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Face Recognition Performance Improvement Using Derivative of Accumulated Absolute Difference Based on Probabilistic Histogram

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Abstract

In the paper we propose a face verifying algorithm for face recognition that can identify two face mismatch pairs in cases of incorrect decisions. The computational approach taken in this system is performed by the derivative of accumulated absolute difference between two faces unseen before. Unlike the traditional multi-dimensional distance measurement, the proposed algorithm also considers an increasing trend of accumulated absolute difference in respect to the Gaussian components. A Gaussian mixture model of bag-of-feature from training faces is also widely applicable to several biometric systems. Evaluation of the proposed algorithm is done on unconstrained environments using Labeled Face in the Wild (LFW) datasets. Experiments show that the proposed algorithm outperforms all conventional face recognition algorithms with advantage of about 4.92% over direct-bag-of-features and 18.05% over principal component analysis-based and is also appropriate for identification task of the face recognition systems. Furthermore, some particular advantages of our approach are that it can be applied to other verification systems.

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Keywords: Gaussian Mixture Model; Expectation Maximisation Algorithm; Accumulated Absolute Difference; Probabilistic Histogram.

1. Introduction

Face recognition[1] is the one of most successful biometric identification methods among several types of biometric information such as fingerprint, signature, palm veins, retina, hand geometry, and *etc*. Computers that recognise faces could be applied to wide rarity of problems including criminal identification, security systems, still image,

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video processing, and human-computer reaction. There are two main procedures that have been proposed for face verification problem, one is based on holistic information[2] and another one is feature geometry model-based which employs local features according to geometrical texture[3]. One issue in the real world face recognition that is still unsolved is the face recognition from uncontrolled condition. Unfortunately, pose mismatched problem is quite difficult[4], because local feature information is changed from normal feature vector components. Thus to address these issues, not only distance of two faces to be considered, but also the differences between each of probabilistic information at any Gaussian component are determined. We therefore focus our research toward developing a face verifying algorithm to determine and correct an incorrect decision in case of matched test. In this paper, we therefore emphasise our research on the pose mismatched problem by reconsidering of two face verification with the differentiated accumulated absolute difference trend graph. The approach describes a recognition system for still-still face verification base from the probabilistic based multi-region histogram (MRH)[5] and has advantages over other face recognition algorithms in accuracy.

2. Face verification system

The face recognition system consists of detection (Haar Feature-based Cascade Classifier), face feature extraction, model parameters estimation, and face signature verification[2]. Each individual face can be extracted from block (or patch) via the 2D-DCT (two-dimensional discrete cosine transform)[6]. Each block consists of 8x8 (64 elements) subsquares with 75% overlap the neighbouring blocks (7 pixels). Based on preliminary experiments, using the 15 DCT coefficients at the top left of 8x8 coefficient matrix is sufficient[7]. The *M*-dimensional Gaussian distribution takes the form[7]

$$N\left(\mathbf{x}|\boldsymbol{\mu},\boldsymbol{\Sigma}\right)=\frac{1}{(2\pi)^{M/2}\left|\boldsymbol{\Sigma}\right|^{1/2}}\exp\left\{-\frac{1}{2}\left(\mathbf{x}-\boldsymbol{\mu}\right)^{T}\cdot\boldsymbol{\Sigma}^{-1}\cdot\left(\mathbf{x}-\boldsymbol{\mu}\right)\right\} \tag{1}$$

where $\boldsymbol{\mu}_k$ is the *M*-dimensional mean vector, $\boldsymbol{\Sigma}_k$ is the $M\times M$ covariance matrix, and $\mathbf{x}$ denotes the random vector from DCT coefficients. Once the descriptive feature vector for a given face *A* is obtained by

$$\boldsymbol{h}_A=\left[\sum_{n=1}^{N}P_1N_1(\mathbf{x}_n\,|\,\boldsymbol{\mu}_1,\boldsymbol{\Sigma}_1),\sum_{n=1}^{N}P_2N_2(\mathbf{x}_n\,|\,\boldsymbol{\mu}_2,\boldsymbol{\Sigma}_2),...,\sum_{n=1}^{N}P_kN_k(\mathbf{x}_n\,|\,\boldsymbol{\mu}_k,\boldsymbol{\Sigma}_k)\right]^{T} \tag{2}$$

where P_k in $\boldsymbol{h}_A$ is the *k*-th population fraction for Gaussian model, and *k*-th element is the posterior probability of vector $\mathbf{x}_n$ according to the Gaussian model of a bag-of-feature[7]. The bag-of-feature is the Gaussian mixture model (GMM) which obtained by extracting descriptive features form Yale database, followed by employing the Expectation Maximisation (EM) algorithm to optimise the GMM parameters.

3. The proposed face signature comparison using accumulated absolute difference

The face images corresponding to the feature vectors are then investigated for similarity by the L_1- norm based distance of each image to the other face images and compared to a predefined threshold. The drawback of this method is the incompetence to identify a contrast in each of Gaussian component. We discover that when we plot element values of the accumulated absolute difference vector $d_{accumulated}=\left[d(1),\ldots,d(j),\ldots,d(k)\right]^{T}$, where $d(j)$ is defined by

$$d(j)=\sum_{i=1}^{j}\left|\boldsymbol{h}_A^{[i]}-\boldsymbol{h}_B^{[i]}\right| \tag{3}$$

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