

# Fusion Levels in Multimodal Biometric Systems– A Review

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**ABSTRACT:** Biometrics is an application area in which different biological traits of a person is taken as input for person identification or authentication. This is highly needed for security reasons. Unimodal biometrics is easy to implement as it uses only one trait or modality of a person but it has many drawbacks like spoofing, non-universality, etc. Multimodal biometrics uses more than one modality of a person like face, fingerprint, iris, retina, gait, etc. Spoofing more than one trait of a person is difficult and so these systems are more secure and reliable.

**KEYWORDS:** Biometrics, unimodal, multimodal, decision, score, feature, fusion.

## I. INTRODUCTION

In today's world, life without computers and gadgets is totally unimaginable. The users wish to communicate with the computers in a similar natural way as humans communicate with each other. This led to the research in the area of using different modalities of humans for interaction with computer. As more and more confidential, important and private data are being stored in the devices the security of these systems has become an important concern. Also it sometimes becomes essential to verify the identity of a person. Initial security systems that were used faced many security problems. And so there was need for more secure and efficient methods. Thus the biometric system was introduced.

Biometrics technology is a metrics which makes use of certain traits of the human, which are unique for each person. It is a technology that measures the biological traits of any human being and extracts the unique features of this trait. These unique features of different individuals are stored in a database and are used as and when required for the authentication of a person [1]. Biometric systems can measure both the physiological characteristics of a person like fingerprint, iris, face, hand, etc. and the behavioral characteristics of a person like voice, signature, cognitive, keystroke patterns, gait etc. [2]

There are many advantages of using biometrics as compared to the earlier conventional systems. In Card based systems, the cards can be stolen or forgotten. In systems where password is used for security the password can be retrieved or found out. But in biometric systems, no such forgery is possible as it is something which a person owns and does not have to be careful about or remember to carry all the time [2]. Using biometrics, it is possible to confirm or establish identity based on "who the individual is", rather than by "what the individual possesses" (e.g., an ID card) or "what the individual remembers" (e.g., a password). [3]

## II. MULTIMODAL BIOMETRICS

A biometric system can be unimodal or multimodal. In unimodal system any one trait of a person is taken and considered for authentication. But in multimodal systems more than one trait of a person is taken into account. The unimodal biometric systems had the disadvantage of noise creeping in into the data, spoofing, non-universality, inter-class variation and is also not very reliable. The voice of any particular person can be imitated, the signatures can be easily forged or finger prints can be manipulated, etc. So, the researchers focused their attention on multimodal biometrics. In multimodal biometrics more than one trait of a person is considered and so forging or manipulating all the traits of a particular person is not easy and so the systems based on multimodal biometrics are more secure and safe. In this the data from different biometrics are captured and pre-processed. Then from each of the biometrics, features are extracted and matched with the stored templates in the database [4]. Different authors have combined

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different traits of a person to get the result. Most common traits used are face recognition, iris recognition, retina recognition and fingerprint scanning.

### III. FUSION LEVELS

There are many different fusion techniques used for combining the different modalities used in the multimodal biometric system. Fusion of these modalities is an important, critical and crucial step. Each of the fusion levels has their own advantages and disadvantages. The different modalities used in a multimodal biometric system can be fused at different levels like feature level, score level etc. The four levels of fusion are as described below:

#### A. Sensor Level

In this the raw data captured from different sensors are taken together. Multiple samples of same biometrics can be taken eg. face image or iris image captured from different cameras and different angles. Single sensors can be used for taking multiple instances of same biometric eg. face images taken after a certain fixed time gap or voice recording done in intervals. Also data from multiple sensors can be used for multiple biometric e.g. fingerprint, iris and face taken using multiple sensors etc.

#### B. Feature Extraction Level

In this firstly all the biometric traits are recorded and then features are extracted from each of the traits separately. So features from different sensors and multiple biometrics are collected at different interval of time and are finally combined together to get the resultant feature vector. In this case care needs to be taken that the trait from all different sensors should be compatible.

#### C. Score Level

In this a match score is obtained from a biometric matcher. It indicates the degree of similarity between the feature vector and the stored template feature vector. For each of the biometrics these match scores are combined and the resultant match score is derived. The similarity scores of the individual biometrics are generated and these scores are fused together.

#### D. Decision Level

In this each of the biometric is pre-classified separately. So first the data is captured, then the features of each of the trait are extracted and then based on this either the traits are accepted or rejected. The decision obtained from each of the different systems are fused together to get the final result.[5, 6, 7, 8, 9, 10]

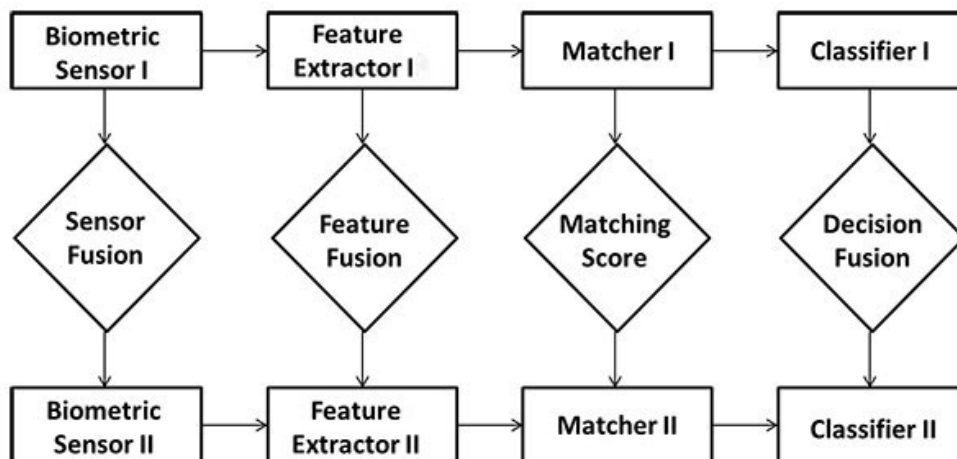


Figure 1: Fusion levels in Multimodal Biometric Systems [2]

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The sensor level and feature level are used at the early stage of matching whereas the score and decision level are used in the later stage of matching. A biometric system can be developed using any one or a combination of these fusion techniques for better recognition.

## IV. RELATED WORK

Much work has been done on multimodal biometrics. Table 1 shows the different work done by different authors in this area. Here the researchers have used different biometric features and have combined them using different fusion algorithms. Multimodal traits like face, iris, gait, fingerprint, speech, palmprint, etc. have been combined. The table shows the algorithms used for feature extraction of the different traits and the fusion levels used for combining the different biometrics. Social behaviour information of the person is also nowadays being used as a trait for the multimodal biometric systems. In [23] the authors have made use of this feature in their research.

TABLE I: Different biometric traits and the levels used for their fusion

References	Biometric Traits Used	Algorithms used for Biometric Features	Fusion Level
[11]	Fingerprint, Face and Speech	Minutiae, Eigenface, HMM and LPC	Decision Level Fusion
[12]	Face feature, Palmprint feature	Gabor transform on both face and palmprint	Sensor Level Fusion
[13]	Palmprint and Iris	Wavelet for both palmprint and iris verification	Feature Level Fusion
[14]	Face, Fingerprint	Zernike Moment (ZM) and Radial Basis Function (RBF) Neural Network	Feature Level Fusion
[15]	Face, Fingerprint and Iris	Used two methods: 1. Fisherfaces, principal component analysis 2. Fisherface, Minutiae extraction, LBP	Feature Level Fusion
[16]	Ear and Iris	In both the features were extracted using Principal Component Analysis (PCA) technique by determining the Eigen vectors for dimensionality reduction without information loss.	Score Level Fusion S
[17]	Iris and Fingerprint traits		Score level
[18]	Face, Gait	PCA + neural network, Euclidean distance between descriptors	Feature Level Fusion
[19]	Face and Iris	Five feature extraction algorithms has been applied as local and global feature extractors, namely Local Binary Pattern Histogram (LBPH), modular Principal Component Analysis (mPCA) and sub-pattern Principal Component Analysis (spPCA) as local methods and Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) as global method	Hybrid Feature, Score and Decision level Fusion n by combining three fusion classifiers with a decision rule
[20]	Keystroke (i.e., behavioral biometric), face (i.e., physiological biometric), and skin color (i.e., soft biometric)	Sliding window algo, PCA and Eigenface, YCbCr color space	Score Level Fusion
[21]	Face, Finger	LBP extracted the Face features from face images and those features are given as input to PCA that generates Face Feature Vector with reduced Dimensions. , Finger features are extracted from	Feature Level Fusion Weighted Summation Fusion method

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		Fingerprint images using LBP and those features are given as input to PCA that generates Finger Feature Vector with reduced Dimensions	
[22]	Fingerprint and Iris	Minutiae matching and Edge detection	Score Level Fusion
[23]	Face, Ear, and Social behavioral information	PCA, PCA, mined from an online social network	Score Level Fusion
[24]	Iris and Fingerprint	Gabor wavelets, Chain Code based feature extractor with contour following to detect minutiae	Score Level Fusion

## V. CONCLUSION & FUTURE WORK

Multimodal biometric systems definitely have an edge over unimodal biometric system. Many systems have been developed which use multi modalities for security of the system and also for person identification and authentication. In the paper I have shown the different modalities combined by different authors using different fusion levels so as to give a secure system. Mostly the users have used 2-3 traits of a person. Certain challenges like number of modalities, choice of suitable model, ideal fusion level and best way of extracting features from the trait still exists. In future for accurate authentication better and efficient systems can be developed keeping in mind the above challenges. This will be especially beneficial for the systems where security of the data is of prime concern.

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