

Research Article

# A Novel Framework for Multimodal Biometrics based on Dimensionality Reduction Technique for Reducing Overlapping Features

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Accepted 28 Jan 2015, Available online 01 Feb 2015, Vol.5, No.1 (Feb 2015)

## Abstract

*In this article, the effect of dimensionality reduction in the authentication process while recognizing the multiple traits is projected. In this paper, the templates of speech face and finger print are fused in serial fusion mode. The concepts Generalized Gamma Distribution (GGD) is considered for modeling the facial data. The performance of the model is evaluated using synthetic data and evaluation is carried out by considering metrics like False Acceptance Rate (FAR), Acceptance Rate, and False Rejection Rate (FRR).*

**Keywords:** Multimodal biometric, Dimensionality Reduction, Serial Fusion, Performance evaluation, Generalized Gamma Distribution (GGD)

## 1. Introduction

Biometrics is an automatic system for establishing the exclusivity of an individual based on physiological or behavior traits such as face, voice, and fingerprint, iris, and palm geometry and so on. Biometrics is deployed in most of the Government sectors and Industries, to enhance security and counteract security threats. Every biometric pattern of an individual is supposed to satisfy set of characteristics namely, universality, permanence, suitability and Acceptability (Souheil Ben-Yacoub *Manas*, 1999; Ibrahim S. I. Abuhaiba *Manas*, 2007). Spoof attack, Reply attack, Substitution attack, transmission attack, intra-class similarity attack are some of the attacks highlighted by many researchers in uni modal biometric systems (J. Fierrez-Aguilara *Manas*, 2004; R. Sanchez-Reillo *Manas*, 2000; K. Jain *Manas*, 1999). To overcome these disadvantages, multimodal biometric systems have been emerged. The main advantages of the multimodal approaches include: perfection in the matching accuracy, less sensitive to imposter attacks, complicated to spoof and ability for continuous tracking in situations when a solitary biometric trait is not enough (W. Shu *Manas*, 1998; D. Zhang *Manas*, 1999). Among the various attacks, subjected to biometrics, an Intra-class similarity is due to overlap of multiple individuals features and leads towards the increase in the False Acceptance Rate. Hence in this paper, we present the concept of dimensionality reduction, to overcome this disadvantage.

Multimodal systems fuse various biometrics either using Fusion prior to matching or fusion after matching. In fusion prior to matching approach, the integration of the information is considered either at sensor level or feature level. These approaches are less preferred as integrating non-homogenous traits is difficult and also concatenation of two feature vectors may lead to huge dimension which leads to curse of dimensionality problem. Hence in this paper we have considered Fusion after matching where abstract decisions based on concept of score level fusion can be arrived based on majority voting, AND - OR rule based and Rank based decisions.

In this article, traits of the finger-print, speech, and face templates fused. The features are obtained using the PDF of GGD and Mel spectral coefficients from speech signal. The evaluation of the developed method is carried out using metrics like FAR (False Acceptance Rate) and FRR (False Rejection Rate). The organization of the paper is as follows. Section-2, of the paper deals with Generalized Gamma Distribution. In Section -3, extraction of biometric traits and feature vectors are discussed. Section-4 of the paper deals with face space and its dimensionality. In the section-5, experimentation together with the results is presented. Evaluation Metrics together with conclusions are presented in section-6.

## 2. Generalized Gamma Distribution (GGD)

In this paper generalized gamma distribution is considered distinguishing an impostor and genuine traits. The main motto behind the consideration of GGD

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is that, the biometric traits considered will be non-homogenous and asymmetric in nature. Therefore, to cater these multiple patterns, it is needed to consider a model which is asymmetric, such as GGD (generalized gamma distribution) as it can handle data both in symmetric and asymmetric features.

The PDF (Probability Density Function) of Generalized Gamma Distribution (GGD) is given

$$f(x, k, c, a, b) = \frac{c(x-a)^{ck-1} e^{-\left(\frac{x-a}{b}\right)^c}}{b^{ck} \Gamma(k)}$$

### 3. Extraction of Biometric Traits

In this article we have measured the biometric templates of face, fingerprint and speech signal for the validation procedure. For the authentication purpose, each of these templates is matched against the templates in the database. The finger print extract is given to GGD as input, MFCC values are considered for extraction of amplitude sequences from the speech signals and pixels of the facial data are given as input to the GGD to extract the PDF. These features are fused using a score level fusion, which is a uses a Logical AND/ OR operation the match is indicated as 'Y', and Mis-Match by 'N'. The confirmation process is based on the value returned.

### 4. Face Space and Its Dimensionality

Study of facial images deal with acquisition of signals from the facial data in the form of pixel values. The pixels values may represent color values or only intensity value. In this article, we have considered grey level intensity value, of the facial data. Each facial image in the data base is normalized and resized into a fixed size of  $m \times n$ , the pixel array is characterized by an  $mn$ -dimensional *image space*. In order to manage such a huge multidimensionality space, the concepts of dimensionality reduction is considered. Also, both Non-Parametric and Parametric based models perform better when the data size is nominal. Hence, each face is converted into subspace, to extract the principal components.

The algorithm for dimensionality reduction is as follows.

Step-1: Fingerprint is scanned and stored in a two tone format i.e. 0 or 1s

Step2: Consider each row and let each row be denoted by  $X_1, X_2, X_3, X_4$

Step-3: Compute

$$\begin{aligned} X_1^T &= (0, 0, 0)^T \\ X_2^T &= (1, 0, 0)^T \\ X_3^T &= (1, 1, 0)^T \\ X_4^T &= (1, 0, 1)^T \end{aligned}$$

Step-4: Compute Covariance-Matrix using the Formula:

$$C_X = \frac{1}{4} \sum_{k=1}^4 X_k X_k^T - M_X M_X^T$$

Where  $M_X$  is the Mean

Step-5: Compute Mean as follow

$$M_X = \frac{1}{4} [(X_1 + X_2 + X_3 + X_4)]$$

Step-6: Compute  $M_X M_X^T$

Step-7: Compute  $\frac{1}{4} \sum_{k=1}^4 X_k X_k^T$

Step-8: Compute the Covariance Matrix i.e. step 4 using step-6 and step-7

### 5. Experimentation

In order to evaluate the model various inputs are considered both from gender dependent and gender independent data. The database consist of 100 fingerprint, 100 facial images and also consist of speech signals of the above 100 subjects. The preprocessing is done on each of the sample and feature vectors are extracted using the concept mentioned in section-3 of the paper. The core features are extracted from each of these biometric inputs and are stored in the database. In order to extract the speech signal, each of the subject's speech data is recorded in .WAV format and are given as input to the MFCC for extracting the amplitude signal. MATLAB voice box is considered for the extraction of these amplitude signals. For the extraction of facial features, each face is normalized into a unit square. Preprocessing is subjected to overcome lightening or illusion effects and orientation is overcome by considering frontal face. These preprocessed faces are given as input to GGD and the PDF is obtained by using the formula given in section-2. Using the MATLAB environment these features are fused using score level fusion, as discussed in section-4 of this paper. The various input and outputs are presented in following figures1, 2 and 3.

### 6. Performance Evaluation and Conclusion

In this paper the concept of multilevel fusion is considered for authentication of a person and ensures security from private and public data. In order to evaluate the current methodology we have considered metric like FAR (False Acceptance Rate), FRR (False Rejection Rate) and Acceptance Rate. The formulas for computing are given below.

$$\begin{aligned} \text{MDR} &= (\text{Total no of missed recognition} / \text{Total Template}) * 100. \\ \text{FAR} &= ((\text{Total considered} - \text{Total Accepted}) / \text{Total Template}) * 100. \\ \text{Acceptance Rate} &= (\text{Total no of Accepted Traits} / \text{Total Traits}) * 100. \end{aligned}$$

**Table 1** Performance of Proposed Model

Biometric Traits	Technique Adopted	Performance of Classification in Percentage (with dimensionality reduction )				Performance of Classification in Percentage (without dimensionality reduction )			
		FAR	FRR	ACC RATE	No.of subjects	FAR	FRR	ACC RATE	No. of subjects
FACE+ Speech+ Finger Print	GMM	1.67	7.84	84	100	3.76	9.17	68	100
	Proposed Model	1.56	6.10	93	100	3.54	6.64	76	100

**Conclusion**

In this paper the concept of multimodal biometric verification is considered for authentication of an individual. This paper presents a novel methodology for establishing the identity of individual by using the concept of GGD (Generalized Gamma Distribution) together with score level fusion. The Normalized data is considered for verification of an individual against template. The Performance is evaluated using FAR/FRR and also compared with the existing methodology of GMM (Gaussian Mixture Model) and is presented in the table. The classification of subject is carried out with and without reducing dimensionality. In both the case the proposed model using GGD shows better accuracy compared to existing methodology using Gamma Mixture Model.

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