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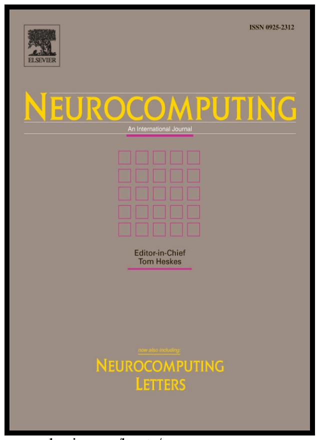

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Cognitive Facial Expression Recognition with Constrained Dimensionality Reduction

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Abstract
Facial expression recognition(FER) is an important research area in human-computer interaction. In this paper, a new dimensionality reduction method together with a new classifier are proposed for FER. The goals of most dimensionality reduction contains minimizing the within-class distances. However, the within-class distances for some expressions could be very large, so that to minimize these distances could largely influence the optimization function. To overcome this defect, a new dimensionality reduction method is proposed by adding a penalty item, which is the sum of within distances that are far from each other. Through maximizing this item, the distances among faces with the same expression that are far from each other cannot be minimized to too small. Besides, this method can partly characterize the density information from training samples. To make full use of density information, a new classification method is developed that is based on the enhanced cognitive gravity model. The conducted experiments validate the proposed approach in term of the performance of facial expression recognition. The approach presents the excellent performance over previously available techniques.
Index Terms—facial expression recognition, dimensionality reduction, cognitive gravity model, manifold learning.

1. Introduction

Affective state plays a fundamental role in human interactions, influencing cognition, perception and even rational decision making. This fact has inspired the research field of affective computing which aims at enabling computers to recognize, interpret and simulate affects [1]. Automatic recognition of facial expressions is an important component in human-machine interfaces, human emotion analysis, and other applications such as learning environment, entertainment, customer service, computer games, security/surveillance, educational software, and driver monitoring [7]. Recently, most of facial expression recognition methods are proposed. Generally, they contain three steps: feature extraction, dimensionality reduction, and classification.

Currently, there are a lot of dimensionality reduction methods available for facial expression recognition [2-16, 52,62]. These methods have some defects, such as, class labels not used [4,7,11,12,13,14], the across-classes relationships not considered [2,3,6,9,10,13], or the manifold structure not preserved [5,8,13,52,62]. As facial expression recognition is a classification problem, the within class relationships, the across-classes relationships, and the class labels are all very important. Furthermore, it is investigated that the faces are often distributed on manifold[66]. Manifold learning should be applied to find the face manifold embedded in high dimensional space. To consider these problems together, some dimensionality reduction algorithms are proposed [17-21]. Among them, the semi-supervised long-term relevance feedback (RF) algorithm is much powerful [21], which can present the excellent representation for multimedia data. RF obtains the transformation matrix by maximizing the across-classes distances, minimizing the within-class distances and preserving the multimedia data distribution in low dimensional space.

However, RF cannot be directly used for facial expression recognition, as the extracted features by RF contain both face recognition information and facial expression recognition information. This makes that the distances among faces of different people with the same expression could be very large. Minimizing these distances could largely influence the overall optimization objective for facial expression recognition. To overcome the above disadvantage, this paper proposes a new dimensionality reduction method named enhanced relevance feedback(ERF), which is developed from RF. In the optimization objective of ERF, a penalty item is added to reduce the negative impact, which is the sum of within distances that are far from each other. Besides, ERF can extract some density information from training samples, as the larger the within-class distances among faces that are far from each other, the larger penalty effect of the item, where the density information is benefit for classification.

Recently, two methods can utilize the density information [22,23], which is ignored by many traditional classifiers used in facial expression recognition, such as support vector machine (SVM) [3,4,45], sparse representation classification (SRC) [46, 55] and *K*-nearest neighbors (KNN) [9,47]. Given a sample with the same distances from two classes, Lizhi Peng et. al. consider that a sample should be more likely classified to the class with larger density [23], whereas Guihua Wen et. al. consider that a sample should be more likely classified to the class with smaller density and then propose the cognitive gravity model (CGM) [22]. CGM is more consistent with human perceptions. However, the mass of a sample in CGM is estimated by self-information, which not only varies with the density of this sample, but also varies with the number of training samples. To overcome this disadvantage, we propose an enhanced cognitive gravity model (ECGM), which can utilize the density information better, as it designs a new algorithm to estimate the mass for the cognitive gravity model, which varies nearly only with the density.

Based on ERF and ECGM, a new hybrid approach is further presented, named as cognitive facial expression recognition (CFER). The main contributions are concluded as follow.

(1) A new dimensionality reduction algorithm named ERF is proposed, which inherits the advantages of RF, overcomes the