انجمن ریاضی ایران
Iranian Mathematicsl Society
چهلمین کنفرانس ریاضی کشور
40TH ANNUAL IRANIAN MATHEMATICS CONFERENCE
Accepted for presentation
Available at http://aimc40.ir/node/593
دانشگاه صنعتی شریف
Sharif University of Technology

Optimization of Face Recognition Algorithms Using Wavelet Transforms

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Abstract

In this paper, wavelet transforms are applied in image fusion to optimize face recognition algorithms. Firstly, the implementation of multimodal analysis in image fusion based on the wavelet decomposition is presented. Then, the methods of merging the wavelet coefficients of single modes and obtaining the wavelet coefficients of multi-mode image are posed. Finally, practical results of some experiments performed on two image databases are given. The results verify accuracy and efficiency of the proposed method. The advantage of this method is to merge the wavelet coefficients of the single modes in the feature extraction stage. It causes the face recognition algorithms to be more accurate and efficient.

1 Introduction

Image fusion using the multimodal analysis is to mix and combine the information obtained of multiple images with this assumption that the images have the same scene. The outcome of the image fusion is a new image that is more suitable for human or machine vision or other purposes such as segmentation, feature extraction and object recognition. The multimodal analysis in the image fusion can be applied in many fields, for example; remote sensing, medical imaging, machine vision and face recognition [Brunel–Yocky].

It is possible that some images of one scene have different information while have the same scene. For example, assume that the images are taken by different sensors [Pohl]. If these different kinds of information be merged to obtain a new and optimized image, then we have a synthetic image and the used concept is called *image fusion based on multimodal analysis*.

For the image fusion, this paper presents a method based on the wavelet decomposition, i.e. a multiresolution approach. This method will be described in the next section. Finally, practical results of some experiments performed on two image databases are given.

2 Image fusion based on the wavelet decomposition

The wavelet decomposition is an effective and powerful method to implement the multimodal analysis in the image fusion. This method includes three steps as follows:

1. Applying the wavelet transform to decompose each of the single modes and obtaining the wavelet coefficients.

2. Using an appropriate algorithm for merging the wavelet coefficients of the single modes and obtaining one mode.

3. Applying the inverse wavelet transform to the wavelet coefficients calculated in the previous step and finally obtaining the synthetic image.

The important step in the image fusion algorithm based on the wavelet decomposition is to merge the coefficients, i.e. selecting an appropriate method for merging. The most common methods for merging the wavelet coefficients are *averaging method*, *selecting maximum value* and *selecting minimum value* [Matlab7, Pajares]. In the averaging method, the mean value of the wavelet coefficients of different modes at each point is considered as the wavelet coefficient of the final mode at that point. In the selecting maximum (minimum) method, the maximum (minimum) value of the coefficients at each point is selected as the wavelet coefficient of the final mode. For example, in the selecting maximum method:

$$\begin{aligned} A^k(r,c) &= max\{|A_1^k(r,c)|, |A_2^k(r,c)|, ..., |A_n^k(r,c)|\} \\ D^k(r,c) &= max\{|D_1^k(r,c)|, |D_2^k(r,c)|, ..., |D_n^k(r,c)|\} \end{aligned} \quad (1)$$

in which,

A_i^k: the approximation coefficients of the ith single mode at kth level of the wavelet decomposition;

D_i^k: the Details coefficients of the ith single mode at kth level of the wavelet decomposition;

index $j = 1, 2, ..., k$: level of the wavelet decomposition;

(r, c): a generic point in the wavelet coefficients.

3 Experiments and results

The method proposed in this article uses discrete wavelet transform to decompose the multiple images and then merge the wavelet coefficients of the images and finally obtain the coefficients of the final image. This method merges the single modes coefficients in the feature extraction stage. For this purpose, the multimodal analysis is used to merge the feature vectors (obtained

Table 1: Recognition rates of the single-mode cases (ORL database)

Wavelet Name	FRR	FAR	Recognition Rate
Haar	10.3 %	12.1 %	77.6 %
Db1	9.2 %	9.7 %	81.1 %
Bior 1.1	7.9 %	12.3 %	79.8 %

Table 2: The recognition rates of the three-modes case (ORL database)

Merge and Combine Method	FRR	FAR	Recognition Rate
Average value	3.6 %	3.1 %	93.3%
Max	2.7 %	3.5%	93.8 %
Min	2.6 %	2.2 %	95.2 %

of the wavelet coefficients of the single modes) and to obtain the synthetic feature vector (of the final mode). Finally, these synthetic feature vectors are used in the recognition algorithm. It causes the feature vectors and subsequently the face recognition algorithm to be more accurate and efficient.

We have obtained the single modes from the wavelet decomposition of the face image using different wavelet transforms. For any face image, three single modes are considered which are obtained of applying the "Haar", "Daubechies" and "Biorthogonal" wavelet transforms to that image. Then, each of the three methods mentioned above is used to merge the coefficients of the single modes and make the multimode image coefficients.

In the performed experiments, the single mode cases have been compared with the multimode case from the viewpoint of the results accuracy. Two face image databases have been used in the experiments, *ORL* and *Yalefaces*.

3.1 Experiments performed on ORL database

The first series of experiments has been performed using the ORL face images.

i. Single-mode case

In this case, the experiments have been performed on the single modes generated using the *Haar*, *Daubechies* and *Biorthogonal* wavelet transforms. Table 1 gives the results. Note that FRR indicates the *False Rejection Rate* and FAR stands for the *False Acceptance Rate*.

ii. Three-modes case

Three modes have been used in this case. These modes have been generated using the Haar, Daubechies and Biorthogonal wavelet transforms, respectively. These are single modes and should be merged together and make the multimode image. The three methods averaging, selecting maximum value and selecting minimum value have been applied for the fusion. The results after merging are given in Table 2.

Table 3: Recognition rates of the single-mode cases (Yalefaces database)

Wavelet Name	FRR	FAR	Recognition Rate
Haar	10.2 %	11.1 %	78.7 %
Db1	9.6 %	8.4 %	83.2 %
Bior 1.1	8.1 %	10.7 %	81.2 %

Table 4: The recognition rates of the three-modes case (Yalefaces database)

Merge and Combine Method	FRR	FAR	Recognition Rate
Average value	2.5 %	2.7 %	94.8%
Max	1.9 %	2.6%	95.5 %
Min	1.3 %	1.8 %	96.9 %

3.2 Experiments performed on Yalefaces database

The second series of experiments has been performed using the Yalefaces face images.

i. Single-mode case
The experiments of this case are performed like 3.1.i. Table 3 shows the results.

ii. Three-modes case
This case and 3.1.ii are alike. The results are given in Table 4.

4 Conclusion

As the numerical results showed, the presented method optimizes face recognition algorithms and improves their recognition rates. The advantage of this method in comparison with other multimodal methods is to merge the single modes coefficients in the feature extraction stage. It causes the face recognition algorithms to be more accurate and efficient. In addition, the results showed that using the method of selecting minimum value for merging the coefficients results in more accuracy in comparison with the two other methods. Also, there is a small difference between the results obtained using the ORL and Yalefaces databases which is due to the difference between the resolutions of the images of these two databases.

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