

A Review of Multimodal Fusion Techniques: Applications and Research Area

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ABSTRACT: Biometric technique is used for authentication which is based on the analysis of people's physical and behavioural characteristics. Unimodal biometric system performs person recognition and authentication based on a single trait of biometric. Use of multiple biometric traits helps to minimize the system error rate. The multimodal system techniques are used to combine the evidences obtained from different levels using an effective fusion scheme can improve the overall system accuracy of the biometric system. This paper is an detailed overview of fusion techniques which facilitates multimodal biometrics user authentication, study includes feature level ,score level and decision level applications to develop the system for higher security area.

KEYWORDS: Multimodal fusion, Feature extraction, Feature Classification.

I. INTRODUCTION

Data security or protection is a major concern in today's life, methods based on key or passwords are not useful because these can be easily spoofed, forgot, stolen, lost, So that use biometric is increase rapidly which recognize an individual based on his/her physical or behavioural characteristics [1] Use of multiple biometrics indicators for identifying individuals known as multimodal biometrics. Person recognition is categorized in two class that is person identification and authentication. The objective of identification system is see the person is registered or not, while in authentication system is to check accepting or rejecting the person who claims to be. Unimodal biometric systems are often affected by the problems like Noisy sensor data, Non-universality, Lack of individuality.

Person Classification is a vibrant area of research under biometrics. It is indeed a pattern recognition problem which is really challenging [2]. Determining Person recognition information from various physiological traits has several important advantages.

This paper presents the review of multimodal biometric techniques which includes applications, challenges and area of research in multimodal biometrics, also discuss about standard data sets which will help the researchers to deal with.

II. DIFFERENT LEVELS OF FUSION IN MULTIMODAL

In this session we discuss in detail about the various methodologies handled by researcher for determining Person recognition from the samples of all physiological traits.

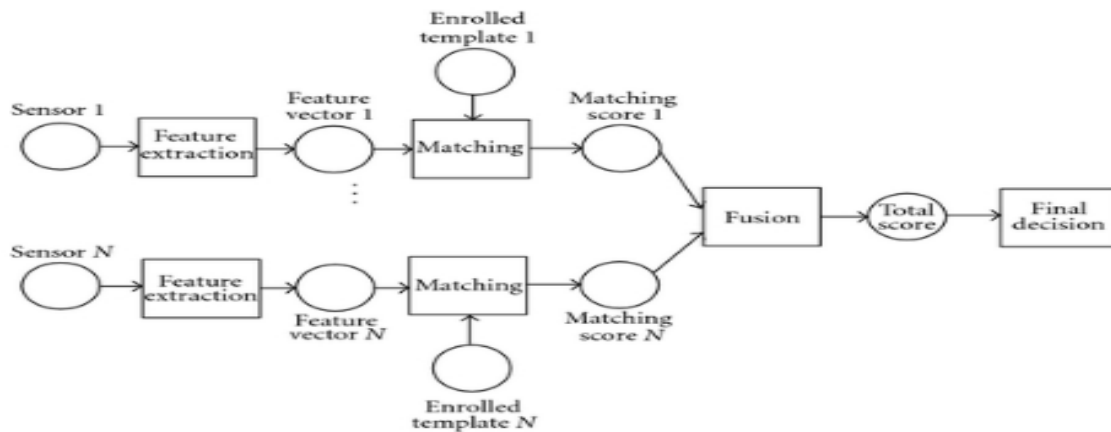


Figure 1 Multimodal Fusion at each level

When we collect the data from any of the modules discussed i.e. input sensor, feature extraction, feature matching and decision-making module they can be fused in more than one biometric system and called 'fusion'. (See fig.1.) [3] Shows the complete structure of multimodal fusion consisting of all level like one and more sensors at input called fusion sensor level, following are the fusion techniques models at each level.

1.Fusion at Score level

In sensor fusion inputs are coming from the sensors like thumbprint Sensor, Iris sensor, Microphone, Videocamera. All this raw data obtained from the sensors are fused and represent as a single trait.

Raghavendra R [4] Proposed a SUM rule technique, where database comprise video and audio recording .VidTIMIT database in which 10 sentences per person and video of each person is stored as a sequence of JPEG image. For speaker verification LPCC &MFCC used as those features analysed using separately by,

$$P(x) = \sum_{i=1}^m p_i b_i(x) \text{ ----- (1)}$$

For face verification used PCA &2LDA

Ms denotes the match score obtained using speech expert and Mf denote the match scores obtained using face expert, then fused score using sum rule is ,

$$FSUM = Ms + Mf \text{ ----- (2)}$$

Mrs Asmita S. Deshpande, Proposed [5] Sensor fusion method in which combination of fingerprint, Palmprint and face has been taken for person recognition, it was totally score based where system is score compared against on the threshold values. PCA and Gabor filter fusion methodology used in this to improve accuracy. The Region of Interest (ROI) detected separately for each of the biometrics [7] considered then the necessary features for obtaining gender information extracted for this three separate Scores are generated, each scores are integrated together and matched with the samples in the database and the decision to accept or reject is taken.

Firas S. Assaad [8] developed a normalization technology for new user registration and authentication which is totally score level where Yale Extended and NIST FERET databases for 100 persons were used and Parameter values for score normalization and fusion Score threshold are Left boundary, Right boundary and Score weight.

Weighted sum of scores (WSS) combines two or more normalized scores with different weights into a single one as follows,

$$WSS_k = \sum_{k=i=10}^{mk} W_i, \phi_i, k \text{ ----- (3)}$$

Where Mk is the number of scores for the k -th match, and w_i is the weight .

Kangroak oh proposed [9] a methodology of score level feature fusion to fuse sclera and periocular features for recognition, AS denser angular grid and a higher number of neighbourhood corresponds to better EER rate. Matching of the score of periocular features is evaluated by Euclidean distance,

Euclidean distance for two feature matrices are, Y_i and Y_j , Where write,

$$d(Y_i, Y_j) = \sqrt{\sum_{t=1}^k \sum_{u=1}^q Y_i(t, u) - (t, u)^2} \dots\dots\dots (4)$$

A Multi-Modal Recognition System Using Face and Speech introduced by Samir Akrouf [10] which is based on User access scenario based on speech and face information in that the Basic System Proposed for user recognition which compiles four major parts those are,

1. An acquisition and parameterization module of the signal which to represent the message in an exploitable form by the system.
 2. A training module who is charged to create avocal reference of the speaker starting from a sample of voice.
 3. A resemblance calculus module to calculate the shuffling coefficient between a sample signal and to reference with the corresponding person.
 4. A decision module based on score matching decision. Some of the score fusion rules are shown here.
- multimodal biometric system based on face, Voice, Palmprint, Iris, age, Gender, Palm vein, Footprint, speech, Gait and fingerprint,

III. MULTIMODAL SCORE FUSION RULE OR FIXED RULES

Sum--The fused score is obtained by simple addition of the individual score values

$$f(s_1, s_2) = (s_1 + s_2)$$

Product-- The product rule computes the fused score as

$$F(s_1, s_2) = (s_1 * s_2)$$

Trained rules [15,16,24,25]

Perceptron: The score produced by the Perceptron-based fusion

$$f(s_1, s_2) = 1 / 1 + \exp[-(w_0 + w_1 s_1 + w_2 s_2)]$$

Bayesian : The fused score produced is :

$$F(s_1, s_2) = (s_1 * s_2) / (1 - s_1)(1 - s_2) + (s_1 * s_2)$$

Where s1 and s2 denote scores provided respectively by face and fingerprint matchers, and s f(s1, s2) is the score fusion rule.

Bayesian Weighted Sum by Linear Discriminate Analysis(LDA):

The individual scores are linearly combined as, $f(s_1, s_2) = w_0 + w_1 s_1 + w_2 s_2$

The weights w0, w1 and w2 are set as the ones that maximize the Fisher distance (FD) between the score distributions of genuine and impostor users. In the case of two matchers, FD is defined as follows,

Face Datasets: We summarize different facial and gait based gender database in table 1, those database are mostly used in face detection and face recognition. Researcher is performed different experiments with this standard database, commonly facial portion is firstly detected and then the background is discarded.

Table 1: Different Face, Speech and Gait Databases

Face Dataset	Number of face/speech and Gait images	Variation Controlled
FERET [8]	14126	Pose, Illumination, Expression
FRGC [20]	50000	Illumination and background
LFW [21]	13223	Illumination, Expression and occlusions.
Agender [12-13]	65364	pitch intensity, stress, rhythm
Prosodic features [6,14]	65364	Intonation, stress, rhythm, pitch intensity
Human gait [22]	1870	Walking surface and shoe
SOTON large gait [23]	More than 600	Front side view, Outdoor and indoor scene.

2. Fusion at Feature Extraction level: The data or feature set which is generated after sensor level fusion using multiple sensors are fused together. In feature level fusion, Feature vectors are formed using the features extracted from each input sensors.

Xuekui Yan proposed technique for unsatisfactory recognition and better performance [11] based on feature extraction level fusion approach in single biometric system, In this system firstly image enhancement done by using the method of Gaussian smoothing then after those feature are move to the next level that is feature extraction fusion which is divided into two parts ,First is feature similarity measures which is totally distance base method and second is threshold base method, this method was efficient for palm vein image recognition when posture change condition occurs.

Feature Extraction based age and gender classification system [12] is developed by B.D.Barkana using speech as input, MFCC,RASTA,PLP-FO methods are used for feature extraction purpose which is totally pitch based for text-independent classification. The highest accuracy is achieved after MFCC+ENERGY+FO feature set worked on agender database in which total 4099speech dataset available.

3. Fusion at Decision Level: At decision fusion level, the decision score output by multiple score are combined to generate a new output algorithm that is used for decision making. Fusion at this stage is used to assessing and processing the match scores compared with the raw data or feature set extracted from the data. The decision module also ensure that to make decision in which users claimed identity is verified based on the matching score[13].3PR approach based where speech feature included parameters to calculate by using min,maximum,mean and standard deviation.

E Yilceoy, V.V.Nabiyev[14] proposed new thing of score level fusion at decision level using feature group like pitch, jitter,shimmer,formants and harmonicity. Here in score fusion level results are obtained using,

$$P_{\text{fusion}} = K1.P_{\text{GMM based}} + K2.P_{\text{SVM-}}$$

based where GMM and SVM are the probabilistic scores resp. according the age and gender characteristics with three different feature vector that is MFCC,PLP and prosodic and GMM-SVM classifier for highest success rate.

Table 2. Technical Evaluation

Ref. NO	Author	Methodology Used	Advantages	Features From Dataset	Limitations
15	Kyle O. Bailey, James S. Okolica	Feature Selection— PCA/MDL Classifier--BayesNet	FAR of 2.24% and FRR of 2.10%	1. Testing over 31 users Features-- Keystroke features, Mouse Stroke, GUI Masseges.	Experiment FRR of 2.10% means that there is a 50% chance the user will be locked out.
16	Mingxing He	SVM, by Min–Max normalization method	Fingerprint (1 finger), face (1 matcher), finger vein (1 finger—99%	fingerprint, face+ and finger vein. Public domain NIST+BSSR database	For large dataset SVM require longer training time
17	K.Sasidhar I, Vijaya L Kakulapati	PCA+Correlation Filter Bank	Accuracy very much improved	Fcae+Palmprint	Recognition time is not reported
18	Wu, T.X.X. C. Lian	Multi-view gender recognition technique	Computationally efficient and recognition multi view	Face features	Complex background affect the technique.
19	Li, Bao-Liang Lu,	Face local feature extraction using ASM and LBP	Classification time rate increase	Face feature, eye, nose, mouth and chin	Complex background affect.

IV. CRITICAL ANALYSIS

Table 2, enlightened weakness and strength of different Person recognition of existing system, shows the methodology adopted for respective fusion levels and what are the beneficial, advantages and limitations along with used datasets.

V. CONCLUSION

A framework has done with assessing the performance of multimodal biometric systems; This paper presents the study of all possible physiological biometric traits used for person recognition. The result of this study shows using multimodal fusion biometric technique can increase the improvement in the performance of the system just by combining the multiple source of information.

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