A Hybrid Model of Multimodal Biometrics System using Fingerprint and Face as Traits

Sonam Shukla, Pradeep Mishra

Abstract— ***The issues associated with identity usurpation are currently at the heart of numerous concerns in our modern society. Establishing the identity of individuals is recognized as fundamental to the numerous administrative operations. Identity documents (IDs) are tools that permit the bearers to prove or confirm their identity with a high degree of certainty. In response to the dangers posed by theft or fraudulent use of identity documents and security threats, a wide range of biometric technologies is emerging, covering e.g. face, fingerprint and iris. They are also proposed to enforce border control and check-in procedures. These are positive developments and they offer specific solutions to enhance document integrity and ensure that the bearer designated on the document is truly the person holding it. Biometric identifiers - conceptually unique attributes - are today portrayed as the panacea for identity verification.***

Biometrics is the science and technology of measuring and analyzing biological data of human body, extracting a feature set from the acquired data, and comparing this set against to the template set in the database. Experimental studies show that Unimodal biometric systems had many disadvantages regarding performance and accuracy. Multimodal biometric systems perform better than unimodal biometric systems and are popular even more complex also. We examine the accuracy and performance of multimodal biometric authentication systems using state of the art Commercial Off- The-Shelf (COTS) products. Here we discuss fingerprint and face biometric systems, decision and fusion techniques used in these systems. We also discuss their advantage over unimodal biometric systems.

Index Terms— ***Fingerprint Recognition; Binarization; Block Filter Method; Matching score and Minutia; Face Recognition; Face Mask; Mask Fitting and Warping.***

I. INTRODUCTION

One of the cardinal security rules is never to rely on a single level or type of security solution. If you, as a business owner, only use a single security solution, you will probably lose control of your business if that solution fails. By definition, a multimodal security system consists of several security solutions, which provide a mutual backup. To reinforce this point, a traditional uni-modal system only addresses security on the basis of 'what you know'. A multimodal system also addresses security on the basis of 'what you have' and 'what you are'.

A multimodal security solution uses two or more levels of security at the points of entry to your place of business (both external and internal). A multimodal (or synchronous) solution would, for example, consist of a swipe card in combination with a PIN code. In contrast, a uni-modal solution would involve the use of a PIN code or swipe card only. It is also possible to use a uni-modal security solution in some parts of the building, and a multimodal solution in others. For a multimodal system to function well, it must use different security systems and technologies within each mode. This way, the quality and accuracy of the verification and authentication processes are optimised. Whereas an impostor may be verified at one level of security, the statistical probability of him or her being verified at another level diminishes exponentially.

Biometric technology offers a very effective multimodal security solution. In fact, as a business owner, you will significantly improve security if you use two or more biometric systems in tandem. A multimodal biometric system offers several advantages compared to other uni-modal security systems. First, a multimodal system can increase the reliability of the verification process. Second, a multimodal system can capture the unique, biometric characteristics of a much larger and more varied target population (some systems experience difficulties enrolling and verifying people of different ethnic origin - a multimodal system can help overcome this problem). Third, a multimodal system is much more difficult to spoof than a single biometric system (not least because multiple biometric templates are presented to the system).

II. FUSION IN MULTIMODAL BIOMETRICS SYSTEM

A Mechanism that can combine the classification results from each biometric channel is called as biometric fusion. We need to design this fusion. Multimodal biometric fusion combines measurements from different biometric traits to enhance the strengths. Fusion at matching score, rank and decision level has been extensively studied in International Journal of Computer Science & Engineering Survey (IJCSES) Vol.1, No.2, November 2010 56 the literature. Various levels of fusion are: Sensor level, feature level, matching score level and decision level.

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(1) Sensor level Fusion: We combine the biometric traits taken from different sensors to form a composite biometric trait and process.

(2) Feature level Fusion: Signal coming from different biometric channels are first pre-processed, and Feature vectors are extracted separately, using specific algorithm and we combine these vectors to form a composite feature vector. This is useful in classification.

(3) Matching score level fusion: Rather than combining the feature vector, we process them separately and individual matching score is found, then depending on the accuracy of each biometric matching score which will be used for classification.

(4) Decision level fusion: Each modality is first pre-classified independently. Multimodal biometric system can implement any of these fusion strategies or combination of them to improve the performance of the system; different levels of fusion are shown in below figure-1

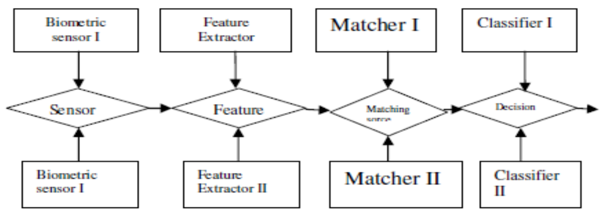

Figure 1(b): A prototype of a Multimodal Biometrics system using face and fingerprint as traits

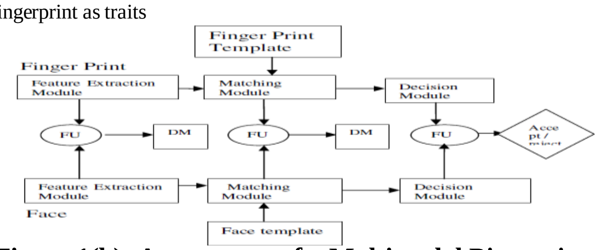

Figure 1(b): A prototype of a Multimodal Biometrics system using face and fingerprint as traits

2.1. Technique for Fingerprint Recognition:

The popular Biometric used to authenticate a person is Fingerprint which is unique and permanent throughout a person's life. A minutia matching is widely used for fingerprint recognition and can be classified as ridge ending and ridge bifurcation. In this paper we projected Fingerprint Recognition using Minutia Score Matching method (FRMSM). For Fingerprint thinning, the Block Filter is used, which scans the image at the boundary to preserves the quality of the image and extract the minutiae from the thinned image. The false matching ratio is better compared to the existing algorithm Figure 2 gives the block diagram of FRMSM which is used to match the test fingerprint with the template database using Minutia Matching Score.

2.1.1 Fingerprint Image:

The input fingerprint image is the gray scale image of a person, which has intensity values ranging from 0 to 255. In a fingerprint image, the ridges appear as dark lines while the valleys are the light areas between the ridges. Minutiae points are the locations where a ridge becomes discontinuous. A ridge can either come to an end, which is called as termination or it can split into two ridges, which is called as bifurcation. The two minutiae types of terminations and bifurcations are of more interest for further processes compared to other features of a fingerprint image.

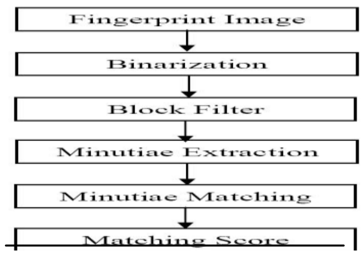

Fig 2: Block Diagram of FRMSM

2.1.2 Binarization:

In the pre-processing stage, the image is converted from greyscale to black and white. This is done by calculating the average background intensity and subtracting this value from the greyscale image. Next greyscale threshold (basic global and adaptive thresholding) is calculated so pixels above this value become black, and the ones below become white.

Figure3: (a) Original Fingerprint, (b) Binarized Fingerprint.

2.1.3 Thinning:

Next the ridges must be thinned to a width of one-pixel. In this step two consecutive fast parallel thinning algorithms are applied, in order to reduce to a single pixel the width of the ridges in the binary image. These operations are necessary to simplify the subsequent structural analysis of the image for the extraction of the fingerprint minutiae. The thinning must be performed without modifying the original ridge structure of the image. During this process, the algorithms cannot miscalculate beginnings, endings and or bifurcation of the ridges, neither ridges can be broken. Figure
4 shows the thinned image of the binarized image.

Figure 4: (a) Binarized Fingerprint , (b) Image after thinning.

2.1.4 Minutiae extraction:

In the last stage, the minutiae from the thinned image are extracted, obtaining accordingly the fingerprint biometric pattern. This process involves the determination of: i) whether a pixel, belongs to a ridge or not and, ii) if so, whether it is a bifurcation, a beginning or an ending point

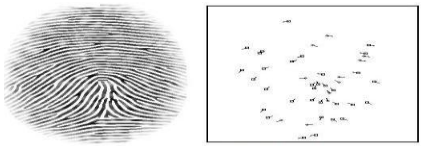

Fig 5: (a) Gray-scale Fingerprint (b) Minutiae points.

Table 1 gives the comparison of False Non Matching Ratio (FNMR) and False Matching Ratios (FMR) for existing method of Fingerprint Recognition Fuzzy Neural Network (FRFNN) and proposed method of Fingerprint Recognition using Minutia Score Matching method (FRMSM). It is observed that the False Non Matching Ratio for both the methods is zero and False Matching Ratio for existing method is 0.23 whereas for the proposed method FRMSM is 0.026.

Table 1: Comparison of FNMR and FMR for FRFNN and FRMSM.

	FRFNN	FRMSM
FNMR	0.00	0.00
FMR	0.23	0.026

2.2 Technique for Face Recognition:

Face recognition is one of the most intensively studied topics in computer vision and pattern recognition. Facial expression, which changes face geometry, usually has an adverse effect on the performance of a face recognition system. On the other hand, face geometry is a useful cue for recognition. Taking these into account, we utilize the idea of separating geometry and texture information in a face image and model the two types of information by projecting them into separate PCA spaces which are specially designed to capture the distinctive features among different individuals.

Our aim in this paper is to design a single-image-based face recognition system which is capable of, given an expressioned testing face image, not only recognizing which individual the testing face belongs to, but also determining which type of facial expression has been carried out. This is a challenging task, since the expression information needs to be separated from the intrinsic face features. An intuitive observation is that even under different expressions, the texture of one's face skin is relatively invariant, with only slight changes due to local lighting effects, or particular changes such as blushing. In addition, certain geometry, e.g., the length of nose and the distance between eyes, is also relatively invariant under different expressions. On the other hand, some geometry can have obvious changes under different expressions. For example, an opened mouth can prolong the chin. In this paper, our proposed face recognition system is based on constructing separate PCA spaces for face texture and those invariant geometry features. In addition, a novel expression PCA space is also constructed for the purpose of classifying expressions. This process begins with fitting a generic mask to reference faces as well as the testing face, where the mask nodes are feature points. We then warp the testing face to each of the reference faces. If we have warped an expressioned face to the reference face of the same individual, we call this warping natural warping; otherwise we call it artificial warping. To compare the texture of a testing face with that of each reference face, we project their textures onto the Eigenfaces [14] spanned by the training faces. The distance between their projections indicates their texture dissimilarity.

2.2.1 Face mask:

The idea of using a mask for registration in a face recognition system is not new. For example, [1] uses a 3D mask to register the frontal view with the profile view. Some existing masks, such as [10], are well designed for fitting deformable surface according to muscle actions. However, when working with planar face images, it is hard to achieve a good registration for all the densely placed vertexes. Besides, although quad-based masks [10] make morphing flexible, triangulated masks are advantageous in texture mapping. Consequently, we use a simplified and triangulated mask, as shown in Fig. 6. On this mask, the grey triangles correspond to regions of the eyebrows, eyes, nose and mouth. They are intentionally set to smaller sizes so as to capture more detailed features. This mask contains only 34 vertexes and 51 triangles, which will be denoted by v and t, respectively

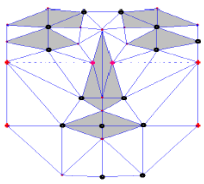

Figure 6. Face mask.

2.2.2 Mask fitting and warping:

Given a testing face, we first fit the mask onto it, by manually selecting 14 markers to register important face features. These markers are shown as the dark dots in Fig. 7. Then, all the other vertexes on the mask can be fitted using the symmetry and common knowledge of face structures. Fig. 8 gives two examples of such a registration process.

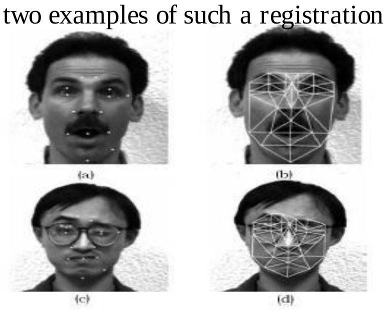

Figure 8. Fitting masks. (a), (c): manually placed markers (white dots); (b), (d):fitted masks.

After warping, expressioned faces have been morphed to have the same geometry as the reference face. After warping, the resulting face will have the same geometry as the reference face. Consequently, the warped face may appear similar to the reference face if their skin textures are close to each other. However, the testing face may belong to another individual whose face geometry differs greatly from that of the reference face. This implies that face geometry carries valuable information. To characterize this, we select the inner angles of each triangle on the fitter mask as a descriptor of its geometry. In addition, this descriptor is invariant under uniform scaling, translation and rotation, which can be caused by inaccurate calibration. These angles are arranged into an angle vector x_{ang}, denoted by:

X_{ang} = [_1 _2 _3 . . . _151 _152 _153]T (1)

where _1 to _3 belong to the first triangle, _4 to _6 belong to the second triangle, etc. There are altogether 51 triangles, yielding a total of 153 angles for each mask. We record the geometric change during the warping process. As the mask of an expressioned face is warped, its angle vector changes. We calculate a vector X_{res} to record this angle change, referred to it as angle residual hereafter, given by

$$X_{res} = X_e^{\ ang} - X_r^{\ ang}. \quad (2)$$

where X_e ang and X_r ang are the angle vectors of the expressioned face and the reference face, respectively.

To compare with typical face recognition methods, we first use Eigenface to recognize the original faces without warping. To align the faces, we manually pick the nose tip. A
150 × 150 square centered at the nose tip is cut off and taken as the aligned face. Our current mask fitting scheme is based on 14 manually picked markers. The usage of markers makes the system less automatic and likely to cause error. Considering that there are existing methods on automatic face feature registration, the combination of our method with these automatic registration algorithms will further highlight the advantages of our method.

III. CONCLUSION

In this paper, for fingerprint recognition, we presented Fingerprint matching using FRMSM and Face recognition using Face Mask Method. The pre-processing of the original fingerprint involves image binarization, ridge thinning, and noise removal. Fingerprint Recognition using Minutia Score Matching method is used for matching the minutia points. The proposed method FRMSM gives better FMR values compared to the existing method. The reliability of any automatic fingerprint recognition system strongly relies on the precision obtained in the extraction process. Extraction of appropriate features is one of the most important tasks for a recognition system.

For Face Recognition, we constructed three PCA spaces separately modeling face texture, intrinsic geometry and expression information by fitting a generic mask and warping the texture. Based on a combination of texture and appropriately defined geometric attributes,
superior recognition performance can be achieved. After face recognition, expressions can be quantitively modeled, enabling our system to classify expressions as well. Our current mask fitting scheme is based on 14 manually picked markers. The usage of markers makes the system less automatic and likely to cause error. Considering that there are existing methods on automatic face feature registration, the combination of our method with these automatic registration algorithms will further highlight the advantages of our method.

Multimodal biometric systems elegantly address several of the problems present in unimodal systems. By combining multiple sources of information, these systems improve matching performance, increase population coverage, deter spoofing, and facilitate indexing. Various fusion levels and scenarios are possible in multimodal systems. Fusion at the match score level is the most popular due to the ease in accessing and consolidating matching scores. Performance gain is pronounced when uncorrelated traits are used in a multimodal system. Incorporating user-specific parameters can further improve performance of these systems. With the widespread deployment of biometric systems in several civilian and government applications, it is only a matter of time before multimodal biometric systems begin to impact the way in which identity is established in the 21st century.

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