Multimodal System Framework for Feature Level Fusion based on CCA with SVM Classifier

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Abstract:
In the biometric recognition, feature fusion is a critical step, especially in case of heterogeneous and incompatible feature representation. Most of the existing methods cannot extract features that are discriminative and at the same time affine invariant, which limits the classification performance. To address this issue, we propose an efficient feature level fusion approach using canonical correlation analysis (CCA) with SVM classification. The feature level fusion approach integrates different features extracted from different modalities into a more discriminative and compact feature representation, which can be further used for classification. We also propose an efficient algorithm that optimizes the whole framework of the multimodal system. The CCA + PCA subspace learning approach is presented to couple dimensionality reduction and feature fusion collectively, which can be used for both unsupervised and supervised learning. The experimental results on the SDUMLA multimodal database show that the proposed approach significantly outperforms than the prevalent feature fusion approaches. We demonstrate that an efficient multimodal classification can be achieved with a significant reduction in the number of feature dimensions by exploiting canonical correlation analysis on the extracted feature sets from iris and fingerprint modalities. We also demonstrate that subspace learning maximizes the correlation between Iris and Fingerprint modalities and excels the recognition performance of the individual modality.

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Contents

Even with the considerable advances in the recent years, the best unimodal biometric systems produces unacceptable error rates and often affected by noisy data, nonuniversality, intraclass variability, and spoof attack [1][2]. One of the possible solutions is the use of multiple unimodal biometric sources referred as multimodal systems [1][3], to make a more reliable recognition performance. Further, multimodal system improves population coverage, decreases the failure to enroll rate and improves the security aspect as well [1][3] but requires more computational and storage resources [3]. Still, their potential advantages make them suitable for implementing large-scale biometric recognition, for example, the proposed UID/Aadhaar biometrics system in India [4]. In multimodal system, information fusion can be done at four different levels [1][3]-sensor, feature extraction, matcher, and decision. The sensor level fusion can preserve the maximum information from each of the biometric modalities, it may no longer be very discriminatory because of noise. In score level fusion, the match score output from multiple individual classifiers or matchers are fused into a single scaler match score in order to take the final robust recognition decision. Most of the research is based on fusion at match score level and decision level [5][6]. In recent years, intelligent feature level fusion has drawn considerable attention due to its ability of information preservation as compared to score and decision level [1] and expected to provide better recognition performance.

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Figures

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Keywords ⌄

Metrics ⌄

Multimodal System Framework for Feature Level Fusion based on CCA with SVM Classifier

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***Abstract*—In the biometric recognition, feature fusion is a critical step, especially in case of heterogeneous and incompatible feature representation. Most of the existing methods cannot extract features that are discriminative and at the same time affine invariant, which limits the classification performance. To address this issue, we propose an efficient feature level fusion approach using canonical correlation analysis (CCA) with SVM classification. The feature level fusion approach integrates different features extracted from different modalities into a more discriminative and compact feature representation, which can be further used for classification. We also propose an efficient algorithm that optimizes the whole framework of the multimodal system. The CCA+PCA subspace learning approach is presented to couple dimensionality reduction and feature fusion collectively, which can be used for both unsupervised and supervised learning. The experimental results on the SDUMLA multimodal database show that the proposed approach significantly outperforms than the prevalent feature fusion approaches. We demonstrate that an efficient multimodal classification can be achieved with a significant reduction in the number of feature dimensions by exploiting canonical correlation analysis on the extracted feature sets from iris and fingerprint modalities. We also demonstrate that subspace learning maximizes the correlation between Iris and Fingerprint modalities and excels the recognition performance of the individual modality.**

***Index Terms*—Feature Fusion, Multimodal Biometric System, Iris and Fingerprint Biometric, Canonical Correlation Analysis, Support Vector Machine**

I. Introduction

Even with the considerable advances in the recent years, the best unimodal biometric systems produces unacceptable error rates and often affected by noisy data, nonuniversality, intraclass variability, and spoof attack [1] [2]. One of the possible solutions is the use of multiple unimodal biometric sources referred as multimodal systems [1] [3], to make a more reliable recognition performance. Further, multimodal system improves population coverage, decreases the failure to enroll rate and improves the security aspect as well [1] [3] but requires more computational and storage resources [3]. Still, their potential advantages make them suitable for implementing large-scale biometric recognition, for example, the proposed UID/Aadhaar biometrics system in India [4]. In multimodal system, information fusion can be done at four different levels [1] [3]- sensor, feature extraction, matcher, and decision. The sensor level fusion can preserve the maximum information from each of the biometric modalities, it may no longer be very discriminatory because of noise. In score level fusion, the match score output from multiple individual classifiers or matchers are fused into a single scaler match score in order to take the final robust recognition decision. Most of the research is based on fusion at match score level and decision level [5] [6]. In recent years, intelligent feature level fusion has drawn considerable attention due to its ability of information preservation as compared to score and decision level [1] and expected to provide better recognition performance.

In practice, it is critical to design feature fusion to combine multiple feature sets effectively for reliable and robust biometric recognition [1] [7]. A concatenation or integration or by performing weighted concatenation of different feature sets are the popular approaches. However, for incompatible feature sets, it becomes difficult to perform concatenation directly due to inherent variation in feature representations [8]. Despite easiness of these approaches, different features information are not equally measured and ignores the intrinsic relationship of the feature sets. So, we explored learning methods based on maximizing mutual information to preserve the powerful discriminant information within the features sets and removes the redundant information [9]. For this, we adopt Canonical Correlation Analysis(CCA) which deals with the mutual information between two sets of multidimensional random variables and maximize the correlations between them [10] [11] and is independent of the affine transformation.In this work, we propose CCA as an efficient tool to extract and represent discriminative features by exploring significant relationships between the heterogenous and incompatible feature sets of Iris and Fingerprint and then perform feature level fusion. Finally, the performance of the proposed system is evaluated by training the multiclass SVM classifier with a fused feature set. The proposed framework is simple and offered efficient fusion method which inherits both advantages of computational efficiency and fast learning speed.

II. Related Work

A. Multimodal Biometric Systems

Based on the fusion level, several fusion algorithms have been proposed and developed for the multimodal biometric

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