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ESTIMATION OF FACE MATCHING USING HISTOGRAM AND CORRELATION TECHNIQUES

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Abstract

In image processing an automatic face recognition technique using mutual combination of bin-based histogram processing and Phase-Only Correlation (POC) - based techniques to obtain effective recognition accuracy. The first phase preprocesses the faces with bin-based histogram approach and extracts the preliminary results which are rotation invariant in nature. The second phase verifies the face patterns with POC based matching technique in order to obtain the exact results which are the same not only distribution-wise but also content wise.

Time effective preprocessing by bin-based histogram approach filters out the mismatches and helps in reduction of the overall complexity of POC. The empirical results obtained on ORL database shows the recognition accuracy of 99.5%, which is very promising and is comparable with any other face recognition scheme.

Keywords: *Histogram, Phase-Only Correlation, POC, Gaint Recognition.*

1. Introduction

Over the last 20 years, human face recognition has been studied and investigated enormously; a survey can be explored in [1]. Commercial face recognition applications have been popular in the fields of access control, security and surveillance systems, biometrics and law enforcement etc due to the availability of cheap and robust hardware equipment. The task of face recognition still poses different challenges like change in illumination, pose, and rotated faces despite success in some commercial systems.

Recognizing objects from large image databases, histogram based methods have proved simplicity and usefulness in last decade. Initially, this idea was based on color histograms that were launched by Swain and Ballard [2]. Following this idea numerous developments were made by different people, exploiting this idea, such as texture histograms for 2D object recognition suggested by Gimelfarb and Jain [3], shape-index histograms for range image recognition proposed by Dorai and Jain [4] and relational histograms used by Huet and Hancock [5] for line-pattern recognition.

Similarly, one dimensional (ID) and two dimensional (2D) histograms are also proposed with diverse variations like ID shape index histogram, 2D maximum and minimum curvature histogram, 2D mean and Gaussian curvature histogram and 2D shape index and curvedness histogram in [6].

Another category known as energy histogram counts the occurrence of the DCT (Discrete Cosine Transform) coefficients in the corresponding bins rather than counting pixel color. Popularity of this approach is its

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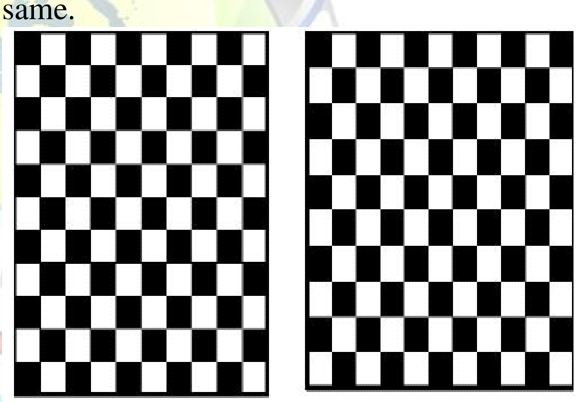
low computational cost. The algorithm of energy histogram for image retrieval has been suggested in [7]. Similarly, overlapping energy histogram measures the distribution of DCT coefficients of an image. Its performance is elaborated and analyzed. Closest distance between histograms of different face images can be used for recognition purposes. Different distance measures may affect the recognition rate [5]. Euclidean distance can be used as it produces stable and satisfactory results [6]. In the proposed system, bin based histogram is used for processing. Frequency of every bin is calculated and mean of consecutive nine frequencies is then computed for every face image that is later on used for testing.

Computed mean vectors are used for calculating the absolute differences among the mean of trained images and the test image. Finally the minimum difference found identifies the matched class with test image. Due to the fast computing time this approach is followed for training of suggested system. For verification purposes, correlation based scheme is suggested i.e. whether the testing image is face object or other than face object. Simple correlation techniques can be applied as well. But selecting Phase- Only Correlation (POC) for proposed system is due to its attractive properties such as achievement of translation and rotation invariance. Similarly, POC is not influenced by change in brightness and it is highly robust against noise. Since these properties of Phase-Only Correlation (POC) matter a lot in case of face images that is why Phase-Only Correlation (POC) is preferred over other ordinary correlation techniques.

2. Histogram Processing

Histogram is defined as the frequency of each gray level present in the image. Number of bins in the histogram is specified by the image type which means histogram of binary image will be using two bins. In Figure 1, two binary images are shown giving a look of checkerboard in which black boxes represent binary 0 and white boxes represents binary 1. Two images seem to be the same but are different in sizes i.e. Figure 1 (a) is 11 x 10 while (b) is 10 x 11 and having different I's and 0's at different locations. But interesting point in both the images is that the frequency of bin 0 and bin 1 is the same in both the images which reflects that histogram of two different images in Figure 1 (a) and (b) are same.



(a) (b)

Figure 1: Analogous checkerboard Images

Histogram of grayscale image will be using 256 bins. Figure 2 shows the sample histogram of the input image. The peak at each bin shows the frequency of that particular bin.

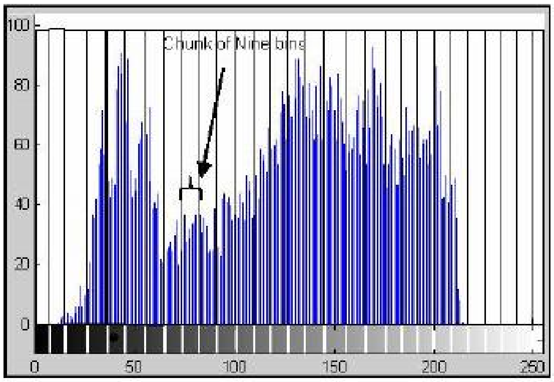


Figure 2: Histogram of an Image

Histogram of face images used for training is unique, but it is possible that any real life test image's histogram will match any one of trained image's histogram most of the time. Christo Ananth et al. [8] proposed a system which uses intermediate features of maximum overlap wavelet transform (IMOWT) as a pre-processing step. The coefficients derived from IMOWT are subjected to 2D histogram Grouping. This method is simple, fast and unsupervised. 2D histograms are used to obtain Grouping of color image. This Grouping output gives three segmentation maps which are fused together to get the final segmented output. This method produces good segmentation results when compared to the direct application of 2D Histogram Grouping. IMOWT is the efficient transform in which a set of wavelet features of the same size of various levels of resolutions and different local window sizes for different levels are used. IMOWT is efficient because of its time effectiveness, flexibility and translation invariance which are useful for good segmentation results.

In worst case scenario two altogether different images may have almost same histograms, so this ambiguity is further verified using Phase-Only Correlation discussed in next section.

3. Phase-Only Correlation (POC)

Phase-Only Correlation function is defined as 2D inverse Fourier transform for the cross-phase spectrum of two images [9].

Similarly Digital image correlation (DIC) techniques have been increasing in popularity, especially in micro- and nano-scale mechanical testing applications due to its relative ease of implementation and use. For POC, consider two images of size N1 X N2 as f (nl, n2) and g (n1, n2). Let F (k1, k2)and G (k1, k2)be their 2D discrete Fourier transforms, then their cross-phase spectrum or normalized cross spectrum RFG is defined as the conjugate of G(kI, k2) multiplied by F(k1, k2) divided by its absolute value as follows.

$$R_{FG}(k_1,k_2) = \frac{F(k_1,k_2)\overline{G(k_1,k_2)}}{\left|F(k_1,k_2)\overline{G(k_1,k_2)}\right|} = e^{j\theta(k_1,k_2)} \quad (1)$$

When 2D Inverse Fourier Transform (2DIFT) is applied on (1), the POC function is generated as follows.

$$r_{fg}(n_1,n_2) = \frac{1}{N_1N_2}\sum_{k_1,k_2} R_{FG}(k_1,k_2) W_{N_1}^{-k_1n_1} W_{N_2}^{-k_2n_2} \quad (2)$$

The POC function in equation (2) holds some interesting properties that can be used for face recognition applications. One of the most remarkable property of POC function, shown in Figure 3 is that when two images are similar in nature, their POC function

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r(n1, n2) gives a distinct sharp peak. When the two images are dissimilar, the top most peak drops significantly, shown in Figure 4 [9]. The height of the top peak is the good measure to judge the similarity between the two images. Thus the POC function exhibits much higher discrimination capability than ordinary correlation function.

With singular value decomposition (SVD) and robust 2-dimensional fitting phase correlation algorithms, it is possible to achieve pixel-to-pixel image co-registration at sub-pixel accuracy via local feature matching. However, the method often fails in featureless and low correlation areas making it not robust for co-registration of images with considerable spectral differences and large featureless ground objects. A median shift propagation (MSP) technique is proposed to eliminate the problem, in a phase correlation and Normalized Cross-Correlation (NCC) combined approach. The experiment results using images from different sensor platforms and spectral bands indicate that the new method is very robust to featureless and low correlation areas and can achieve very accurate pixel-to-pixel image co-registration with good tolerance of spectral and spatial differences between images

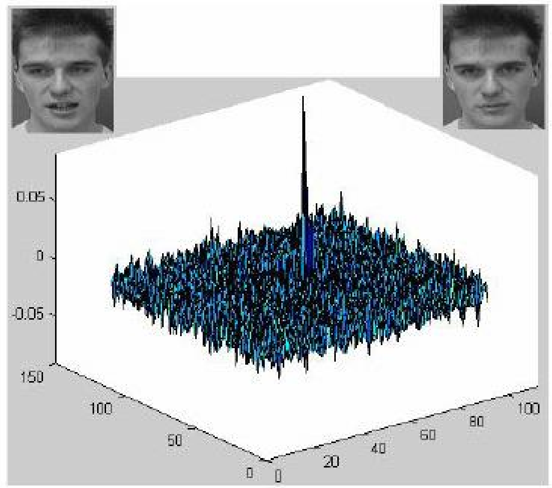

Figure 3: Examples of POC Function - Distinct sharp peak at centre for same image types

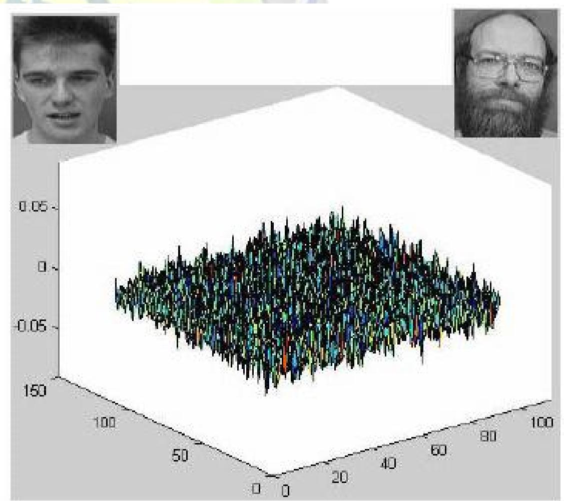

Figure 4: Example of POC Function - No distinct peak for two different images.

Another important property of POC function is that by making use of shift property of Fourier Transform, POC function easily achieves shift invariance in 2D. Letf2 (x, y) be a shifted version of imagef (x, y) so that f2 (x, y)= f1 (x- x0, y-yo), then by shift property of Fourier Transform:

$$F_2(k_1, k_2) = F_1(k_1, k_2)\, e^{-j(k_1 x_0 + k_2 y_0)}$$

The translational offsets (x0, yo) can be recovered by locating the impulse (peak) associated with the phase correlation of two images.

$$\frac{F_1(k_1,k_2)\,\overline{F_2(k_1,k_2)}}{\left|F_1(k_1,k_2)\,\overline{F_2(k_1,k_2)}\right|} = \delta(x + x_0, y + y_0) \quad (3)$$

Equation (3) implies that the correlation peak is shifted by (xo, yo) and the value of peak is invariant with respect to the positional image translation. Image shift (x0, yo) can be estimated by detecting the location of corresponding peak. Similarly, POC function is highly robust against variance in brightness and presence of noise [9].

4. Gaint Recognition

Gait recognition is a method with an adapted low resolution face recognition. For this, we experiment with a new automated segmentation technique based on alpha-matting. This allows better construction of feature images used for gait recognition. The same segmentation is also used as a basis for finding and recognizing low-resolution facial profile images in the same database. Both, gait and face recognition methods show results comparable to the state of the art. Next, the two approaches are fused (which to our knowledge, has not yet been done for the Human ID Gait Challenge). With this fusion gain, we show significant performance improvement. Moreover, we reach the highest recognition rates and the largest absolute number of correct detections to date.

5. Proposed Technique

For achieving the perfection in accuracy of proposed system, the merger of histogram and Phase-Only Correlation (POC) techniques is used in implementation of suggested system. For training, grayscale images with 256 bins are used. Firstly, frequency of every bin is computed and stored in vectors for further processing. Secondly, mean of consecutive nine frequencies from the stored vectors is calculated and are stored in another vectors for later use in testing phase. This mean vector is used for calculating the absolute differences among the mean of trained images and the test image. Finally the minimum difference found identifies the matched class with test image.

Similarly, the preliminary steps of testing are the same as training.

The proposed algorithms used for training and testing are shown in Figure 5 and 6 respectively.

Procedure: Training
Input: Five (5) images from every subject (40) of ORL
Begin
1. Calculate frequency of every bin and store in matrix.
2. Calculate mean of consecutive nine frequencies and store in matrix for later comparison.

end

Figure 5: Training Algorithm

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Procedure: Testing
Input: Five (5) images from every subject (40) of ORL (*Not used in Training*)
Output:

- Absolute processed histogram differences.
- POC values with matched subject.

Begin

1. Calculate frequency of every bin of test image.
2. Calculate mean of consecutive nine frequencies of test image.
3. Compare the means of test image with all trained matrix mean values in (2) of training algorithm.
4. Identify the image with minimum absolute difference.
5. Calculate POC values with that identified image in step (4).
6. Compare POC values with cutoff value for verification.

End

Figure 6: Testing Algorithm

6. Results and Discussion

The above system is trained and tested using MATLAB 7.0 and is executed on Pentium-IV, 3.20 GHz processor with 512MB of memory. For checking the correctness of proposed technique ORL (Olivetti Research Laboratory) database was used, which consists of 40 subjects with 10 images per subject, total of 40 X 10 = 400 images. Out of 400 images, 200 images were used for training and remaining 200 used for testing purposes. The total training time for 200 images was found to be 1.625 seconds. The total testing time was found to be 22.715 seconds for remaining 200 images. Processed Histogram & Phase-Only Correlation (PH-POC) system is compared with other existing face recognition techniques such Principal Component Analysis (PCA) [10], Sub Holistic-Principal Component Analysis (SH-PCA) [11], Low Resolution-Single Neural Network (LRS-NN) [12], Hybrid-Sub Holistic & Holistic-Technique (H-SHHT) with single Holon, Hybrid-Sub Holistic & Holistic- Technique (H-SHH-T) with five Holon [11]. Figure 7 shows the comparison among different face recognition techniques in which the curve for proposed technique i.e. PH-POC is at the top of all other curves of various techniques that exist in literature while increasing the number of ORL classes.

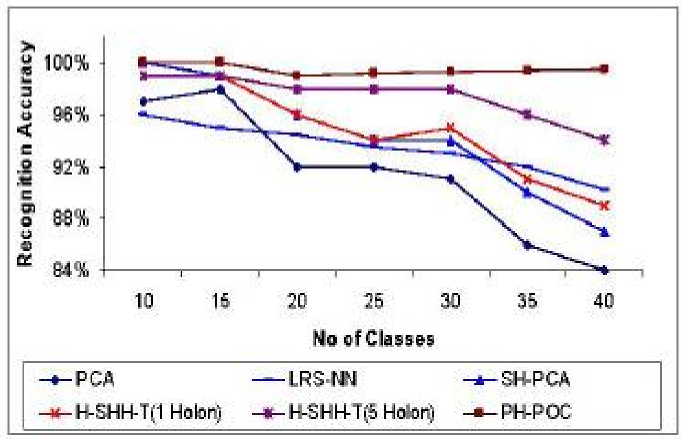

Figure 7: Comparison of Face Recognition Techniques.

Table 1 shows the comparison of training time among different techniques. Training time of proposed technique i.e. PH-POC is very fast in comparison with others. This makes it suitable for real life applications where initially huge organizations are having large database of images that needs to be trained.

Recognition Techniques	Total Training Time in seconds (200 images)
PCA	29
H-SHH-T	50
LR-SNN-T	60
PH-POC	1.625

Table 1: Training Time Comparison of Face Recognition Techniques.

Table 2 shows the comparison of testing time among different face recognition techniques. Testing time of PH-POC is relatively more as POC technique is used for getting better results during recognition and further verification.

Recognition Techniques	Total Testing Time in seconds (200 images)
PCA	3.8
H-SHH-T	73
LR-SNN-T	18.68
PH-POC	22.715

Table 2: Testing Time Comparison of Face Recognition Techniques

7. Conclusion

Face recognition is one of the most challenging tasks for machine recognition. Although humans seem to recognize faces in muddled scenes with relative ease, machine recognition is much more daunting task. In this proposed technique, we have proposed a very simple yet highly reliable face recognition technique called Processed Histogram and POC approach. The main goal was to devise time inexpensive and more accurate system. Separate processing on histogram works fine and produces the results with the same accuracy found in our system. But POC gives us the strong verification result that filters out objects other than faces. In future, the proposed algorithm can be applied on different databases and colored histogram based approaches can also be suggested.

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