Secure high-precision face recognition based on immune computation

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Abstract. A secure and effective design for high-precision face recognition is presented. The disturbances of facial pose, illumination, and expression (PIE) are overcome to recognize the faces more accurately for security, with the improved clonal selection algorithm and enough diverse samples. Then, the most similar sample for the unknown face image is searched with the improved clonal selection algorithm, and the matching between the unknown one and the most similar sample allows some movement differences in an acceptable range. The novel immunity-based face recognition are compared with some state-of-the-art algorithms, and the experimental results on the ORL face database show that the proposed approach outperforms the other algorithms.

Keywords: Face recognition; high-precision; security; PIE; immunity.

1 Introduction

The high-precision face recognition is of high recognition rate of faces, and this is important for many applications of security, management and service. To increase the recognition rate, face recognition algorithms have to minimize the disturbances of facial pose, illumination, and expression (PIE) \cite{1}. He et al. proposed a Laplacianface method of locality preserving projection (LPP) to preserve the local structure of training samples \cite{2}. This approach was improved by Cai et al. with an orthogonal locality preserving projection (OLPP) to use more local information \cite{3}. Jiang et al. proposed a method to enhance maximum likelihood face recognition \cite{4}. In this paper, a novel high-precision face recognition approach is proposed with an improved clonal selection algorithm of immune computation. It filters some disturbances of PIE and hence boosts the high accuracy of the face recognition approach.
2 Face Recognition Model Based on Immunity

The face recognition model based on immunity is proposed and comprised of feature acquiring of the target face images, similarity searching in the feature space $R^d$ of known face images, and classification of the target face images. Consider $N$ $d$-dimensional samples $x_1, x_2, \ldots, x_N$, which constitute $N_C$ classes of faces. Let $x_i^j$ denote a sample in the feature space $R^d$ representing the $j$th sample in the $i$th class of size $N_i$. The known samples $x_1, x_2, \ldots, x_N$ are used to train the face recognition model based on immunity, and this model is built on the strategy for searching the most similar sample of the unknown objects $\omega_o, \alpha = 1, 2, \ldots, N_o$ in the feature space $R^d$ of the samples. The antigens $A_{g,o}, \alpha = 1, 2, \ldots, N_o$ and the antibodies $A_{b,m}, m = 1, 2, \ldots, N$ are the two repertories of face image matrixes in the improved clonal selection algorithm.

$$N = \sum_{i=1}^{N_C} N_i$$

In the pattern recognition cases of traditional clonal selection algorithms, the affinity measure was calculated with the Hamming distance between the antigen $A_{g,o}$ and an antibody $A_{b,m}$ [5]. Because the binary coding of the face images causes the loss of some image pixel data, the affinity measure is improved and calculated below.

$$M_m = \sum_{k=1}^{Ltp} (\delta_{mk} + \rho_{mk}),$$

where $Ltp = Mtp \times Ntp$, $\delta_{mk} = \begin{cases} u, & \text{if } A_{b,m} \pm \varepsilon \in A_{g,o}, 1 \leq \omega \leq Ltp, u + v = 1. \\
0, & \text{otherwise} \end{cases}$

3 Experimental Results

Some experiments were conducted to test the effectiveness in Table 1, and the benchmark ORL face database was used [6]. The ORL face data set is comprised of 400 images of size 92 by 112 and 40 individuals (10 images per person), with different PIE. All testing samples are matched with the training samples using some matching rules, and the sums of the training samples are respectively 4 and 5.

<table>
<thead>
<tr>
<th>Rate type</th>
<th>The highest recognition rates</th>
<th>Average recognition rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trains</td>
<td>4 Trains</td>
<td>5 Trains</td>
</tr>
<tr>
<td>PCA+LPPFace</td>
<td>91.25(41)</td>
<td>97.00(51)</td>
</tr>
<tr>
<td>PCA+OLPPFace</td>
<td>94.17(37)</td>
<td>97.00(22)</td>
</tr>
<tr>
<td>PCA+ONPDA</td>
<td>91.92(61)</td>
<td>95.25(27)</td>
</tr>
<tr>
<td>PCA+MFA</td>
<td>89.16(69)</td>
<td>95.00(69)</td>
</tr>
<tr>
<td>PCA+NFLE F1</td>
<td>94.17(41)</td>
<td>95.00(22)</td>
</tr>
</tbody>
</table>
The highest recognition rates of various training samples in the ORL face database for the comparing algorithms are listed in Table 1, and the standard derivations for these data sets are also compared in Table 1 to analyze the robustness of the proposed method. Therefore, the performance of the novel face recognition approach is better than those of the other algorithms.

4 Conclusion

The improved clonal selection frame of immune computation and the diverse samples are useful for recognize the face images with high recognition rates. The face recognition model based on the immunity can maximize the effectiveness of the feature search of the most similar samples to the target face images, and the affinity measure should be improved for matching the face feature with small differences due to the disturbances of PIE. The diversity and typicality are important to keep the high recognition rates, because the face recognition is sensitive to the unknown features of the face images. The high accuracy of the proposed approach is substantiated by the experiments on the ORL face database.

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References