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ROBUST CLASSIFICATION OF FACE IMAGE BASED ON SURFACE INFORMATION FOR TWO DATE-SETS ANALYSIS

Arash Kalami, Tohid Sedghi
Department of Electrical Engineering, Urmia Branch, Islamic Azad University, Urmia, Iran
Ar.kalami@gmail.com, Sedghi.tohid@gmail.com

ABSTRACT

The evaluation of the proposed algorithm was performed on standard data, the FRAV3D FERET datasets. Feature-selection was used as a preliminary step for a learning algorithm. The learning algorithm we used, was a simple nearest-neighbor on the selected features. We experimented with the following features: pixel values, the Viola and Jones integral images, Fourier, DCT, and Walsh Transform coefficients. The FRAV3D dataset consists of images of 20 objects. Each object has 72 images taken from different poses and there is a 5 degree pose difference between consecutive images of each object. The size of each image is 128 × 128. We evaluated the experiment using the classic 10-fold cross-validation technique. The Experimental results guarantee robustness of our proposed method.

I. INTRODUCTION

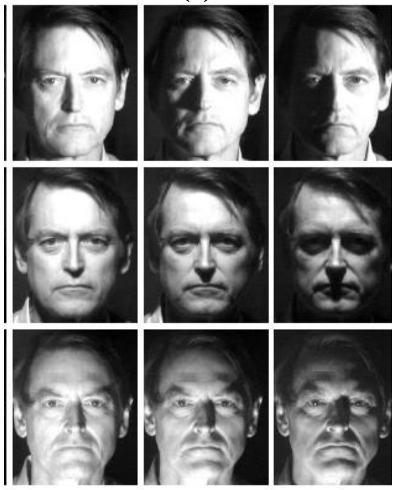
Face-detection is an important research topic in computer vision. The performance of many computer vision systems relies heavily on face-detection. For example, content based image-retrieval systems sometimes attempt to detect particular faces in images [1-3] currently developed face recognition and surveillance systems require the ability to detect faces [1-7], auto navigation systems need to detect obstacles and landmarks etc. Face-detection is a challenging problem due to the large variety of faces, illumination, pose, and the high dimensionality of the image data. The research described here is aimed at developing new and improved methods for face-detection. We are especially interested in methods that can lead to real time implementations. Our research improves upon several classic face and object-detection methods. These include the classic template-matching technique [1-2], feature-selection techniques [2-3], and the recently developed Ada-Boosting technique [7]. Integral-Images based template-matching by normalized correlations is a simple and commonly used approach to face-detection. For an image of size n and a template of size k, template matching by normalized correlations requires order of kn operations. Using fast convolution method, it is possible to compute matching values in order of n log n operations [2]. This is a big improvement when k is large, but it may not be enough since it involves a large constant, and still grows nonlinearly in n. The non-linearity is considered a problem for real time applications. We have developed a linear run time template-matching method based on the integral images idea introduced by Viola and Jones in [7]. Fast template-matching is performed using a localized polynomial approximation of images. All local polynomial approximations are derived from integral images and can be computed in just one pass over the image. A common approach to face-detection by template-matching is to compute matching values at every possible location in the image and at many different scales. We have developed a selective matching method that enables us to compute matching values only at a few locations. Our method is based on the idea that a match is detected as a local maximum of the matching criterion. Therefore: One needs only consider locations with matching values greater than matching values of their neighbors. Using this idea, the search for good matches can be formulated as an optimization problem, and likely matches can be identified using a hill climbing search method. Applying this idea, the detection run time can be significantly improved since one needs only compute a small fraction of the matching values.

II. METHOD AND MATERIALS

2.1 Selection of pixels as features

We first describe results of testing the performance of the proposed feature-selection method using pixel values as features. In our formulation this is equivalent to choosing the matrix W as the identity matrix. The first step in the algorithm is the computation of the approximate SVD factorization of the matrix consisting of the training images. We retained only k = 50 principal. In Figure 1 some sample images of two datasets which have been studied is shown.

(a)



(b)

Figure 1 Sample images from two different database (a) FRAV3D (b) FERET

The location of each selected pixel is shown as a white cross. The right picture combines the results of all 30 experiments. The location of each selected pixel is shown as a red dot on figure 2. The locations of the selected feature are clearly clustered. Components for the SVD approximation, using eigenvectors corresponding to the largest 50 singular values. The matrices $\tilde{U}$ and $\tilde{\Sigma}$ were computed and retained. The selection of pixels as features was performed according to the Ada-boost algorithm. We observe that in this case we have $\tilde{H} = \tilde{U}$. Three runs of 10-fold cross validation, a total of 30 training/testing experiments were performed. The results are shown in Figures 3. The recognition accuracy (in percentage) is plotted as a function of the number of selected pixels. The locations of the face selected by the algorithm in a typical run and Transformed of the sample images selected by our algorithm for FERET in Figure 4. The right picture shows the locations of the 20 pixels selected in all 30 experiments. In both cases the locations are plotted on top of the average image of the FRAV3D FERET datasets. The plot of the results obtained from all 30 experiments shows that different runs of the algorithm choose similar pixel locations. The recognition rate grows very rapidly with the increase in the number of pixels. An accuracy of more than 95% is achieved with less than 20 pixels selected from each image, and recognition rate of 99% is achieved with less than 50 pixels. It is interesting to compare these results to the results reported in [5]. In [3] report recognition rate of about 100% using 6-8 principal components. While this number is significantly smaller than the 50 pixels that we need in order to obtain similar accuracy, their features require access to all pixels. In order to compute the projections on the principal components. Thus, the performance of nearest neighbors with 50 pixels should enable much faster run time, when combined with efficient nearest neighbor routines such as those described in [2].

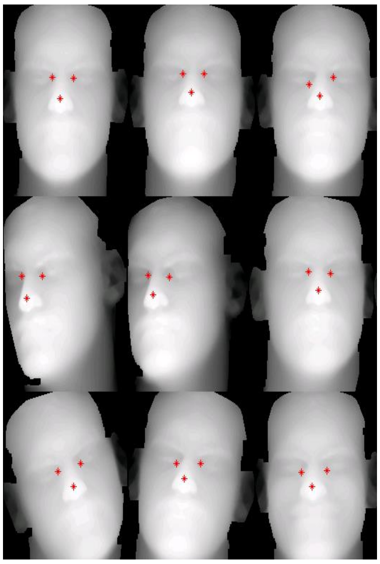


Figure 2. The location of each selected pixel is shown as a red dot on figure 2 for image set FRAV3D

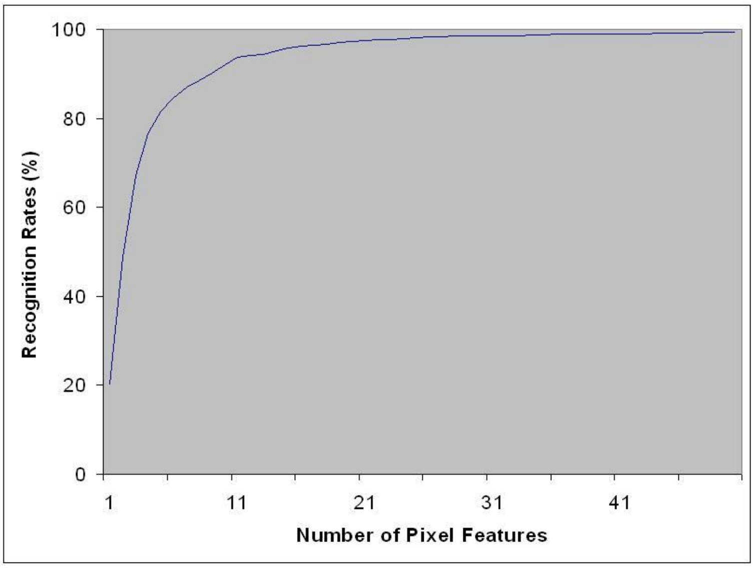


Figure 3. Recognition rate plotted as a function of the number of pixel features.

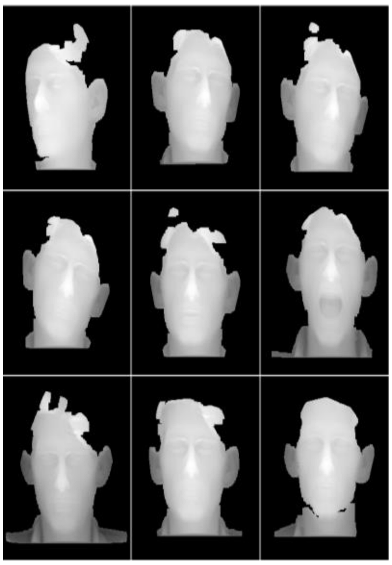


Figure 4. The locations of the face selected by the algorithm in a typical run and Transformed of the sample images selected by our algorithm for FERET

III. RESULT AND DISCUSSION

3.1 Comparison to the GKS algorithm

A comparison of results obtained by our algorithm to the results obtained by the standard GKS, as, is shown in Figure 5. Both algorithms were applied to pixel selection. The performance appears to be very similar. The darker plot shows the performance of our algorithm, while the lighter plot shows the performance of the GKS.

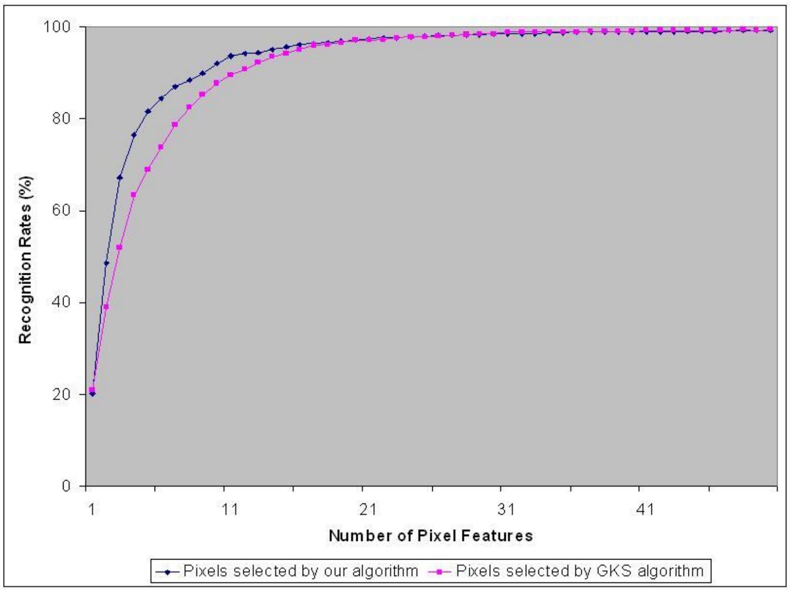


Figure 5. Comparing recognition rate of our algorithm and the GKS algorithm. Recognition rates are plotted as a function of the number of pixel features.

3.2 Selection of integral images as features

Integral images were used by [7] for designing a very fast face detection system. The integral image at location (x,y) is defined as the sum of the pixels above and to the left of (x,y). The location of each selected integral image is shown as a white cross. The location of each selected pixel is shown as a white dot. The locations of the selected feature are clearly clustered. It is shown in [7] that all integral images can be computed in linear time in one pass over the original image. As in the previous section the reported experiments are the results of 3 runs of 10- fold cross-validation, a total of 30 training/testing experiments. As expected, many of the integral images are selected on the right and bottom of the image. These correspond to averages over larger rectangles than the integral images at the top left. To evaluate the effectiveness of the selected features we used the nearest neighbor algorithm applied to the selected integral-image values. Figure 6 shows a plot of the recognition performance as a function of the number of selected features.

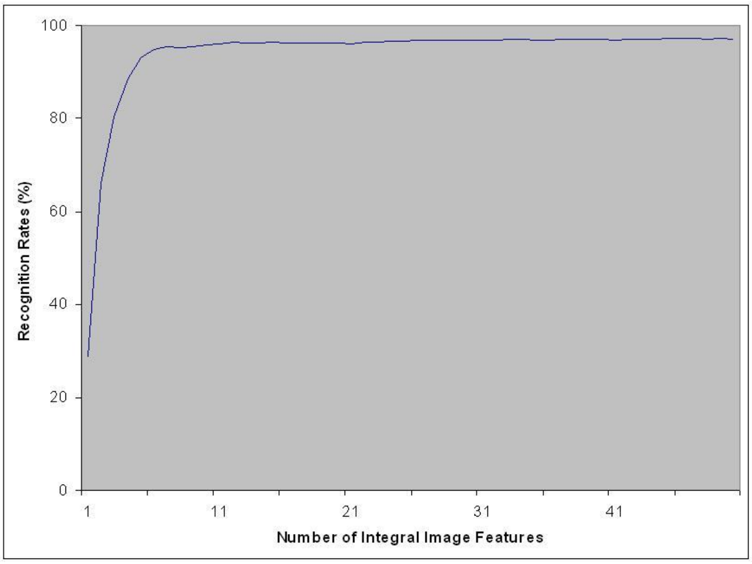


Figure 6. Recognition rate plotted as a function of the number of integral image features.

3.3 Selection of common transform coefficients as features

This section describes experimental results of selecting features among coefficients of the following transforms: Fourier Transform, Discrete Cosine Transform and the Walsh Transform. These are commonly used linear transforms in image and signal processing. As in the previous sections the reported experiments are the result of 3 runs of 10-fold cross-validation, a total of 30 training/testing experiments. The effectiveness of the selected features are evaluated using the nearest neighbor algorithm applied on the selected transform coefficients. The Fourier coefficients are complex. We tested several features that can be computed from Fourier coefficients. These include Spectrum, Phase, Real component, and the Imaginary component. Observe that the spectrum and phase are both nonlinear as a function of pixel values. The results obtained for the Fourier spectrum values are very good, even though it were very bad. In fact, choosing phase value at locations that were selected in the Fourier spectrum experiment produce significantly better results than letting the algorithm choose the best phase values. This indicated a failure of the algorithm when applied recognition as a function of the number of selected Spectrum coefficients.

IV. CONCLUSION

An algorithm for fast feature-selection from image data was proposed. The key idea is to apply the classic QR factorization with column pivoting to the data after a preliminary dimensionality reduction step. The derivation is correct only for linear features, but the algorithm can also be applied as a heuristic to obtain selection of nonlinear features. We describe experimental results which show that this heuristic sometimes works. The proposed algorithm determines the selection of features using training data. It speeds up not only the computation of the QR factorization step but also the computation of the features themselves. This is the result of the fact that one can swap the order of computing the eigenvector decomposition and computing features from the images. Thus, it is enough to compute features from the eigenvectors, saving the expensive step of computing all the features from all the training data.

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AUTHORS

Arash Kalami received the B.S degree in Electronic engineering from Urmia University, Iran. He received M.S degree in electrical engineering in Razi University, Kermanshah, Iran. His research interests include Steg analysis and watermarking. He has published more than twelve papers in his referred international journal and more than 10 papers in national/international conferences, he is now working as University Professor at department of Electrical Engineering, Urmia Branch, Islamic Azad University.

Tohid Sedghi received the B.S degree in Electronic engineering from IAU, Uurmia Branch, Urmia, Iran, in 2007. He received M.S degree in electrical engineering in University of Urmia, Iran in 2009. Now he is working toward Phd, His research interests include Localized, regional Content Based Image Retrieval and intelligent computing and Steg-Analysis.