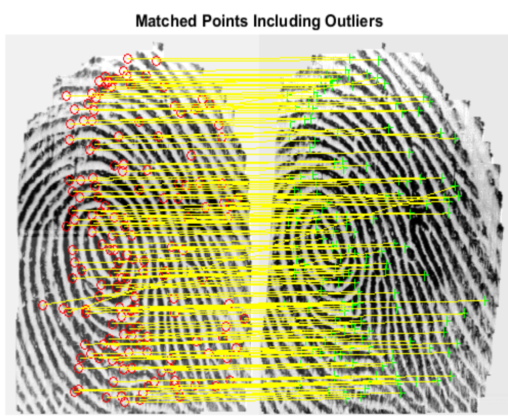

Figure 10 Matching Features Including Outlier Features

C. Proposed system, may stop the processes when there are a few number of valid features that satisfy the matching percentage, so we adjust matching percentage in the range of [15:35] to find best matching among selected samples.

D. Next step includes eliminate of the outliers features by applying RANSAC algorithm if the both samples have sufficient number of valid features as shown in the following figure (figure 11).

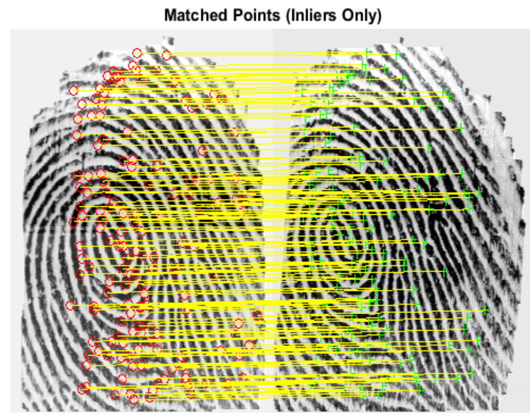

Figure 11 Inlier Features in Both Samples

E. finally, the proposed system calculates the matching (similarity) score by applying the formula in equation (Eq.9). hence, if the similarity score between the candidate samples is less than similarity threshold [0.30:0.40], samples are not similar and there is no matching between them, otherwise tested sample is matching references sample as shown in figure 12, which represent the matching between two samples.

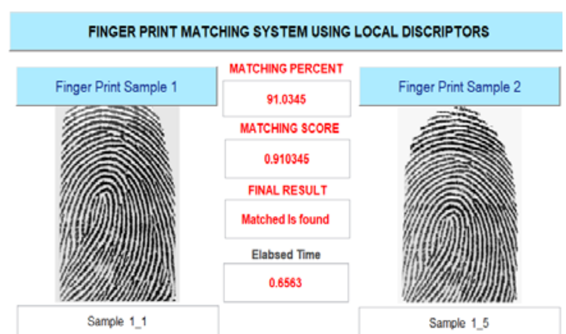

Figure 12 Matching Between Reference and Tested Fingerprint Image

Next figure (figure 13), shows the matching percentage when selected two different reference and tested fingerprint samples.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

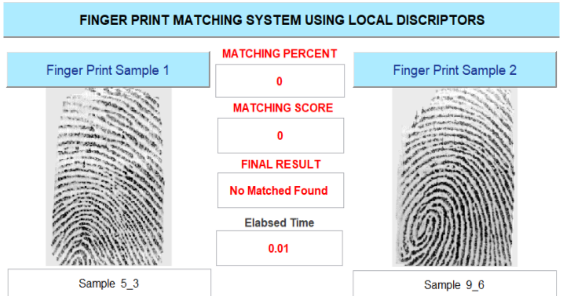

Figure 13 Calculate the Similarity Between Two Different Fingerprint Image

6.2 Reading Fingerprints (1:M) Matching

Proposed system also perform (1:M) matching, in such a way when tested fingerprint is selected through the mainframe, system is checking the whole existing fingerprints in dataset, then view similar fingerprints that satisfy similarity threshold as shown in the figure 14.

Figure 14 Similar Fingerprints to Tested (object1) Image

From the above figure 14, we can see that the tested fingerprint image is belong to the object1, and the proposed system successfully retrieve all the related fingerprints with time complexity equal to (3 millisecond) and also view in the upper textbox the name of sample in dataset, and in the lower textbox the similarity score for every individual sample. The following figure 15, shows the related result to the object2 in our dataset where the real number of fingerprints that belong to this object is (3) and the system retrieve all related fingerprints samples successfully with time complexity (2,4 millisecond) as shown below.

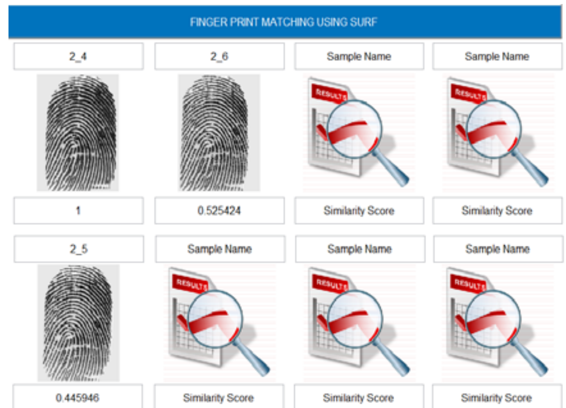

Figure 15 Similar Fingerprints of Tested (object2) Image

7. PERFORMANCE EVALUATION

The performance of our proposed system is evaluated through the experiments by using public dataset namely FVC2002 and FVC2004. The performance parameters used for evaluating our experimental results which are defined as follow: *False Acceptance Ratio (FAR), False Rejection Ratio (FRR), Success Match Ratio (SMR), Equal Error Ratio (EER) and finally Accuracy measure*.

FAR: its defined as the ratio of the number of false accepts images (FA) to the total number of verification images (T), in other words is ratio of the number of consider fingerprints of different persons (objects) / total number of fingerprints of the same person (object) in dataset.

$$FAR = \frac{FA}{T} \times 100 \quad (10)$$

FRR: its defined as the ratio of the number of rejected images (FR) to the total number of verification images (T), in other words is the ratio of incorrectly rejected images of the same person (object) / total number of fingerprints of the same person (object) in dataset.

$$FRR = \frac{FR}{T} \times 100 \quad (11)$$

SMR: its defined as the ratio of the number of successfully acceptance fingerprints that belong to same person (object) / total number of fingerprints of the same person (object) in dataset.

$$SMR = \frac{SM}{T} \times 100 \quad (12)$$

EER: its defined as the ratio at which FAR is equal to FRR, and can be consider as the best value that describes the performance of proposed system, where lower values refers to lower performance.

$$ERR = \frac{FAR + FRR}{2} \quad (13)$$

Accuracy: it's can be defined as the ratio of the corrected classified samples to the total number of classes. In our situation, we calculate the performance of our proposed system to predict the classes of other fingerprint samples to its correct class. Hence, for the fingerprints that belong to same person (object) must be classified by system to the class one, and so on for others.

To evaluate our proposed system, we select (10) objects from our dataset, (5) objects from every database:
[**FVC2002_DB1; FVC2004_DB1**].
The experimental results of selected objects are illustrated in table3.

TABLE 3. Evaluation Statistics of Proposed System

Object Name	Evaluation Parameters				
	FAR	FRR	SMR	EER	Accuracy
Object1	0.0	0	100.0	0	100.0
Object2	0.0	0	100.0	0	100.0
Object3	0.0	0	100.0	0	100.0
Object4	0.0	0	100.0	0	100.0
Object5	0.05	0.04	99.5	0.04	99.7
Object6	0.02	0.03	99.8	0.03	99.3
Object7	0.08	0.02	99.2	0.05	99.2
Object8	0	0	100.0	0	100.0
Object9	0.09	0.04	99.1	0.06	99.4
Object10	0.06	0.04	99.4	0.05	99.3
Average	0.03	0.05	99.8	0.06	99.4

The following table (table 4), illustrate the execution time for each stage in proposed system.

TABLE 4. Time Execution of Proposed System Stages

Stage	Elapsed Time in Millisecond
Pre-processing and Image Enhancement	1.20
Feature extraction	0.88
Feature selection	0.94
Matching	2.30
Recognition	2.15
Detection	3.20
Total	**10.67**

According to selecting samples, the following figure (figure 16) shows the average percentage of matching samples over whole selected dataset, in such a way that the selected sample when used in proposed system there are number of fingerprint images are matched, then we selected only related samples and calculate the average of matching percentage of these samples, second par graph represent the matching time in millisecond as shown in the following figure.

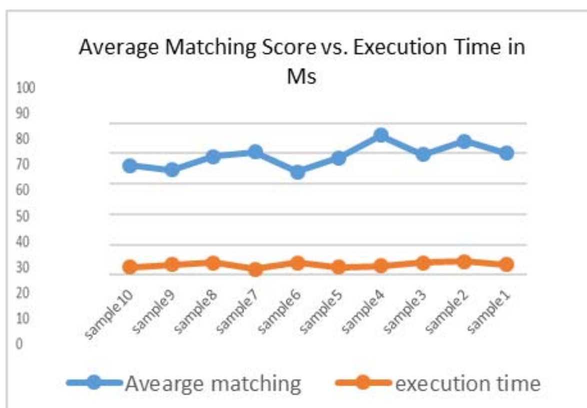

Figure 16 Performance Evaluation of Proposed System

8. STUFF TECHNIQUES IN PROPOSED SYSTEM

As mention in introduction and related work sections, proposed system not only enhanced the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

matching procedure that followed by traditional fingerprint matching system, but also reduce the time complexity to give a decision regarding the elect fingerprint sample. Thus, in many traditional system, time is very sensitive metric when the authentication technique required a fast decision to complete the desired procedure. Proposed system also, enhanced the retrieving matching process by view most related result across all databases and provide a flexible GUI that accepted variant inputs from user to view an easy result. Finally, its calculate the matching score not only for the first candidate, but also for all other candidate.

9. CONCLUSION

The of Fingerprint matching technique has attracted consider an interested field in many security systems. Minutiae approach is the most commonly technique used to find matching either between two fingerprints or across the whole samples in database. Minutiae-based approach has many drawbacks such as when fingerprints are rotated or degraded. Minutiae approach don't have the ability to find matching between the fingerprints that rotated or degraded under any circumstances. Image based approach comes to cover such of these issue, where the key idea of using image-based approach is to solve the issues of minutiae approach, proposed system using image based approach based on using a robust algorithm (SURF) that able to detect set of strongest interest points, then by using feature selection and matching criteria, similar fingerprints can be found for every sample in selected database. Proposed system used FVC2002 DB1, and FVC2004 DB1, to test the work of our proposed technique, and FAR, FRR, SMR, EER and Accuracy measures are used to evaluate the performance of proposed system. In this paper, we introduce a novel technique to view the matching results (1:1 and 1:M), where most previous techniques are just view the matching or the result when fingerprints are existing in selected database and do not show if there are another sample may match the query fingerprint image. FAR and FRR values, have been shown that our proposed system is very robust against other degradation issues and log average values that fall in range [0.03-0.05], while SMR is [99.8] and accuracy is [99.4].

10. FUTURE WORK

The future work plan focused on improving an efficient indexing and retrieving fingerprint system based on modifying SURF algorithm and latent analysis of the features that extracted from whole fingerprints to adopts a technique that able to discover the real communities in fingerprints which helps to predict the fingerprint classes.

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