

A Novel Approach Based on CVQ Technique for Face Recognition

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Abstract—Face recognition has been widely used to identify faces according to the patterns of mouth, lip, eyes and so on. Existing face recognition techniques provide a reasonable accuracy. However, their effectiveness significantly degrades in presence of uncontrolled conditions such as variations of background light and image sizes. To deal with this problem, we propose a novel approach based on Classified Vector Quantization (CVQ) technique for face recognition. The new approach divides images into some blocks and each block is classified into several patterns. The Vector Quantization technique (VQ) is applied on the vectors of each pattern. A major benefit of this technique is to consider the geometric structure of face and skin correlations which provide recognition based on changes on human's age. In order to evaluate our approach, experiments on some standard image databases have been conducted. The results demonstrate the high recognition rate and accuracy of our technique.

Index Terms—Face recognition, vector quantization (VQ), classified vector quantization (CVQ)

I. INTRODUCTION

Although many studies have been done in the context of pattern recognition, especially face recognition, there are free rooms to improve the performance of these methods significantly. The most important reason that face recognition has become a popular area of research is due to its wide range of commercial and law enforcement applications, such as biometric authentication, video surveillance and information security [1]. According to this urgency, automatic recognition of people can be achieved based on physiological and characteristic behaviors, such as finger print, iris [2] -[4], ear [5] or vein face and so on [6].

Nowadays, by increasing in violence and crime rate, security and safety applications of systems are of great importance. According to this requirement, face recognition of convicts can be considered as the main purpose in implementation of these systems. In addition, since the events of September 11, the process of development and implementation of automated biometric solutions have been accelerated [7], [8].

By using the natural structure of finger print, ear, iris and similar parts of body which is unique for each human, we can enjoy these characteristics to recognize persons and distinguish them from each other. Ear recognition is a new

class of biometrics and it has certain advantages over the more established biometrics; it has a rich and stable structure that is preserved well from birth into the old ages [5]. Iris recognition is one of the most accurate biometric systems when a high level of security is required, so designing these systems have attracted the attention of a large number of research teams [2, 4, 9, 10].

But, recognition based on human face, unlike of other biometric methods doesn't have any robust control mechanism: In ear recognition method, we need a half face image of each person and it is not proper for facial expression recognition. In iris recognition method, if eyes were closed, it is accepted that recognition will not done and we still need robust control mechanism. Besides, recognition based on the geometric structure of face [34, 35] also needs robust control mechanism because face with various angles will not be recognized [11].

In this paper, we propose a novel approach for face recognition based on Classified Vector Quantization (CVQ) technique. On one hand, using classification on the blocks of each face image is very advantageous, because parts of faces are classified into some patterns. As a result, selection of primary patterns is important which should be done by considering the common curves on faces. On the other hand, Vector Quantization (VQ) as a robust technique is done on all vectors of each class.

The remaining of paper is organized as follows. In section 2, we introduce the face recognition problem, its challenges and current issues. In order to interpret this approach, we refer to two used techniques in sections 3 and 4. In section 5 the new approach is presented. Finally, experimental results and conclusion are discussed in sections 6 and 7 correspondingly.

II. FACE RECOGNITION

Face recognition problem has been one of the important issues in the last decade. The major reason of this claim is that its applications of security and protection has made it a necessity in our lives; including automated crowd surveillance, access control, identification of convicts, face reconstruction and so on. In computer vision, there are two important methods with the aim of face recognition. The first group is holistic appearance base methods (including PCA, LDA, and so on), whereas in these methods, a facial image is regarded as an instance in N dimensional feature space, where N is the number of pixels in the image. The second group is local facial based methods (such as elastic bunch graph matching), whereas in these methods, a set of

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orthogonal basis vectors, that maximize the variance of facial image data, are obtained by Eigen decomposition of the scatter matrix of facial images. Combination of the two above methods, that are named hybrid methods, can be used for face recognition purpose.

Face recognition algorithms have been focused on some unique properties on face such as iris, ear, skin, and so on. Among the different components of face, brow is the most important for face recognition purpose. According to the existing researches [20]-[23], all face features or components don't play equal role in face recognition. Most of the results of experiments and researches show that in the field of face recognition, nose and mouth are more important than eyes. Although, comparatively speaking, brows have equal value with other face components; attention toward effects of brows is less than other face features in front of researchers [24]. Thus, an algorithm that utilizes these features would perform better than existing ones. The proposed method of this paper enjoys of these features to achieve the best recognition.

III. VECTOR QUANTIZATION (VQ)

In VQ technique [29], original image is partitioned into several blocks with the size of $n \times m$ and then they are arranged to form of vectors. According to these vectors, codebook is updated, which is a 2D array and is initialized randomly. Now, difference between each vector of original image in comparison with code words in codebook is calculated by using of Euclidean distance:

$$D(B_i, C_j) = \sqrt{\sum_{j=1}^n (B_i - C_j)^2} \quad (1)$$

In this equation, B_i is the i th vector of input vectors, C_j is one of the code words from 1 to n and n is the number of code words in codebook. Thus, by using this distance formula, the nearest codeword, with index j , from point of distance, to selected block with index i , is found and finally code words are updated by the centroid of all training vectors, which were mapped during coding [12].

Finding the optimized codebook is the major goal in VQ. Optimality of VQ design has been shown in [13] and is depicted in Fig. 1.

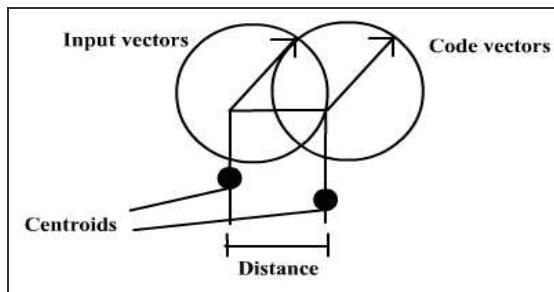


Fig. 1. Optimality of VQ design

In VQ technique, each block of the original image is indexed with an index (number of nearest code word in code book). VQ is commonly used for image compression [14, 16]. In the decompressing phase, replacing of each index i with

code word with index i in code book is achieved. The response time is an important factor in real time applications [17] and VQ-based recognition provides this feature.

IV. CLASSIFIED VECTOR QUANTIZATION (CVQ)

Edge is a very significant feature perceptually in an image. A truthful coding that preserves the edge information is of importance [30]. Classified Vector Quantization (CVQ) has proved to be an efficient technique for lossy image compression at low bit rates [21]. CVQ technique can be used to reduce the computational complexity of VQ technique [24]. In this technique [33], each input vector is located into a class and then VQ is achieved on vectors of each class. Now, we have two indexes for each input vector: One for specifying the number of class and another for specifying the index of the nearest codeword in codebook. This is shown in Fig. 2.

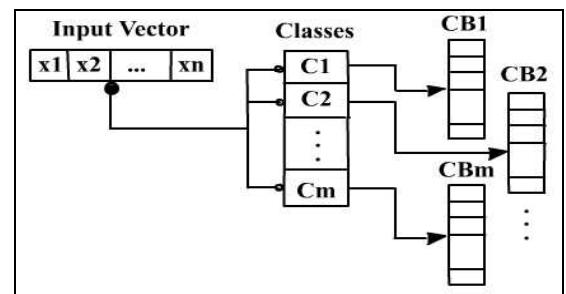


Fig. 2. A schematic of CVQ design

V. THE PROPOSED APPROACH

VQ technique is very robust in face recognition based on human's skin. But the main problem is when the number of training vectors of images is increased, VQ cannot distinguish among a lot of vectors and it is the only limitation in the usage of this technique. Now, each block is indexed with a number of each pattern. After this, when all of image blocks were indexed, VQ technique is applied over all the vectors of each pattern's vectors.

CVQ has been applied to overcome the issues of the aforementioned problem. In our proposed approach, each block of original image of the face is compared with several predefined patterns. These patterns are defined according to the curves that are most seen in face. Fig. 3 depicts some samples of patterns.

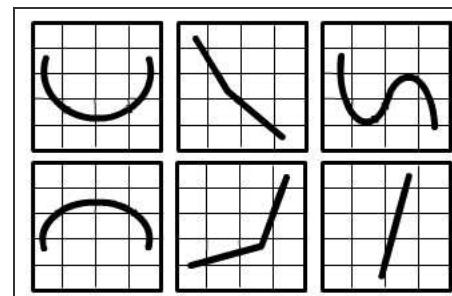


Fig. 3. Some samples of patterns

Several studies [25]-[26] show that all features and components in the face do not play equal role in face recognition. So, our focus on all features in face can guide us

to the better results in face recognition field. Since edge rendition in face and also skin correlation are important factors in the recognition process, the application of Classified VQ would be obviously appeared.

On the other hand, input vectors are partitioned into some patterns and then quantization is achieved in all vectors of each pattern. So, this can be a proper technique for the topic of face recognition. Since CVQ technique classifies the vectors in several classes, it is more precise than VQ.

According to the above descriptions, we can present our method in the following steps:

- First, we need to detect the edges of the faces related to each original image. For example, Sobel filter can be used for this purpose.
- According to the first step, we can classify each block of the original image to one of the predefined patterns. Suppose that all blocks have been classified into classes C_1 to C_n . So, there would be a number for each block between 1 to n, so that it can describe the class number of the block.
- After all, we can do vector quantization (VQ) technique on all original blocks which have the same class number. Thus, we will have n code book.
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VI. EXPERIMENTAL RESULTS

In this section, we have presented the results of two techniques, VQ and CVQ.

A. VQ Results

In order to implement this technique for the purpose of face recognition, we have used a low pass filter (2D- Moving average with mask 9×9) on each of face images at the first step. It can remove the noises of images and is able to detect the components of the face. Then we applied a code book with 128 code vectors. Next, we tested the code books of different size and we found that code book with size 128 is the optimal.

Finally, for each training image, we created a histogram based on the number of similar vectors of each code word. Fig. 4 shows a sample of histogram for a face image. As a result, we will have a histogram for each of the training images. In order to find the output image, the histogram of input image and existing images in the database has been compared and the closest histogram was found.

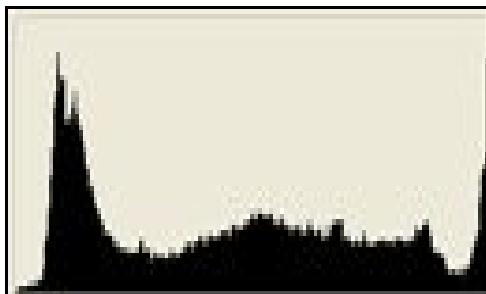


Fig. 4. A sample of face histogram obtained with our method

We implemented this method using Delphi language, standard image databases ORL, AR, Yale and PC with CPU 2.19 GHz and 1.87 GB Ram. We observed the recognition rate between 95% and 97% (depending on the size of used

mask). In this experiment, Error Recognition Rate (ERR) has been measured to 2.6%.

The demanding time for preprocessing has been 12 msec and for recognition has been at most 25 msec. Therefore, the total time would be 37 msec. This amount of time is less than existing algorithms in the literature. The reason why we could achieve less processing time is that the proposed algorithm avoids from complex calculations. This will consequently improve the overall performance of the recognition with higher accuracy.

B. CVQ Results

The implementation results of this technique, demonstrates high amount of accuracy in the context of face recognition. VQ is a robust technique for face recognition, especially in real time systems, however it cannot have good benefits when the number of input vectors of images are increased. Nevertheless, CVQ classifies the vectors into some patterns and then VQ can be used for vectors of each class. Moreover, by using this technique, we can enjoy of two unique characteristics in human face, geometric structure of the face and skin correlations. Hence, recognition rate is improved in comparison with other existing face recognition methods.

The proposed method was implemented and tested using MIT-CBCL, AR, Yale and ORL databases. At the first step, the faces in images are cropped. Then a filter such as Sobel filter is applied on each cropped face images in order to edge detection in faces. This enables us to classify each block $n \times n$ in each of predefined patterns. Finally, VQ technique is used for all the blocks of the same pattern.

We have implemented this method using Java language, CPU 2.4 GHz and 512 MB Ram. The recognition rate has been between 93% and 100% (depending on the type of database). Table I shows the recognition rate in some major face recognition methods.

TABLE I :RECOGNITION RATE OF SOME FACE RECOGNITION METHODS [36]

Method	Percent of Recognition Rate
Global PZM	82.91
AWPPZMA	92.31
Eigen face(k=20)	55.56
Eigen face(k=60)	69.23
Eigen face(k=117)	76.07
Modular PCA(k=64)	76.06
Our method	93

VII. CONCLUSIONS

In this paper, a new face recognition approach based on Classified Vector Quantization (CVQ) has been proposed. We extended the concept of this technique in order to classify components of face images into some patterns and then we used Vector Quantization in order to create a code book for each pattern.

In Comparison with other methods, our algorithm can be implemented without using hard mathematical computations. In order to increase the efficiency of face recognition, our future work will focus on some methods in order to improve the effectiveness of our proposed method. One of them is to focus on faces with different illuminations in face images.

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