Study of Multimodal Biometric System: A Score Level Fusion Approach

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Abstract **- Biometrics is the area of automatic persons identification based on the biological characteristics of human body. As in our day-to-day life automatic person's identification is an important task as per the high security issues. Unimodal biometric system has many limitations about security, accuracy, performance and robustness. A multimodal biometric system combines information obtained from different biometric characteristics and offers better recognition performance as compared to the unimodal system. Multimodal biometrics is the level based approach where fusion takes place at different levels as sensor, feature, matching score and decision. Fusion at matching score level is more preferable because matching ranks are easily available and contains sufficient information to distinguish. There is sufficient scope to design a proficient matching score level fusion approach. Fusion at matching score level is likely to provide better recognition performance as it contains more contented information which is both feasible and practical. So this is the review paper mainly focuses on the study of matching score level fusion in multimodal biometric system.**

Index Terms**— Biometrics, Multimodal biometrics, fusion levels, score level fusion.**

I. INTRODUCTION

A biometrics is the system used for the automatic person's identification and verification. As in our today's life, security consideration is the most important issue. Now a day in all areas there is need for identification of an individual for authentication and authorization purpose. A biometric system is a pattern recognition system that operates by obtaining biological data from person, mining a feature set from the achieved data, and equating this feature set against the data set in the database. Passwords, PINs, keys, and tokens are the old methods for identification and verification, but these methods have certain disadvantages as it can be stolen, it can be shared or it can be lost. So biometrics is the system which overcomes all these limitations.

In biometric system there are three main processes as enrollment, verification and identification. In enrollment process we have to enter the data into the database by feature extraction. In verification process it makes the comparison between the input data and the data stored in the database at the time of enrollment. It verifies that whether to accept or reject. In identification process it checks whether any data in the database is matching with the input data. It makes the comparison between input data with the multiple templates in the database to find the identity.

In the biometric system if it uses single source of information then it is a unimodal biometric system. But it has following limitations.

1) *Noisy data*. The detected data might be noisy or inaccurate. Examples of noisy data are voice changed by cold or a fingerprint with a scratch. Noisy data could also be the result of faulty or incorrectly kept sensors for example gathering of dirt on a fingerprint sensor or harsh ambient conditions for example in a face recognition system, no clear data due to poor light on user's face. Noisy biometric data may increase false reject rate.

2) *Intra-class variations*. The biometric data obtained from an individual during authentication may be varying from the data that was used during the enrollment process. This variation is typically initiated by a user who is erroneously cooperating with the sensor or when characteristics of sensors are changed for example by changing different sensors so it causes the sensor interoperability problem during the verification phase. As another example, the changing psychological character of an individual might result in different behavioral characteristics at various time instances.

3) *Uniqueness*. While a biometric characteristic is likely to vary significantly across individuals, there may similarity in features of particular individuals for example twins may have same characteristics.

4) *Nonuniversality*. It might be possible that some individuals do not have the particular biometric characteristics. So this is also a large problem in unimodal system.

5) *Spoof attacks*. A fraud individual may attempt to spoof the biometric characteristics of a genuine enrolled user. This type of attack is usually happened with behavioral characteristics as voice and signature are used. It can be also possible with physical biometric characteristics.

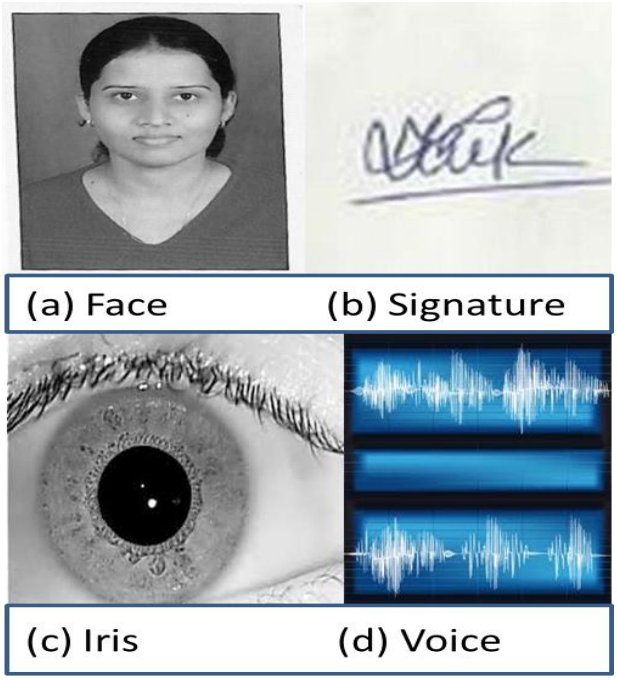

Fig: Examples of some biometric traits

II. MULTIMODAL BIOMETRIC SYSTEMS

As discussed earlier multimodal biometric systems uses multiple source of information that is, it takes input from one or more sensors and measures more than one multiple modalities of biometric characteristics. It provides the better performance in the identification task as well as security task. It has many advantages therefore it is widely accepted in many application fields. For example now Government of India has make "Aadhar card" compulsory to every Indian as an identity. So in this process they take information of two biometric characteristics of person as iris recognition and fingerprint recognition. So this is very common example of our day to day life. As we seen there are many disadvantages of single modal system in the process of enrollment, verification and identification. Multimodal system overcomes all these limitations. It provides better improvement in performance, accuracy, security and robustness. The main purpose of multi biometrics is to reduce the following rates.

- False accept rate (FAR)
- False reject rate (FRR)
- Failure to enroll rate (FTE)

If any user who is not an enrolled, but still he gets access then it is false acceptance. Similarly if enrolled user gets rejection then it is false rejection. Sometimes the user is not getting enrolled due to some reason like damage or absence of any characteristics. These situations may happens due to the noisy data, intra-class variations etc. So by using different methods in multimodal biometrics system, all these rates can be reduced. Multimodal biometrics has various forms as in multi algorithmic system processing with two or more algorithms, in multi instance system taking samples of two or more instances of same characteristics and in multi sensorial system using two or more sensors.

Multimodal biometrics is the layer based approach in which fusion of different modalities takes place at various levels.

III. FUSION LEVELS

Biometric fusion combines the results of classification from every biometric station. Multimodal biometric system fusion combines the multiple biometric sources of information as face, fingerprint, hand geometry, voice etc. So the fusion takes place at various levels as sensor level fusion, feature level fusion, matching score level fusion and decision level fusion.

1. Sensor level Fusion: It combines the biometric characteristics from different sensors to get a compound result for processing.

2. Feature level Fusion: Data coming from different sensors first pre-processed and features are extracted independently of this data, and then these results are combined to get a compound feature vector.

3. Matching score level fusion: In this fusion level instead of combining feature vectors, they processed separately. After those scores are individually found and based on that, accuracy is measured.

4. Decision level fusion: In this fusion level, each characteristic are firstly processed individually and then fusion takes place at decision level module.

According to me score level fusion has the better performance than other levels of fusion because matching ranks are easily available as well as it contains sufficient information to distinguish. As it contains sufficient information so it gives better performance in both feasible and practical way. There is sufficient scope to design a score level fusion. So my survey is basically on score level fusion approach. I have studied five papers in my literature survey which I have mentioned in this paper. My future work should be based on that.

In the following sections I have discussed the prior work and my proposed system to enhance the performance of the existing system. This is a review paper of all work done previously.

IV. PRIOR WORK

There are different score level fusion approaches studied in literature. One of the famous approaches is sum rule in which individual modal scores are summed up and then it provides a final score. It is the simplest method but it does not guarantee optimality for all points on the Receiver Operating Characteristics (ROC). ROC curves come from signal detection theory. It shows the tradeoff between the true

positive rate and false positive rate. True positive rate is the proportion of positive tuples that are correctly identified and false positive rate is the proportion of negative tuples that are incorrectly identified.

In transformation score fusion, match scores are first normalized to common area and then combined. For normalization, there are multiple classifiers used such as support vector machine (SVM), probabilistic neural network classifier, etc.

In classification based score fusion technique, scores from various matchers are considered to be feature vectors and then classifier is constructed to identify genuine and impostor scores [3]. SVM is the model or an algorithm for the classification of both linear and nonlinear data. It uses mapping technique to transform the original data into higher dimensions. In this new dimension, it finds the linear optimal separating hyperplane. Using support vectors, SVM finds this hyperplane or training tuples. SVM can be used for prediction as well as classification. Youssef ELMIR, Zakaria ELBERRICHI and Reda ADJOUDJ et al. [4] applied SVM classifier to classify fusion codes of fingerprint and voice. They presented the score level fusion performance of multimodal biometric system against different unimodal biometric system based on the fingerprint and voice biometric characteristics. They concluded based on their result that fusion based biometric system gives higher recognition rate. Following table shows their experimental result.

Biometric system	Recognition Rate
Speaker identification	50
Fingerprint identification	60
Feature level fusion	70
Score level fusion	70

Table. Results recognition

They concluded a although both score level and feature level fusion gives same recognition rate but score level fusion gave better identification rate since the second rank, while system based on feature level fusion delayed till the rank nine to achieve that rate.

Probability density based score fusion depends on score distribution approximation. For that naïve Bayesian and the Gaussian Mixture Model (GMM) are well known methods. Yasushi Makihara, Daigo Muramatsu, Yasushi Yagi and Md. Altab Hossain [3] presented score level fusion based on the direct estimation of the Bayes error gradient distribution. They studied the methods for optimality of the ROC curve such as probability density function (PDF). But the main challenge for that is how to accurately estimate the PDFs of a client and an imposter. So they introduced a new framework that overcomes this troublesome. It is an energy minimization framework in which they allocated lattice type control points in a multiple score space and then Bayes error gradients are estimated on the control points. They applied it on N training samples which are pairs of M-dimensional distance vectors and then lattice type control points are allocated.

Takao Murakami and Kenta Takahashi proposed a technique based on distance based indexing and score level fusion to reduce the identification error rate and response time [2].

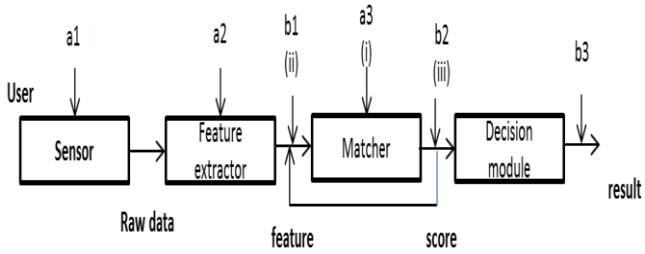

Fig. Strategies to improve the accuracy and the response time [2].

They presented above figure and presented strategies for the improvement in the accuracy and response time. In that improvement is in (a1- a3), fusions at (b1-b3) and (i-iii) are improvement, classification or indexing and indexing. They mainly focused on (b2) and (iii) that is score level fusion and indexing which is distance based. They evaluated this technique using the Biosecure DS2 dataset and the CASIA-FingerprintV5 dataset.

A score level fusion using a particle swarm optimization is the technique to achieve the expected performance presented by Ajay Kumar, Vivek Kanhangad and David Zhang. They introduced a new framework for adaptive combination of multiple characteristics to obtain the best performance for the high level of security. They used Particle Swarm Optimization search algorithm which is based on the behavior of the birds trying to fly to a favorable environment [1]. They proposed a system using adaptive score- level combination as shown in the following block diagram.

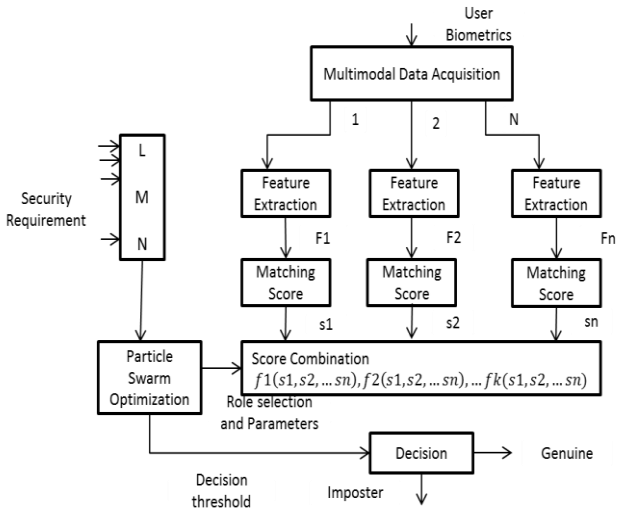

Fig. Block diagram of system using adaptive score level combination

So according to various experimental results they concluded that dynamic selection of fusion rules and their parameters using the hybrid PSO- based approach can offer better performance than the decision level using PSO.

Yali Zang et al. [5] introduced a new kind of information and proposed a score level fusion method with prior knowledge of fingerprint with sigmoid function.

V. PROPOSED SYSTEM

Fusion at matching score level is mostly preferred because it is easy to access and combine the matching scores. Subsequently resulting matching scores of different modalities are diverse, so before combining them it is necessary to normalize them. Choosing appropriate normalization technique is a difficult task because it may affect a recognition rate. To build an effective and well performing system, suspicious selection of the method, different characteristics, different sensors, different environments and all are important. So it is proved that SVM has better results in various systems of classification and pattern recognition. Moreover, for different prediction and classification applications, SVM has already been demonstrated to offer better simplification performance than previous techniques particularly when input values are huge. So due to all these advantages of SVM, I assessed the SVM for my fused feature vector. The proposed approach implements an new idea to fuse the scores of two different modalities - face and fingerprint. Following block diagram shows the basic steps:

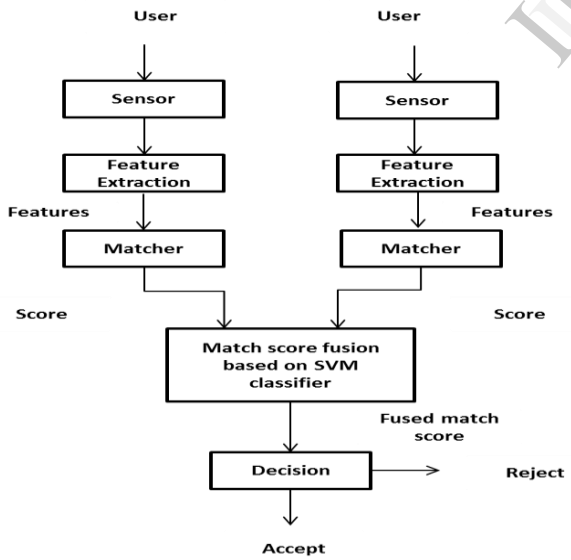

Fig. Block diagram of proposed system

1. Preprocessing step obtains the interested region for next processing.
2. In this step features are extracted which provides the resulting features.
3. Matcher matches the resulting features with the template in the database and provides matching scores.
4. This is SVM classifier based match score fusion step which combines the different scores of unimodal.
5. According to fused match score decision step provides result accept or reject.

VII. CONCLUSION AND FUTURE WORK

Biometric Systems are widely used for the person's automatic verification and Identification. But Unimodal biometric systems have many limitations as per the high security issues. Therefore in this seminar Multimodal biometric system is discussed which combines multiple biometric traits. Also there are different fusion levels, among these score level fusion has been discussed. Different methods studied in literature are also discussed for score level fusion. Proposed system is presented in the paper which is SVM classifier based.

As score level fusion has many advantages as compared to other level fusion strategies. Fusion at matching score level is likely to provide better recognition performance as it contains more contented information which is both feasible and practical. So my future work should be to find out the way to implement the score level fusion classification based technique. As support vector machine (SVM) classifier provides better results, so it should be the choice of classifier.

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