Performance Evaluation of Face Recognition Technique using Hartley and DCT with Fractional Feature Vector

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ABSTRACT
This paper contributes to the performance evaluation of face recognition system that uses Hartley transform. Feature extraction is an important step in face recognition system. In transform based face recognition system, full and partial feature vectors are considered. Hartley transform is applied on resized image of size 128x128. Partial feature vector is selected by cropping the equal sized squares from four corners of transformed image. These cropped feature vectors are concatenated to form the resultant feature vector. Accuracy is calculated by varying the size of cropped feature vector at the corner of transformed image. Accuracy obtained by Hartley transform is compared with accuracy obtained by 2D-DCT. Both transforms give same accuracy and even computational complexity of both is same.

General Terms
Face recognition, Biometrics.

Keywords
Hartley Transform, Feature vector.

1. INTRODUCTION
In Biometrics field, different techniques are rapidly developing to identify the human being. Face recognition has been actively researched in recent years.

In the literatures, face recognition problem can be formulated as: given static (still) or video images of a scene, identify or verify one or more persons in the scene by comparing with faces stored in a database [1].

In general, a biometric identification system makes use of either physiological characteristics such as a fingerprint, iris pattern, or face or behavior patterns such as hand-writing, voice, or key-stroke pattern to identify a person. Face recognition is preferred over other methods because it does not require explicit cooperation from user and special costly equipments. A human face is complex object with features that can vary over the time due to aging. Other factors that influence face recognition include shape, pose, poor lighting, occlusion, sunglasses, long hair, or other objects partially covering the subject's face and low resolution images [2]. A face recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. A face recognition system can operate in following two modes:

Verification: A one to one comparison of a captured biometric with a stored template to verify that the individual is who he claims to be.

Identification: A one to many comparisons of the captured biometric against a biometric database in attempt to identify an unknown individual. The identification only succeeds in identifying the individual if the comparison of the biometric sample to a template in the database falls within a previously set threshold [3, 4, 5].

General steps in Face Recognition [4]:

1. Capture the image:

First step is to capture the image of the person who is to be recognized.

2. Face detection:

It determines the locations and sizes of human faces in arbitrary (digital) images. It detects facial features and ignores anything else, such as buildings, trees and bodies.

3. Feature extraction:

After a face has been detected, the task of feature extraction is to obtain features that are fed into a face recognition system. These features can be local features such as lines or fiducial points, or facial features such as eyes, nose and mouth.

4. Face Recognition:

The last step is face recognition, where extracted features of input image are compared with the features in the database.

Remaining paper is organized as follows: in section 2 related work carried out in the field of face recognition is presented. Section 3 contains proposed approach and experimental work for face recognition. Results are tabulated in section 4. Conclusion has been outlined in section 5.

2. RELATED WORK
Major human face recognition techniques apply mostly to frontal faces. 2D face recognition using eigenfaces is one of the oldest types of face recognition. It is argued that any face images could be approximately reconstructed by a small collection of weights for each face and a standard face picture (eigen picture). The weights describing each face are obtained by projecting the face image onto the eigenpicture. There is limited robustness to changes in lighting, angle, and distance

[6]. 2D recognition systems do not capture the actual size of the face, which is a fundamental problem [4].

These limits affect the technique's application with security cameras because frontal shots and consistent lighting cannot be relied upon. In LDA samples of unknown classes are classified based on training samples of known classes. EBGM method considers nonlinear characteristics of face [7]. Transform based coding is also widely used in biometric applications. Popularly used transform is Discrete Cosine Transform (DCT). DCT separates images into part of different frequencies. The less important frequencies are discarded. Only the most important frequencies that remain are used to retrieve the image. These are located at the topmost left corner of the transformed matrix [8]. Histogram based methods were proposed in last decade. They are useful for recognizing images from large image databases. Gimelfarb and Jain has suggested texture histograms for 2D object recognition [4], shape-index histograms for range image recognition has been proposed by Dorai and Jain [9] and relational histograms have been used by Huet and Hancock [10] for line-pattern recognition. VQ histogram is yet another approach which is based on vector quantization.

The discrete Hartley transform (DHT) resembles the discrete Fourier transform (DFT) but is free from two characteristics of the DFT:

The inverse DHT is identical with the direct transform, and so it is not necessary to keep track of the +i and −i versions as with the DFT. Also, the DHT has real rather than complex values and thus does not require provision for complex arithmetic or separately managed storage for real and imaginary parts. This paper involves study of Hartley Transform on face recognition.

3. PROPOSED ALGORITHM AND EXPERIMENTAL WORK

3.1 Algorithm

1. Resize each image in training set to size 128x128 and convert it to gray scale.
2. Apply Hartley Transform on gray scale image.
3. Choose fractional coefficients by selection of four equal sized squares from each corner of the transformed image as shown in Figure 1.

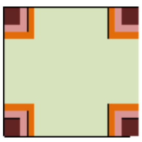

Figure 1: Fractional coefficients selected in Hartley transform

Squares with same color indicate the selected corners of same size.

4. Concatenate these selected equal sized corners as shown in Figure 2. To form one whole image. This is the feature vector of an image obtained by Hartley Transform.
5. Apply steps 1 to 4 for test image set to obtain feature vectors of test images.
6. Calculate Euclidean distance between feature vectors of test image with that of trainee images. Declare an image with minimum Euclidean distance as matching image.

I	II
III	IV

Figure 2: Concatenation of cropped feature vectors in Hartley transformed image.

Above steps are repeated by varying the size of selected equal sized squares from each corner of the image.

Proposed algorithm is applied on Indian Face Database which consists of total 500 images. These images are bitmap color images of varying size. Image database is divided into two sets, Trainee set and Test set. Out of 500 images 150 images are used as test images and remaining 350 are used as Trainee images and results are observed. Some of the sample images are shown in Figure 3.

Figure 3: Sample images from Indian Face Database

4. RESULTS

Here proposed technique is compared with 2D-DCT [11] on test image. In DCT energy distribution of an image is observed at the topmost left corner as shown in Figure 4.

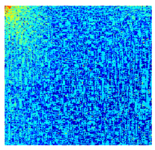

Figure 4: Energy distribution for one of the test images using DCT

Because of this energy distribution, feature vector in DCT of an image is cropped as in Figure 5.

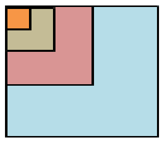

Figure 5: Feature vector selection in DCT of an image

Whereas, in Hartley transform, energy distribution is observed at the four corners of an image. It is shown in Figure 6.

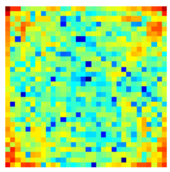

Figure 6: Energy distribution for one of the test images using Hartley Transform

Hence cropping of feature vector is done at the corners of transformed image as shown in Figure 1 above.

Table 1 show the result when DCT is applied on the images. Different sizes of feature vector are cropped from transformed image.

Table 1. Accuracy (%) in DCT for various sizes of feature vectors

Feature vector size	Accuracy (%)
128*128	83.57
96*96	85.57
64*64	86.42
32*32	**88.67**
16*16	**88.67**
8*8	**88.67**
4*4	87.57

Table 1 shows that, as we reduce the size of feature vector, accuracy goes on increasing. It remains constant and then decreases with decrease in feature vector size. Maximum accuracy is obtained for minimum feature vector size 8*8 and also for size 16*16 and 32*32.

Result of Hartley transform is shown in Table 2 for different sizes of cropped feature vectors.

Table 2. Accuracy (%) in Hartley Transform for various sizes of cropped feature vectors

Corner size	Feature vector size	Accuracy (%)
64x64	128*128	88
32x32	64*64	88
16x16	32*32	88.66
12x12	24*24	88.66
10x10	20*20	88.66
8x8	**16*16**	**90**
6x6	**12*12**	**90**
4x4	8*8	84
2x2	4*4	80

From Table 2, it is observed that, feature vector size is reduced by reducing the size of cropped corner of the transformed image. Accuracy increases with decrease in size of feature vector. Highest accuracy of 90% is obtained for minimum feature vector size 12*12 and 16*16.

5. CONCLUSION

From the experimental work carried out, it can be observed that Hartley transform can also be efficiently used for face recognition like 2D-DCT. In DCT, accuracy of the system goes on increasing till a specific size of cropped feature vector and then it starts decreasing. In Hartley transform, accuracy is highest for smallest size feature vector. The computational complexity of Hartley transform is $2N^3$ multiplications and $2N^2(N-1)$ additions, which is same as that of DCT. Major difference is the area from where feature vector is cropped. This shows that we can use Hartley transform for face recognition.

6. REFERENCES

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