Application Of Row Feature And Column Feature Vector of WHT For Face Recognition

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Abstract
In this paper we propose fast face recognition system based on the Walsh-Hadamard transform (WHT) row feature vector and column feature vector. This scheme can be easily implemented and number of coefficients required for face recognition reduces drastically. Thus computational burden decreases. It is observed that row or column vector coefficients with minimum 80% energy are required for face recognition. Walsh transform performs better than DCT or PCA. We have used ORL database which gives accurate results.However locally constructed database with male and female faces give 95% accuracy.

Categories and Subject Descriptors
1.4 IMAGE PROCESSING AND COMPUTER VISION

Genral Term
Algorithms, Design

Keywords
Face recognition, Walsh Hadamard transform(WHT),DCT,PCA ,eigenfaces ,energy compaction.

1 INTRODUCTION
Face recognition has received significant attention during last couple of years. It can be applied in various fields including man and machine interaction, surveillance and authentication.[1] Researchers have explored various techniques on feature extraction and matching algorithms, yet these are still challenging field for better, easier and faster techniques. Face recognition is broadly classified as feature based recognition in spatial domain and transform based recognition techniques. In feature based system parameters for classification images are normalized distances and ratios among points such as eye corners, mouth corner, nose tip and chin point etc.[2]. The main difficulty with this method is that it is highly subjective and calculation of exact features is very difficult. These algorithms under the pose variation and age effect[4] gives poor results.

To over come the difficulty in appearance based method like Principal component analysis (PCA) [3]Eigen faces are calculated which are the combination of different characteristics of database images. The PCA enjoys the important advantages like model parameters can be computed easily and ease of matrix, simple matrix multiplication is required for finding parameters. For identifying person a similarity measure of

Eucldiean distance used is as given below[5]

$$D^2 = \sum_{i=1}^{N} (y_i - y_{ki})^2 \qquad (1)$$

where D refers to the Euclidian distance, y_i is unknown sample, y_{ki} represent a vector describing the k^{th} face in the set.. Main drawback of PCA is scalability of the database.. For each additional face the face-space distribution changes and calculation for eigen face is to be replicated which increases time required for computation which makes system less efficient for real time applications. To overcome this difficulty different transforms are taken as identification means such that addition of new face to database does not pose any problem of scalability. Different transforms like DCT [6],Wavelet transform[7][8], Walsh Hadamard transforms are tried. A local appearance based face recognition algorithm is proposed by Hazem et. al [9] where local information is extracted using block based DCT, obtained features are compare for identification. In [10] combination of wavelet transform and PCA is tried. Instead of face images as input to covariance matrix wavelet transform coefficients of image is utilized. In[11] wavelet transform is used for dimensionality reduction of database and neural network classifier with radial basis function is tried for approximation. The paper on Walsh Hadamard transform [12] uses correlation between local pixels of an image. The main goal of the present approach is to show that transformed based face recognition is more robust and compact compared to holistic approach like CA[2],LDA[13],ICA[14]. In this paper we utilize transformed based information by using row or column feature vectors. The main idea is mitigate the effects of expression, illumination and occlusion variations by performing transform analysis. The reason for performing WHT row wise or column wise separately is to achieve fast recognition rate for real time processing. Using coefficients with 80% energy of full transform reduces the number of coefficients to be compared by a factor of 5. This is further reduced when we take only row feature vector or column feature vector.

2 WALSH HADAMARD TRANSFORM

The WHT is an important fast transform in terms of energy compaction in the field of image processing. It is computationally fast as compared to DFT and DCT since it doe not involve any multiplications. The Walsh matrix is sequency ordered Hadamard matrix which can be generated recursively as the transform in matrix has only $\pm$ 1 entries.[16] The rows and the columns of the Hadamard matrix is orthogonal. Hadamard matrices of order of 2^n can be recursively generated as

$$H(2^n) = H(2) \otimes H(2^{n-1}) \quad (2)$$

Where symbol $\otimes$ indicated Kronecker product and H(2) is seed matrix given by

$$H(2)=[1\ \ 1;\ 1,-1] \quad (3)$$

Walsh matrix is obtained from Hadamard matrix by arranging rows in increasing sequency order. Sequency of any Hadamard matrix is obtained by number of sign changes. The algorithm to transform hadamrd matrix in walsh matrix is given below.

Kekre's Algorithm[17]

This algorithm gives the sequence of numbers according to which the Hadamard rows can be arranged so that we obtain Walsh rows.

Step 1: Arrange the rows in ascending order.

For Hadamard matrix of dimension 16 x 16, ascending ordered rows are,

0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15.

Step2: Split the row in 'N/2', the last part is written below the upper row but in reverse order as follows.

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**

Step3: We get two rows, each of this row is again split in N/2 and inserted below the upper row after reversing. Finally we get one column matrix which is

0,15,7,8,3,12,4,11,1,14,6,9,2,13,5,10

Entire procedure is tabulated in table1.

Step 4 According to this sequence the Hadamard rows are arranged to get Walsh coefficients.

3 PROPOSED ALGORITHM

Algorithm for calculating row and column feature vectors

Step 1 : To prepare row feature vector

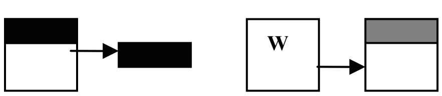

Image WHT Transformed row

Fig1: Procedure for generation of row feature vector.

Table1

0	1	2	3	4	5	6	7
15	14	13	12	11	10	9	8
7	6	5	4				
8	9	10	11				
3	2						
12	13						
4	5						
11	10						
1							
14							
6							
10							
2							
13							
5							
10							

As shown in above figure at a time one row of image is taken as input. Dimension of row vector is 1xN for image of size NxN. By multiplication with WHT get a row vector in transform domain. These coefficients are in general descending order of energy.

Step 2 : To prepare column mean vector

Image WHT Transformed column

Fig2: Procedure for generation of column feature vector

Here we take one column at a time from given image and multiply with WHT to get column feature vector in transform domain.

Step 3 : Store all the transformed images of given training database after processing it according to step 1 and 2

Step 4 : Matching of WHT feature vectors for recognition

For testing the query image, it is passed through step 1 and 2 to calculate its row feature vector and column feature vector using minimum Euclidian distance as a similarity criteria for row feature vector and column feature vector the best match is found for minimum distance. This minimum distance is compared with predetermined threshold value and it is rejected if it exceeds threshold.

Step 5 Optimum coefficient calculations

Transforms gives good energy compaction. Maximum energy is concentrated in very few low sequency coefficients. This step calculates the minimum required energy to reconstruct the face image for recognition.

After step 1 per row of transformed image has descending order of energy concentration. Similarly after step 2 per column of transformed image has descending order of energy concentration. Now number of minimum coefficients required(row and column wise) for different energy levels are calculated. Out of this optimum energy level is decided which will give accurate results. To achieve this optimum energy level in image the number of coefficients required in row feature vector and column feature vector is calculated. These coefficients are called optimum coefficients and are very few, less than 20% as compared to original row and column feature vectors.

3.1 Algorithm for adding new face in database

For the image which is to be added to the face database, WHT row and column feature vector are computed using the steps 1 and 2 discussed in 3A. Then these WHT features are inserted into the table of row feature vector and column feature vector respectively of the database. This completes addition of new image into the face database

4 RESULT ANALYSIS AND DISCUSSION

The proposed method is tested on ORL database prepared by AT & T lab [18][19].Here 9 different persons with 5 distinct expressions are selected. Each face image is of size 64 x 64. Figure 4 shows locally generated database of Indian origin. Here 4 different male and female subjects are selected each with five different expressions and poses. Following figure3 and figure4 shows the database with few selected faces for illustration.

Fig 3 ORL Database

Fig 4 Locally created database

The row feature vector and column feature vector is selected as described in section 3A. The algorithm is tested on all the images of the database as well as diverse expression of the person present in the database. Figure 5 shows the result for locally generated database and Figure 6 shows the recognition result of ORL database .

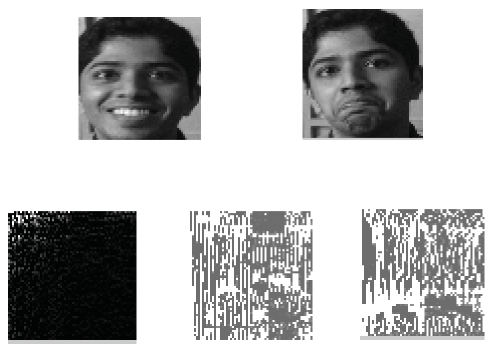

Fig 5 (a) Test image of local database with different Facial expression

(c), (d),(e) Transformed image with full WHT, Row feature vector, Column feature vector

(b) Recognized face from database

(a) (b) (c)

(d) (e) (f)

(g) (h) (i)

Fig 6 (a) ,(d),(g) Original image
(b), (e),(h) Transformed image with full WHT, Row feature vector, Column feature vector respectively after histogram equalization for better observation
(c),(f),(i) final recognition result

It is very obvious from above figures that energies are concentrated in descending ordered in row and column feature vectors. The algorithm also detects the image with different expressions then in database of same person.

The Algorithm is also tested for various level of occlusion. Table 2 shows the obtained result.

Table2: Number of coefficients require for different percentage of occlusion

%occlusion	Row	column
10	1738	622
20	2290	3926
30	2816	3926
40	3136	3926
50	3456	3926
60	3873	3926
70	4034	Fails

Fig 7 Original image and 70% occluded image

Above table shows that as percentage occlusion on image increases number of coefficients require for row feature vector and column feature vector increase rapidly. We get correct recognition up to 80% occluded image for the given database with 95% of energy in image. As energy contain of image further reduces the number of coefficients required for recognition increases. Row feature vectors are more robust than column feature vectors in terms of withstanding the occlusion. Here after applying 60% of occlusion on image column feature vector starts giving falls recognition.

In this paper we are performing a comparative study of existing algorithms like DCT, PCA, full WHT applied on image for face recognition with row feature vector and column feature vector method in terms of coefficients requirement as one of the performance parameter. Following table 3 shows the results

5 CONCLUSION

We have proposed a novel faster, better and energy compact face identification technique based on row feature vector and column feature vector of WHT. Algorithm successfully works with occluded images also. The feature extraction is faster because the computational complexity is reduced due to row feature vector and column feature vector of size 1xN instead of entire image of size NxN. Further study reveals that all the coefficients need not be used for comparison but for given image NxN we need to consider only those coefficient which make energy equal to 80%of the total energy yielding acceptable results. Even the extension of the database is not only rapid but also comparatively easier in the proposed method.

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Table 3 Comparative study for number of coefficients required in different methods

Energy	WHT for ORL Database			WHT for Local Database			DCT[ORL]			PCA[ORL]	
	Row	Column	Full	Row	Column	Full	Row	Column	Full	Eigen faces	Coefficients
80	768	579	849	576	576	64	659	568	640	08	32768
85	832	590	1168	576	649	130	670	568	838	10	40960
90	832	663	1666	576	2573	261	764	586	1132	13	53248
95	832	787	2498	576	4032	584	945	751	1819	19	77824