A Review on Various Fusion and Features Extraction Approaches for Multi-Modal Biometric Authentication System

Hardeep Kaur[1], Paramjit Kaur[2]

Abstract: ***Biometric system has been used for the various identification and authentication process. This approach utilize under various bio-metric traits for authentication processes. Multimodal biometric authentication system utilizes different traits in combination to perform various activities. This paper comprises various approaches used for the purpose of fusion of features using Face, Finger and Iris traits. The features of face, finger and iris can be extracted and utilized for the purpose of fusion by using different fusion approaches like feature level and score level. In this paper various approaches has been studied for the purpose of feature extraction and fusion.***

Keywords: Fast Fourier Transforms, Discrete Wavelet Transform, Local Directional Pattern, Fusion

1. Introduction

1.1 Biometric

Multimodal biometrics will use a combination of the above recognition technologies, up to three of them, to compare the identity of a person therefore providing the best security available to you. If one of the technologies fails for any reason, your system can still use another one or two of them to provide accurate identification of a person. The benefits of multimodal biometrics is that by using more than one means of identification, your system can retain a high threshold recognition setting and your system administrator can decide the level of security that is needed. For a very high security site, you may need to use up to three biometric identifiers and for a lower security site, you may only need one or two of them. This greatly reduces the probability of admitting an imposter. There is a great need for multimodal biometrics as most biometric systems used in real applications are unimodal, which means they rely on only one area of identification. Some examples of these are fingerprints, faces and voices and these systems are quite vulnerable to many problems such as noisy data, non-universality and spoofing. This leads to a high false acceptance rate and false rejection rate, limited discrimination capability, and lack of permanence. You can overcome the limitations of unimodal biometric systems by using multimodal biometrics where you use two or more sources to validate identity. Multimodal systems are more reliable because you are using many independent biometrics that meet very high performance requirements and they counteract the problems listed above. They also effectively deter spoofing because it is near impossible to spoof multiple biometric traits and the system can request the user to present random traits that only a live person can do.

Some of the benefits of using multimodal biometrics, and for very secure environments the biometrics could include fingerprint, iris and voice, to allow you to safely reset passwords, process payments, and access control to a secure area. And it can also be used in the following areas

- Time and attendance keeping
- Border management
- Law enforcement

Now come some of the challenges in designing multimodal biometrics systems and the successful pursuit of these challenges will produce great advances to your safety and security in the future. The sensors must be consistent in performance under many environmental operations, have embedded privacy functions, protective solutions, enhance public confidence in biometric technology and must totally safeguard your personal information.

1.2 Various characteristics used in Biometric

- Face
- Finger
- Iris
- Gait
- Voice
- Hand Geometry
- Fingerprint

1.2.1 Face

Face recognition is a non-nosy technique, and facial pictures are most likely the most widely recognized biometric trademark utilized by people to make an individual recognition. Static or video images of a face can be used to facilitate recognition. Modern approaches are only indirectly based on the location, shape, and spatial relationships of facial landmarks such as eyes, nose, lips, and chin, and so on. Signal processing techniques based on localized filter responses on the image have largely replaced earlier techniques based on representing the face as a weighted combination of a set of canonical faces. Recognition can be quite good if canonical poses and simple backgrounds are employed, but changes in illumination and angle create challenges. The time that elapses between enrollment in a system and when recognition is attempted can also be a challenge, because facial appearance changes over time.

People regularly utilize countenances to perceive people, and headways in registering capacity over the recent decades now empower comparative distinguishment consequently. Early facial distinguishment calculations utilized basic geometric models, yet the distinguishment process has now developed into a study of modern scientific representations and matching methodologies. Significant progressions and activities in the previous 10 to 15 years have impelled facial distinguishment engineering into the spotlight. Facial distinguishment can be utilized for both check and ID.

The applications of facial distinguishment range from a static, controlled "mug-shot" confirmation to a dynamic, uncontrolled face ID in a jumbled foundation. The most well known methodologies to face distinguishment are focused around either: 1) the area and state of facial characteristics, for example, the eyes, eyebrows, nose, lips and button, and their spatial connections, or 2) the general (worldwide) investigation of the face picture that speaks to a face as a weighted mix of various accepted appearances. While the confirmation execution of the face distinguishment frameworks that are financially accessible is sensible, they force various limitations on how the facial pictures are acquired, in some cases obliging a settled and basic foundation or uncommon light. These frameworks additionally experience issues in perceiving a face from pictures caught from two radically diverse perspectives and under distinctive brightening conditions. It is flawed whether the face itself, without any logical data, is a sufficient premise for perceiving an individual from an expansive number of characters with an amazingly abnormal state of certainty [4]. In place for a facial distinguishment framework to function admirably by and by, it ought to naturally: 1) discover whether a face is introduce in the obtained picture; 2) find the face if there is one; and 3) perceive the face from a general view point.

1.2.2 Finger

Fingerprints—the patterns of ridges and valleys on the "friction ridge" surfaces of fingers—have been used in forensic applications for over a century. Friction ridges are formed in utero during fetal development, and even identical twins do not have the same fingerprints. The recognition performance of currently available fingerprint-based recognition systems using prints from multiple fingers is quite good. One factor in recognition accuracy is whether a single print is used or whether multiple or ten prints (one from each finger) are used. Multiple prints provide additional information that can be valuable in very large scale systems. Challenges include the fact that large-scale fingerprint recognition systems are computationally intensive, particularly when trying to find a match among millions of references. Unique mark recognizable proof is a standout amongst the most remarkable and plugged biometrics. Due to their uniqueness and consistency over the long haul, fingerprints have been utilized for distinguishing proof for more than a century, all the more as of late getting to be computerized (i.e., a biometric) because of progressions in processing capacities. Unique finger impression distinguishing proof is prevalent in light of the natural simplicity in securing, the various sources (10 fingers) accessible for gathering, and their secured utilize and accumulations by law implementation and migration.

1.2.3 Iris Reorganization

We are living in the age, in which the demand on security is increasing greatly. Consequently, biometric recognition, which is a safe, reliable and convenient technology for personal recognition, appears. Iris recognition is the procedure of perceiving an individual by dissecting the irregular example of the iris. The computerized system for iris recognition is generally youthful, existing in patent since just 1994. The iris is a muscle inside the eye that directs the extent of the student, controlling the measure of light that enters the eye. It is the shaded parcel of the eye, and the coloring is focused around the measure of melatonin color inside the muscle. Despite the fact that the coloration and structure of the iris are hereditarily connected, the example subtle elements are most certainly not [16]. The iris creates amid pre-birth development through a methodology of tight shaping and collapsing of the tissue film. Before conception, degeneration happens, bringing about the understudy opening and the iris framing arbitrary, one of kind examples. Despite the fact that hereditarily indistinguishable, an individual's iris is novel and structurally different, which takes into account them to be utilized for recognition purposes? This technology makes use of physiological or behavioral characteristics to identify individual.. A biometric system is a pattern recognition system including acquiring the biometric feature from individual, extracting the feature vector from the raw data and comparing this feature vector to another person's feature vector. Fingerprint, palm-prints, face, iris, gait, speech and signature are widely used biometric features. Biometric recognition can be used in computer network login, internet access, ATM, credit card, national ID card, driver's license and so on. Nowadays, fingerprint recognition is used widely and successfully. Face recognition is studied by many scholars and experts. Iris recognition is a relatively new branch of biometric recognition. The human iris is the annular part between pupil and sclera. It has distinct feature such as freckles, coronas, stripes, furrows and so on.

1.2.3.1 Steps of Iris Recognition

Major steps of iris recognition are given following:

- **Segmentation**: A technique is required to isolate and exclude the artefacts as well as locating the circular iris region. The inner and the outer boundaries of the iris are calculated.
- **Normalization**: Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have Characteristic features at the same spatial location.
- **Feature extraction**: The significant features of the iris must be encoded so that comparisons between templates can be made. Most iris recognition systems make use of a band pass decomposition of the iris image to create a biometric template. Iris provides abundant texture information. a feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images.
- **Matching of an Image**: To authenticate via identification (one-to-many template matching) or verification (one to- one template matching), a template created by imaging the iris is compared to a stored value

template in a database. If the Hamming distance is below the decision threshold, a positive identification has effectively been made e.g. a hamming distance of 0 would result in a perfect match.

Fusion in biometrics

In the biometric fusion three possible levels of fusions are: (a) fusion at the feature extraction level, (b) fusion at the matching scores level, (c) fusion at the decision level.

(1) Fusion at the feature extraction level: The data obtained from each sensor is used to compute a feature vector. As the features extracted from one biometric trait are independent of those extracted from the other, it is reasonable to concatenate the two vectors into a single new vector. The new feature vector now has a higher dimensionality and represents a person Nonidentity in a different (and hopefully more discriminating) hyperspace. Feature reduction techniques may be employed to extract useful features from the larger set of features.

(2) Fusion at the matching scores level: Each system provides a matching score indicating the proximity of the feature vector with the template vector. These scores can be combined to assert the veracity of the claimed identity. Techniques such as logistic regression may be used to combine the scores reported by the two sensors. These techniques attempt to minimize the FRR for a given FAR (Jain et al., 1999b).

(3) Fusion at the decision level: Each sensor can capture multiple biometric data and the resulting feature vectors individually classified into the two classes—accept or reject. A majority vote scheme, such as that employed in (Zuev and Ivanon, 1996) can be used to make the final decision.

Fusion in the context of biometrics can take the following forms:
(1) Single biometric multiple representation.
(2) Single biometric multiple matchers.
(3) Multiple biometric fusions

1. Single Biometric Fusion
Single biometric multiple matchers It is also possible to incorporate multiple matching strategies in the matching module of a biometric system and combine the scores generated by these strategies. Jain et al. (1999b) use the logistic function to map the matching scores obtained from two different fingerprint matching algorithms into a single score. The authors demonstrate that such an integration strategy improves the overall performance of a fingerprint verification system. This type of fusion also takes place at the matching stage of a biometric system. Although there are multiple matchers in this case, all matchers operate on the same representation of the biometric data.

2. Multiple biometric fusions
Multi biometric fusion refers to the fusion of multiple biometric indicators. Such systems seek to improve the speed and reliability (accuracy) of a biometric system (Hong and Jain, 1998) by inte- grating matching scores obtained from multiple biometric sources. A variety of fusion schemes have been described in the literature to combine these various\

2. Related Work

Dale, M.P et al [1] “Fingerprint matching using transforms features”, in the fingerprint recognition application utilizing more information other than minutiae is much helpful. We present here a fingerprint matching scheme based on transform features and their comparison. The technique described here obviates the need for extracting minutiae points to match fingerprint images. The proposed scheme uses Discrete Cosine Transform (DCT), Fast Fourier Transform (FFT) and Discrete Wavelet Transform (DWT) to create feature vector for fingerprints. After finding out the core point, fingerprint image of size 64times64 is cropped around the core point. The transform is applied on the cropped image without any pre-processing. The transform coefficients are arranged in specific manner and are used to obtain the feature vector in terms of standard deviation. The fingerprint matching is based on the minimum Euclidean distance between two feature vectors. Here database is formed by capturing 8 images per person using 500 dpi optical scanners. Training images used to form feature vector are 2, 4 or 6 per person. In the matching phase either all or remaining images are checked in identification mode to find out the percentage recognition rate. Comparison for all the three transform is presented here and it is observed that DCT and DFT gives better result as compared DWT.

Darwish, A.A. et al [2] “Human Authentication Using Face and Fingerprint Biometrics”, Multimodal biometric approaches are growing in importance for personal verification and identification, since they provide better recognition results and hence improve security compared to biometrics based on a single modality. In this paper, we present a multimodal biometric system that is based on the fusion of face and fingerprint biometrics. For face recognition, we employ uniform local binary patterns (ULBP), while minutiae extraction is used for fingerprint recognition. Fusion at matching score level is then applied to enhance recognition performance. In particular, we employ the product rule in our investigation. The final identification is then performed using a nearest neighbor classifier which is fast and effective. Experimental results confirm that our approach achieves excellent recognition performance, and that the fusion approach outperforms biometric identification based on single modalities.

Shenglin Yang et al [3] “Secure IRIS Verification” In this paper, we present a novel secure iris verification system, where a transformed version of the iris template instead of the plain reference is stored for protecting the sensitive biometric data. An error correcting code (ECC) technique is adopted to perform the comparison in the transformed domain. A two-segment method is proposed to execute the feature verification, where a Bose-Chaudhuri-Hochquenghem (BCH) code of a random bit-stream is introduced to eliminate the considerable differences between the features extracted from different scans of irises. A reliable bits selection process during the iris feature generation stage reduces the system error rate from 6.0% to 0.8%. The appropriate size of the set of reliable bits is determined by investigating the best match between the associated error correct cutting edge and the actual verification accuracy.

Hariprasath, S et al [4] "Biometric personal identification based on iris pattern recognition using Wavelet Packet Transform" A new iris recognition system based on Wavelet Packet Analysis and Morlet wavelet is described. Morlet wavelet calculations are easy compared to Gabor wavelets. Moreover Gabor wavelet based iris recognition system is patented which blocks its further development. The most unique phenotypic feature visible in a person's face is the detailed texture of each eye's iris. The visible texture of a person's iris is encoded into a compact sequence of 2-D Morlet wavelet coefficients, which generate an "iris code" of 4096-bits. Two different iris codes are compared using exclusively OR comparisons. In this paper, we propose a novel multi-resolution approach based on Wavelet Packet Transform (WPT) for iris texture analysis and recognition. The development of this approach is motivated by the observation that dominant frequencies of iris texture are located in the low and middle frequency channels. With an adaptive threshold, WPT sub images coefficients are quantized into 1, 0 or -1 as iris signature. This signature presents the local information of different irises. The signature of the new iris pattern is compared against the stored pattern after computing the signature of new iris pattern and identification is performed.

Huifang Huang et al [5] "A PC-Based System for Automated Iris Recognition under Open Environment", This paper presents an entirely automatic system designed to realize accurate and fast personal identification from the iris images acquired under open environment. The acquisition device detects the appearance of a user at any moment using an ultrasonic transducer, guides the user in positioning himself in the acquisition range and acquires the best iris image of the user through quality evaluation. Iris recognition is done using the band pass characteristic of wavelets and wavelet transform principles for detecting singularities to extract iris features and adopting Hamming distance to match iris codes. The authentication service software can enroll a user's iris image into a database and perform verification of a claimed identity or identification of an unknown entity. The identification rate is high and the recognition result is available about 6 s starting at iris image acquisition. This system is promising to be used in applications requiring personal identification.

Jia-Jun Wong et al [6] "Recognizing Human Emotion from Partial Facial Features" Recognizing human emotions from partial facial features are quite hard to achieve reasonable accuracy. In this paper, we propose to use a tree structure representation to simulate as human perceiving the real human face and both the entities and relationship could contribute to the facial expression features. Moreover, a new structural connectionist architecture based on a probabilistic approach to adaptive processing of data structures is presented to generalize the Face emotion tree structures (FEETS). We demonstrated the robustness of our proposed system in recognizing the correct emotion based on partial face features. The system yields an accuracy of about 90% for subjects with partial face covered by artifacts.

Benzaoui, A. et al [7] "DLBP and PCA for face recognition", A new algorithm for face recognition is proposed in this work, this algorithm is mainly based on LBP texture analysis in one dimensional space 1DLBP and Principal Component Analysis PCA as a technique for dimensionalities reduction. The extraction of the face's features is inspired from the principal that the human visual system combines between local and global features to differentiate between people. Starting from this assumption, the facial image is decomposed into several blocks with different resolution, and each decomposed block is projected in one dimensional space. Next, the proposed descriptor 1DLBP is applied for each projected block. Then, the resulting vectors will be concatenated in one global vector. Finley, Principal Component Analysis is used to reduce the dimensionalities of the global vectors and to keep only the pertinent information for each person. The experimental results applied on AR database have showed that the proposed descriptor 1DLBP combined with PCA have given a very significant improvement at the recognition rate and the false alarm rate compared with other methods of face recognition, and a good effectiveness against to deferent external factors as: illumination, rotations and noise.

3. Various Approaches for Biometric System

Fast Fourier transforms (FFT)

The FFT is a complicated algorithm, and its details are usually left to those that Specialize in such things. This section describes the general operation of the FFT, but skirts a key issue: the use of complex numbers. If you have a background in complex mathematics, you can read between the lines to understand the true nature of the algorithm. Doesn't worry if the details elude you; few scientists and engineers that use the FFT could write the program from scratch? In complex notation, the time and frequency domains each contain one signal made up of N complex points. Each of these complex points is composed of two numbers, the real part and the imaginary part. For example, when we talk about complex sample, it refers to the combination of and X, REX [42]. In other words, each complex variable holds two numbers. When IMAX [42] two complex variables are multiplied, the four individual components must be combined to form the two components of the product. The following discussion on "How the FFT works" uses this jargon of complex notation. That is, the singular terms: signal, point, sample, and value, refer to the combination of the real part and the imaginary part.

Discrete wavelet transforms (DWT)

In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency *and* location information (location in time).
The first DWT was invented by the Hungarian mathematician Alfred Hear. For an input represented by a list of 2^n numbers, the Haar wavelet transform may be considered to simply pair up input values, storing the difference and passing the sum. This process is repeated

recursively, pairing up the sums to provide the next scale: finally resulting in $2^n - 1$differences and one final sum.

Local Binary Pattern (LBP)

LBP is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. Due to its discriminative power and computational simplicity, LBP texture operator has become a popular approach in various applications. It can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis. Perhaps the most important property of the LBP operator in real-world applications is its robustness to monotonic gray-scale changes caused, for example, by illumination variations. Another important property is its computational simplicity, which makes it possible to analyze images in challenging real-time settings.

Local Directional Pattern (LDP) Algorithm

In this algorithm the local directional patterns are used for the texture descriptor in this LDP uses the different edge response values and uses these values to encode the image descriptor. LDP feature encodes the different local neighborhood property image pixels with a binary bit sequence .code is produced from the collection of the different gradient responses computed over the local region. This algorithm provides the better consistent texture representation in the presence of the random noise and non-monotonic illumination variation. LDP assigns a 8 bit binary no. to each pixel of the input image. This pattern is then calculated by comparing the relative edge response values of a pixel by using Kirsch edge detector. These LDP codes are used for the face recognition.

4. Conclusion and Future Work

Multimodal biometric system for various biometric traits has been utilized under various conditions. In the biometric review various approaches has been studied for feature extraction from different database of biometric traits. By reviewing these different approaches, one can conclude that fusion plays an important role in verification process of various biometric traits. Features can be extracted using different approaches for biometric traits. Fusion of features can be done on the basis of two different approaches one is score level and another is rank level. By studying various literatures on fusion approaches one can conclude that feature level or score level fusion provides better results for fusion of various features of biometric traits.

References

[1] Dale, M.P **"**Fingerprint matching using transforms features", IEEE Conf. on TENCON, Nov 2008, pp 1 – 5.
[2] Darwish, A.A. "Human Authentication Using Face and Fingerprint Biometrics", IEEE Conf. on Computational Intelligence, Communication Systems and Networks (CICSyN), July 2010, pp 274 – 278.
[3] Shenglin Yang **"**Secure IRIS Verification" IEEE Conf. on Acoustics, Speech and Signal Processing, 2007, April 2007, pp II-133 - II-136.
[4] Hariprasath, S et al [4] "Biometric personal identification based on iris pattern recognition using Wavelet Packet Transform", Computing Communication and Networking Technologies (ICCCNT), July 2010, 1 – 5.
[5] Huifang Huang et al [5] "A PC-Based System for Automated Iris Recognition under Open Environment", International Conf. on Innovative Computing, Information and Control, Sept 2007, 596.
[6] Jia-Jun Wong "Recognizing Human Emotion from Partial Facial Features", International Conf. on Neural Networks,, 2006, pp 166 – 173.
[7] Benzaoui, A. et al [7] "1DLBP and PCA for face recognition", International Conf. on Programming and Systems (ISPS), April 2013, 7 – 11.
[8] Pong C. Yuen, J.H. Lai "Face representation using independent component analysis" the journal of Pattern Recognition society, Pattern Recognition volume 35 (2002) Page No.1247–1257.
[9] Jian Yang, Davis Zhang, Alejandro F. Frangi and Jing Ju Yang "Two-Dimensional PCA:A New Approach to Appearance-Based Face Representation and Recognition" IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. 26, No. 1, January 2004
[10] Timo Ahonen, Abdenour Hadid, and Matti Pietikainen "Face Description with Local Binary Patterns: Application to Face Recognition" IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 28, No. 12, December 2006.
[11] Niloofar Amani1, Asadollah Shahbahrami2 and Manoochehr Nahvi1 "A new approach for face image enhancement and recognition", International Journal of Advanced Science and Technology Vol. 52, March, 2013.
[12] Dong-Ju Kim, Sang-Heon Lee and Myoung-Kyu Sohn "Face Recognition with Local Directional Patterns" International Journal of Security and Its Applications Vol. 7, No. 2, March, 2013
[13] Jian Yang, Yong Xu and Jing-yu Yang "Bi-2DPCA: A Fast Face Coding Method for Recognition", 5633-7654, 86-98, IEEE, 2013.
[14] Dong-Ju Kim, Sang-Heon Lee and Myoung-Kyu Sohn "Face Recognition with Local Directional Patterns" International Journal of Security and Its Applications Vol. 7, No. 2, March, 2013