Face Recognition Based on Genetic Algorithms For Feature Correlation

Luigi Rosa
L.S. "Ettore Majorana", Via Frattini 11 10137, Turin, ITALY
Mobile +39 3207214179
Email luigi.rosa@tiscali.it
Web Site http://www.advancedsourcecode.com

Abstract

The correlation filters have been extensively studied in the field of face recognition. Correlation filters can be used directly on image pixels but also on proper feature spaces. We propose an effective algorithm for feature extraction using a genetic algorithm (GA). The algorithm generates a population of genomes that represents the 2D filter coefficient where new genomes are generated by crossover, mutation operations methods. GA feature correlation filters can achieve better improvements compared with standard filtering techniques.

1. Introduction

Human face recognition is currently a very active research area with focus on ways to perform robust and reliable biometric identification. Face recognition, the art of matching a given face to a database of known faces, is a non-intrusive biometric method that dates back to the 1960s. In efforts going back to far earlier times, people have tried to understand which facial features help us perform recognition tasks, such as identifying a person, deciding on an individual's age and gender, and classifying facial expression and even beauty. A recognition system has to be invariant both to external changes, like environmental light, partial occlusions and the person's position and distance from the camera, and internal deformations, like facial expression and aging. Because most commercial applications use large databases of faces, recognition systems have to be computationally efficient.

2. Existing algorithms

Most face recognition algorithms fall into one of two main groups: model-based methods which employ shape and texture of the face, along with 3D depth information and appearance-based methods which use holistic texture features. Feature-based methods explore a set of geometric features, such as the distance between the eyes or the size of the eyes, and use these measures to represent the given face. These features are computed using simple correlation filters with expected templates. These methods can partially or totally compensate for changes in camera location and are somewhat invariant to changes in illumination. Many algorithms have been developed to focus on the different conditions: occlusion, expression, illumination, aging, pose etc. Among the proposed approaches, Minimum Average Correlation Energy (MACE) filter is one the most popular algorithm for its high discrimination performance, making it ideal for such verification application. MACE filters [1-6] can operate directly on the raw image pixel data but also on different feature spaces. Feature Correlation Filters combine the feature representations of faces and the advantages of the correlation method. The concept of correlation filter is so extended to the feature space.

2.1. MACE Filter

MACE filter is designed to minimize the average correlation energy (ACE) of the correlation outputs due to the training images while simultaneously satisfying the correlation peak constraints at the origin. The effect of minimizing the ACE is that the resulting correlation planes would yield values close to zero everywhere except at the location of a trained object, where it would produce a strong peak.

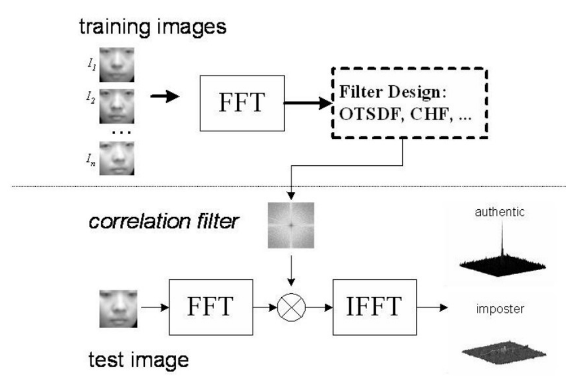

Fig.1 Correlation filter design

Resulting MACE filter is as follows in a vector form:

$$h_{MACE} = D^{-1} X \left(X^{+} D^{-1} X \right)^{-1} c \qquad (1)$$

Suppose that we have N training images from the true class with each image having d pixels in it. We perform two dimensional (2-D) FFTs on these images and convert the 2-D FFT arrays into one dimensional (1-D) column vectors by lexicographic ordering. These vectors are the column vectors of the $d \times N$ matrix X in Eq. (1). Column vector c with N elements contains the prespecified correlation peak values of the training images and the $d \times d$ diagonal matrix D contains along its diagonal the average power spectrum of the training images (i.e., average of the magnitude squares of the columns of X). Note that the synthesized h_{MACE} is a column vector with d elements and the 2-D correlation filter is obtained by reordering the column vector back to a 2-D array. The $+$ symbol represents the complex conjugate transpose.

2.2. MACE in Feature Space

In feature space [7] all linear features can be expressed as follows:

$$y_i = v^{+} x_i \qquad (2)$$

where $v = \left[v_1 v_2 \ldots v_M \right]$ is a $d \times M$ feature extraction matrix, x_i is 2-dimensional image considered as a $d \times 1$ column vector (d is the number of pixels), y_i is the feature vector of length M. M depends on what feature to use. As shown in [7] Feature Correlation Filter and MACE Filter share the same formulation. In this way it is possible to incorporate the feature representations of faces into correlation filters.

3. Proposed approach

Let assume that facial image is a $P \times Q$ matrix, with such assumption the number of pixels is $d = P \cdot Q$. We compute the two-dimensional convolution of input image and a 2D filter that consists of a $R \times S$ kernel matrix:

$$I_f[m,n] = \sum_{j=-\infty}^{j=+\infty} \sum_{i=-\infty}^{i=+\infty} I[i,j] \cdot F[m-i, n-j] \qquad (3)$$

where $I[i,j]$ is pixel value of input image at location $[i,j]$, with $1 \le i \le P$ and $1 \le j \le Q$, F is filter and I_f is filtered image.

The coefficients of filter F have been found using a genetic algorithm [9-10]. The objective function that has been minimized by GA is Equal Error Rate (EER) of overall face identification system. By considering a 2D convolution MACE algorithm continues to be translation invariant if compared to other filter extraction schemes [8]. For large kernel sizes the filtering can become computationally expensive: convolution can be made more efficiently in frequency domain.

4. Results

The performances of the proposed algorithm are evaluated using Facial Expression Database collected at the Advanced Multimedia Processing Lab at Carnegie Mellon University (CMU) [11]. Database consists of 13 subjects, each with 75 images. The size of each image is 64×64 pixels, with 256 grey levels per pixel. Using standard MACE filter we have obtained an EER equal to 8.25%. A 5×5 filter has been designed using genetic algorithms. With GA Feature Correlation we have achieved an EER equal to 3.70%.

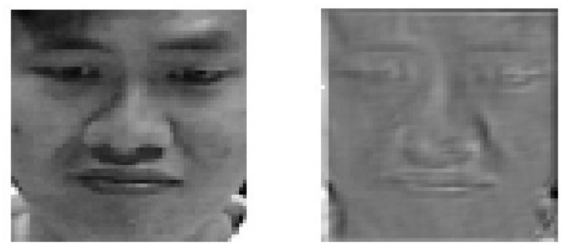

Fig.2 Input image and filtered image using designed filter

Designed 2-D filter is able to correlate producing a high response with images of the same class and a low response with images of different classes.

5. Conclusions

For to do Filter Design and coefficient optimization, we have used the genetic algorithm as efficient and powerful tool. When genetic algorithm designing new 2-D filters, it directly optimizes the coefficients by creating finite impulse response filters with automatic, rapid and less computational complexity by an efficient Genetic approach. Future research on this topic involves investigating the impact of filter kernel size on EER and a possible nonlinear extension.

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