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Multi-Biometric Personal Authentication with 3d Face and Iris Images Using Sum Rule Based Fusion of Matching Scores

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Abstract:
In this paper we propose a multi-biometric system for personal authentication with two biometric traits using image fusion after matching. Regardless of significant advances in the latest years, there are still several limitations derived from utilizing one biometric trait. The problem with a unimodal biometric verification system is that since it uses only a single biometric trait it suffers from the disadvantages such as lack of universality, interclass variation and sensitivity to attacks which lead to spoofing of the authentication system. In order to overcome these shortcomings, multi- biometric systems are introduced. In this paper the combination of iris and face biometric authentication system is implemented and analyzed with several matching score level fusion techniques. In the system, a dynamic 3D face verification and improved iris segmentation and verification are developed and they are fused using sum rule based matching scores fusion technique.

Keywords: *Biometrics, sum rule, image fusion, matching scores, 3D face, iris.*

1. Introduction

Automatic personal authentication has become a very important topic though there exists several high level security mechanisms using biometric verification. Especially in fields like military security agencies, corporate firms automated person authentication is a problem of considerable practical significance. It has numerous applications including automated screening, surveillance, and authentication. Most real-life biometric systems are still unimodal. These unimodal biometric systems are faced with a variety of problems, noise in sensed data, non universality, inter-class similarities, and spoof attacks. And, it is often not possible to achieve a higher recognition rate and attempt to improve the performance of single matchers. In such situations, single recognizer may not prove to be effective due to inherent problems. By utilizing a multi-biometric system, these problems can easily be alleviated by providing multiple pieces of evidence of the same human subject, thus achieving higher and more reliable recognition.

2. Related Works

Information fusion is necessary to arrive at unanimous decision with multiple outputs in multimodal biometric system. The individual sensors provide raw image data acquired from the person to be authenticated; signal processing algorithms extract the feature vectors from the raw data; matching algorithms provide the match data. All these data from multiple sources are aggregated for the decision process. Information fusion for a multi-modal biometric verification system can be classified into sensor-level fusion, feature-level fusion, score-level fusion and decision-level fusion [3]. A person authentication system developed by Long and Thai [4] is multi modal and multi algorithmic.

The modalities considered in the system are face and fingerprint images. The features are obtained using multiple algorithms such as Orthogonal Moments, Zernike Moment (ZM), Pseudo Zernike Moment (PZM), Polar Cosine Transform (PCT) and Radial Basis Function (RBF) Neural Networks. With such integration of multi-modal and multi-algorithms, this system minimizes the possibility of forge in authentication but the training process is very complex. Nouyed et. al. [5] has developed multiple algorithmic approaches for facial authentication based on different Gabor phase feature representations. In the first approach, similarity score having the highest classification accuracy is used as threshold of the Gabor filter. In the second one, minimum intra-personal similarity score is used as individual subject’s threshold for authentication.

3. Background

3.1. 3D Face Matching

A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database. In this paper, a method is proposed for three dimensional faces recognition based on local ternary patterns with MLDA algorithm. Here, 3D frontal view human faces of are considered. A novel approach for 3D frontal face recognition is proposed using local ternary patterns with multi-linear discriminant analysis [MLDA] algorithm. Input images with varying lighting conditions are considered. Hence, the image passes through a preprocessing stage prior to the recognition stage. The algorithm developed using the fusion of LTP and DOG filter performs well under difficult lighting conditions [2].

The fused image is obtained using DOG filtered image and the LTP and face recognition is then performed using MLDA algorithm [2]. Since the recognition is performed by taking the fusion of DOG and LTP rather than by taking any one alone, the performance of the proposed technique is better

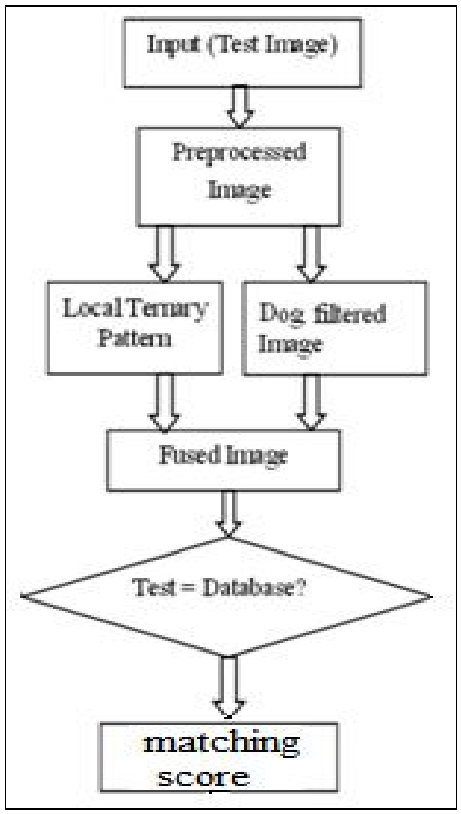

Figure 1 Flow chart of the proposed face recognition system

The image after preprocessing is fed to the face recognition stage.

3.2. Iris matching

In this phase, curvlet transform is proposed [1] for image enhancement, after the eye detection and segmentation. We consider the iris enhanced image as an input image in Wavelet based contourlet transforms according to their flow- graphs to extract iris features.

The wavelet based contourlet transformation is used [1] for feature extraction and based on the selected features, adaptive neuro fuzzy inference system is used for classification of the system [1]. Then it is compared with the existing samples in the database.

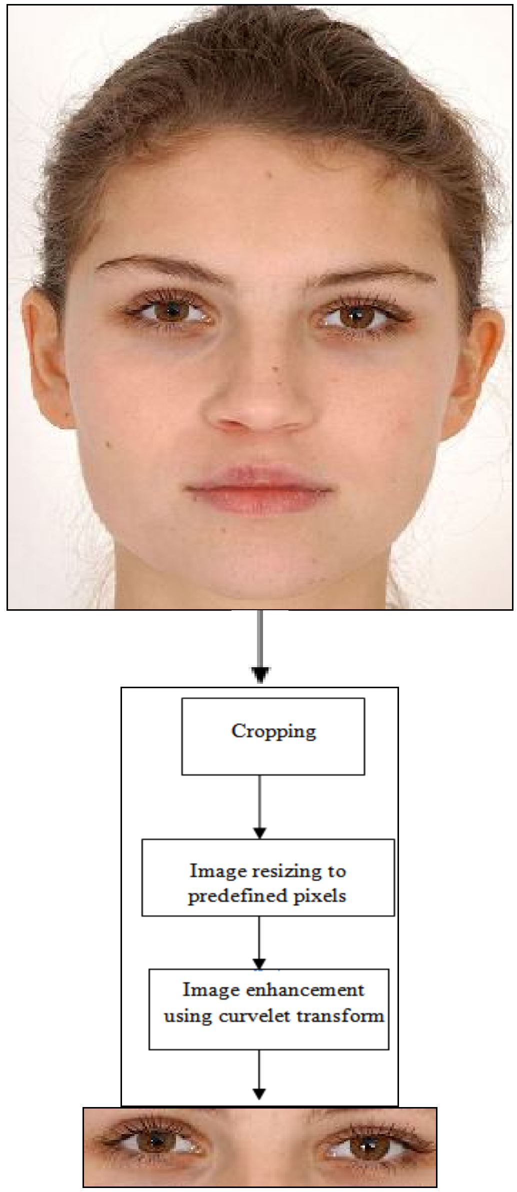

Figure 2 Flow chart of the iris segmentation system

4. Proposed Methodology

Here, 3D frontal view human faces are considered. The standard frontal pose is required as input for the system. Then the iris image is extracted from the face image. The flow chart of the proposed authentication system is shown in Figure 4. Input images with varying lighting conditions are considered. Hence, the image passes through a preprocessing stage prior to the recognition stage.

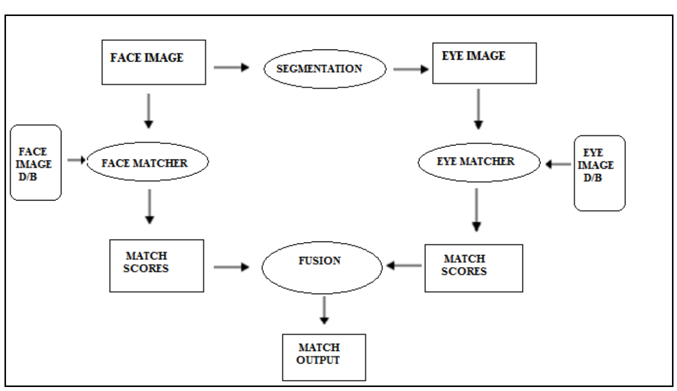

Figure 3 Flow chart of the proposed authentication system

4.1. Sum rule based matching scores fusion

Score level fusion refers to the combination of matching scores provided by the unimodal classifiers in the system. This is the most widely used fusion approach, as evidenced by the experts in the field. One could think that merging information from the different modalities at some previous stage of the system (sensor level, feature level) will provide more effectiveness, but there are several reasons that support score fusion, such as conceptual simplicity, ease implementation, practical aspects, etc. But before the fusion step, in order to combine the matching scores, we should first normalize these scores. Transforming the raw-scores obtained using different modalities to a common domain using a mapping function is called Normalization. There are different types of normalization, Min-max, median -MAD and z-score [21]. We use the first type Min-max which transforms scores into a common range [0, 1].

Min-max normalization: Given matching scores $\{s_k\}$, k=1,2,..,n the normalized scores are given by:

$$s' = \frac{s - \min\{s_k\}}{\max\{s_k\} - \min\{s_k\}}$$

In order to combine the scores reported by the three matchers we use sum based fusion rule.

$$Sum = \sum_{i=1}^{n} S_i$$

Where n is number of match scores wanted to be fused and S is the matching score.

5. Experimental Results

5.1. Performance Measure Of The Biometric Systems

In this research, the 3D frontal view human face is used as testing and training images. Test images are taken with 3D sensor camera. The format is JPEG with 325X480 pixels resolution with RGB colors. The algorithm has run by using Matlab 7.6, on a Pentium 4, 2.66 MHZ, 3 MB RAM computer. Only one of the input images was used for testing the system, the rest was performed in training the system.

Generally, the performance of the biometric verification system is measured by False Acceptance Rate (FAR) or False Positive Rate (FPR) and False Rejection Rate (FRR) or Genuine Acceptance Rate (GAR) [11] [12]. FRR, FAR or FPR, GAR and Total Error Rate (TER) are determined as follow:

$$FAR(\%) = \frac{false\ acceptance\ numbers}{No\ of\ imposter\ test} X100\%$$

$$FRR(\%) = \frac{false\ rejection\ numbers}{No\ of\ client\ test} X100\%$$

$$GAR(\%) = 100 - FRR(\%)$$

$$TER(\%) = FRR(\%) + FAR(\%)$$

The main goal of these experiments is to prove that we can design a system that achieves the desired performance or the best desired performance when using two or three types of biometrics. But, according to the system security requirements, the system can use the three types of biometrics or choosing randomly only two from them and achieve the desired performance.

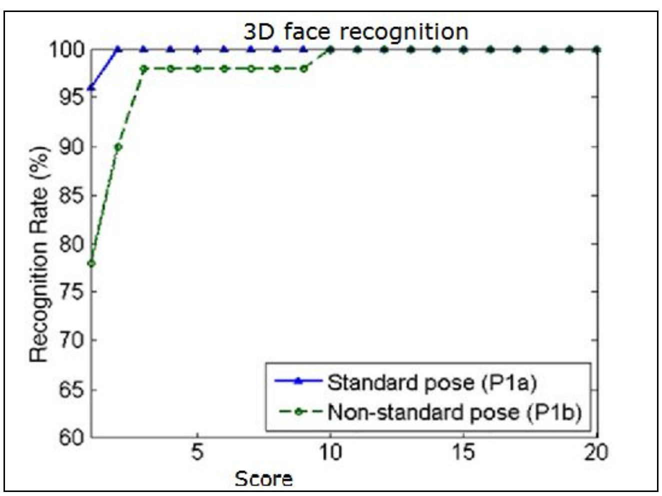

Figure4. Results of 3D face recognition

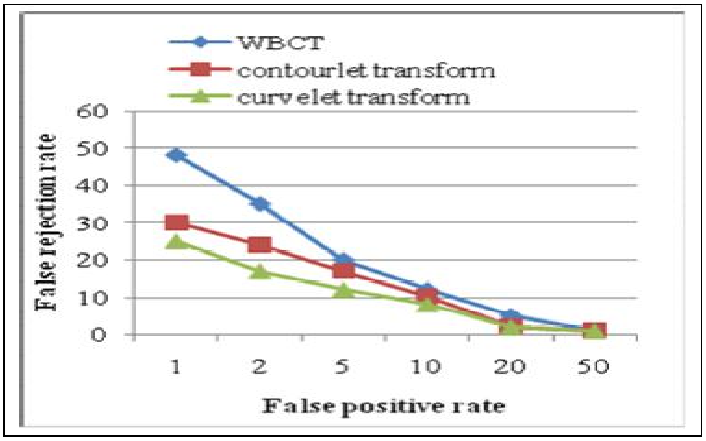

Figure5. Comparison of iris recognition results

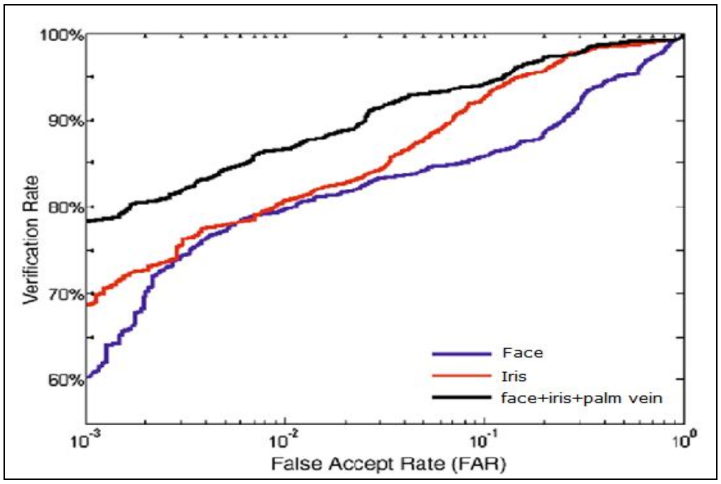

Figure6. Comparison results of multi-biometrics

6. Conclusion

In this paper, we illustrated the sum rule based; normalized matching scores fusion technique for combining the matching scores of the biometrics i.e. face and iris. We show that our system also exhibits an excellent authentication performance and outperforms unimodal systems whether we use two or three biometrics. In the future, new methods of fusion and matching will be explored, quality metrics and partial-face matching can be introduced.

7. References

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