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Performance Analysis of Feature Vector based on Walsh Transform Coefficients of Row, Column and Diagonal Means for Hyper Spectral Face Recognition

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ABSTRACT

Biometric authentication systems have become ubiquitous with the increasing number of surveillance cameras that are deployed almost everywhere, the use of biometric attendance systems and also its large scale use in forensic laboratories. Hyperspectral images are used widely in biometric research because of the immense amount of unique data they generate has proved to be helpful in solving the drawbacks of existing biometric systems. The main focus of the research was to use hyperspectral face images having 33 bands for face recognition using Fast Walsh transform coefficients. Face is a biometric trait which requires low user co-operation and provides better accuracy which makes it preferable over other biometric traits. With the use of hyperspectral face images, the accuracy rate was found to be improved. However the main drawback of these Hyperspectral images was that they generated large amount of redundant data and hence row, column and diagonal mean were computed instead of using the entire image so as reduce the memory and storage constraints. Orthogonal transforms such as Fast Walsh transform was used for texture feature extraction to generate the coefficients for the row, column and diagonal mean vectors. The extracted feature vectors are then subjected to intra class and inter class testing using Euclidian distance measure. The performance of the system was analysed.

Keywords

Biometrics, Hyperspectral Images, Face Recognition, Fast Walsh Transform (FWHT).

1. INTRODUCTION

1.1 Biometrics

Biometrics is a specialized branch of science that deals with uniquely recognizing individuals based on their intrinsic physical or behavioral properties. Biometric authentication systems are widely used as they have proved to be the most accurate way for identifying human beings based on their biometric traits [1], [7]. Biometric traits include face, fingerprint, retina, iris, knuckle, hand geometry, palmprint, signature, voice etc. These traits can be utilized based on the need of application. The biometric system can be either unimodal or multimodal [8].

1.2 Face Recognition

Face recognition systems have widespread application due to its ease of deployability in public premises such as railway stations, airports, hotels etc. and also at private places such as organizations, research labs. Face recognition stands distinguished from other biometric traits due to its low user co-operation requirement [4]. Improvements in this field have led to the use of various other techniques such as 3D Face, Facial Thermogram, IR Imaging and Hyperspectral Imaging etc. [1], [8] and [9]. The current research is focused on the use of hyperspectral images for face recognition.

1.3 Hyperspectral Images

The problem with existing face recognition system was that of low accuracy [4], [5]. This arises because of the less significant data available for unique identification [11], [12]. Hyperspectral imaging can acquire the intrinsic spectral information of the skin at different wavelengths, which may reveal the skin information based on the reflected, absorbed and emitted electromagnetic energy and has the potential to overcome the difficulties in traditional face recognition [6] and [10].

The current research makes use of PolyU Hyperspectral Face Database from where the face image samples have been taken. It includes hyperspectral dataset of 300 hyperspectral face images that are taken within the visible range of 400nm-720nm. The images are stored in MAT format. Each Mat file is 3-D data cube with size: 220 (height) *180 (width) *33 (no. of bands) [18]. Figure.1 shows a set of 33 Hyperspectral face bands from Honk Kong Polytechnic University's Hyperspectral face database.

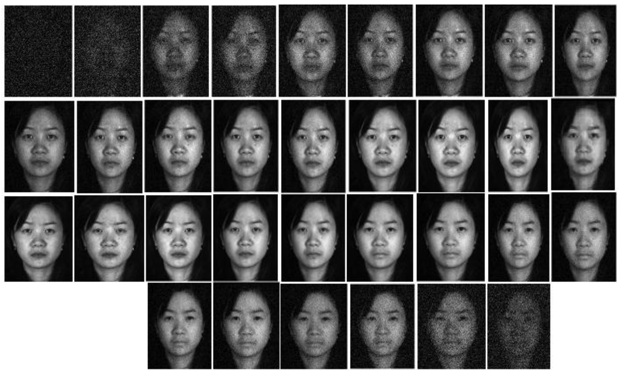

Figure 1: Illustration of a 33 hyperspectral face bands.

2. LITERATURE SURVEY

Biometric authentication systems have been widely deployed these days considering the security as well as law enforcement purposes. Biometric systems can be developed using one or more than one biometric traits as per requirements. Either the physiological aspects or the behavioral aspects are captured using such authentication systems [3], [13] and [14].Many face based biometric systems have been explored in the past years [8] and [9]. With the ever increasing need for accuracy in such system, Zhihong Pan, Glenn Healey, Manish Prasad, and Bruce Tromberg [4] proposed Face recognition using Hyperspectral Imaging introducing a new and improved technique for face recognition. Wei Di, Lei Zhang, David Zhang and Quan Pan [6] proposed Hyperspectral Face Recognition in Visible Spectrum with Feature Band Selection to obtain more accurate results from specified bands. For feature extraction of hyperspectral images, Xudong Kang, Shutao Li, Leyuan Fang and Jón Atli Benediktsson [5] proposed method called Intrinsic Image Decomposition. H B Kekre, V A Bharadi, S Tauro and V I Singh in [14] compared the performance of FFT, WHT & Kekre's Transform. T K Sarode and Prachi Patil [15] performed comparison of Transform Domain Techniques and Vector Quantization Techniques for Face Detection and Recognition which stated that the performance of row mean/column mean DCT/WHT is better than Full DCT/WHT.

In [1] V A Bharadi and Payal Mishra proposed a novel technique using KMCG and KFCG which stated that clustering on hyperspectral images found to reduce the feature vector size and reduced no. of computations were required. The use of multimodal biometric system for Hyperspectral Face Images was proposed by V.A Bharadi, Payal Mishra and Bhavesh Pandya in [2], [3] where multimodal system was developed using multidimensional clustering. V.A Bharadi and Pallavi Vartak proposed Hyperspectral Face Recognition using Hybrid Wavelet Type I ,Type II and Kekre's Wavelet [16] to compare the performance of Type I ,Type II and Kekre's Wavelets which clearly stated that multimodal and multi-algorithmic system gave better performance as compared to unimodal systems and also proposed Performance Improvement of Hyperspectral Face Recognition by Multimodal and Multi Algorithmic Feature Fusion of Hybrid and Kekre Wavelets based Feature Vectors [17] which stated that multi-algorithmic system (HWI+HWII+KW) gives better performance than unimodal systems. Since different transforms are used for feature extraction, their performances have to be compared to detect which one stands best.

3. PROPOSED SYSTEM

Face recognition systems have been in operation for a long time. Face biometrics require low user co-operation as compared to other biometric systems. But the problem with these systems is the relatively lower accuracy [4]. Various technologies have been integrated with traditional face recognition system so as to obtain better performance [8], and [9]. One such technology used was face recognition using hyperspectral images [1], [13], [16]. Hyperspectral images provide vast amount of data i.e. for every single pixel, a contiguous spectrum of data is obtained [6]. While it solves the problem of accuracy, at the same time it adds to the problem of storage and complexity. Vector Quantization techniques, Hybrid Wavelets etc were the other techniques used to reduce the dimensionality of data [1], [2], [16], [17]. It is found that orthogonal transform coefficient can outperform other techniques that were used in a traditional face recognition system [9]. Due to the vast amount of data that was generated while using hyperspectral images, it was important to identify the most appropriate technique for dimensionality reduction. Orthogonal transform are known for dimensionality reduction and hence in this research, FWHT was used for texture feature extraction to achieve dimensionality reduction. Figure 2 shows the block diagram of the proposed system.

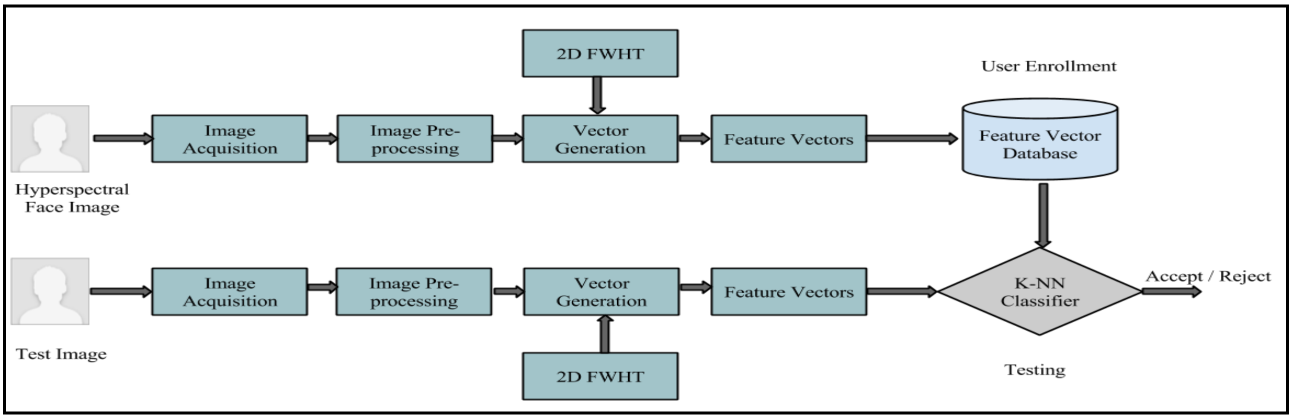

Figure 2: Block Diagram of the Proposed System.

3.1 Explanation of Block Diagram

The proposed system consists of following steps:

3.1.1 *Image Acquisition*

In this stage, the images for the research are acquired either from database or using real time capturing. Capturing of Hyperspectral images require a specific hyperspectral face imaging system. For the ease of implantation, current research has made the use of PolyU HSFD [18] consisting of 33 bands of images for front, left and right stored separately was used. The images stored in 3D MAT format are extracted from the database. The size of each extracted image is 180 * 220 * 33.

3.1.2 *Image Pre-processing*

After acquisition of an image from the face database, the image is read for all the 33 bands. Then the images of size 180*220 is converted to a standardized size of 256 * 256 and stored. The images are also subjected to normalization so that the gray values lie between 0-255. Now the images are in a pre-processed stage on which the further processing takes place.

3.1.3 *Vector Generation*

After the images are pre-processed, the row mean, column mean, forward diagonal mean and backward diagonal mean of the pre-processed image of size 256*256 is computed for each image band from 0 to 32 and stored as separate vectors. The generated vectors for row mean, column mean and diagonal mean are stacked row-wise to form a single 2D array each for row mean, column mean and diagonal mean both forward and backward. Thus, a total of four 2D array is generated on which the transforms can be applied.

3.1.4 *Fast Walsh Hadamard Transform (FWHT)*

FWHT is an orthogonal transforms which has been used in the current research. The significance of the orthogonal transform is their ability to group low frequency components into few coefficients. They can also regenerate the entire image with minimum distortion [9]. When orthogonal transforms are applied to an N x N array, it results in transform coefficient of size N x N. Here the 2D FWHT will be applied on the 2D arrays obtained for row mean, column mean and forward and backward diagonal mean so as to generate orthogonal transform coefficients.

3.1.5 Feature Vectors and Feature Vector Database

Texture feature extraction using FWHT results in the generation of coefficient (feature vectors) for row mean, column mean, forward diagonal mean and backward diagonal mean respectively. These extracted feature vectors have to be stored in a feature vector database which will be used for testing purpose to evaluate the accuracy and performance of the system.

3.1.6 *DistanceComputation using K-NN Classifier*

This is the testing stage where the coefficients stored within the database during user enrollment phase is extracted and compared with the coefficients of the test sample. The same set of procedure is performed on test image as well. The distance measures is computed for intra class as well as inter class images. The distance measure that will be used for the current research is Euclidian Distance (ED). The mean squared error value is determined between two feature vectors. The images with minimum error are considered to be the correct match.

3.2 Proposed Algorithm

Algorithm for the proposed system is as follows:

Step 1: Firstly, the MAT file and its face cubes were read from the PolyU HSFD, this gave a composite Array for 33 Bands of the Face cubes data for Front face samples.

Step 2: Images for all the 33 bands were obtained each of size 180 * 220. The images were normalized so that the grey levels are in-between 0 to 255. The normalized images were then converted to a size of 256 * 256 by padding pixels.

Step 3: Row mean, column mean and diagonal mean both forward diagonal mean and backward diagonal mean of the preprocessed image 256* 256 image were computed for each 0 to 32 bands. The vectors generated for each band were stacked onto a single 2D array, each one for row, column and diagonal respectively.

Step 4: 2D Fast Walsh transforms were applied on these row, column and diagonal mean vectors to obtain the required coefficients.

Step 5: Coefficients for the sample image and the test image were generated and stored for performing testing using Euclidian Distance measure.

Step 6: The results for inter class as well as intra class testing of the images were obtained and the image with minimum distance was considered to be the best match

Step 7: The results of intra class and inter class testing was tabulated and the performance analysis was done.

Figure 3 shows the row mean, column mean, forward diagonal mean and backward diagonal mean plot for Band 14. Figure 4 shows the Walsh coefficient plot for row mean feature vectors. Figure 5 shows the Walsh coefficient plot for column mean feature vectors. Figure 6 shows the Walsh coefficient plot for forward diagonal mean feature vectors. Figure 7 shows the Walsh coefficient plot for backward diagonal mean feature vectors

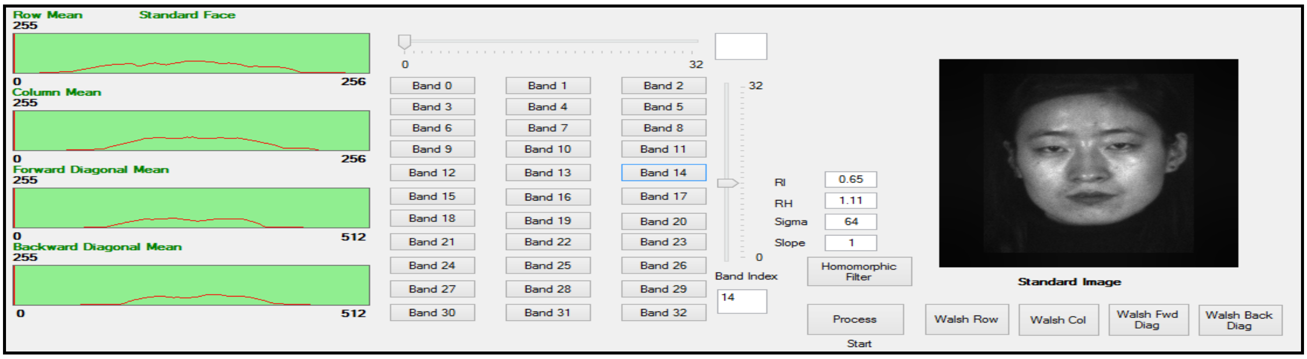

Figure 3: Row, Column and Diagonal mean plot for Selected Band Index

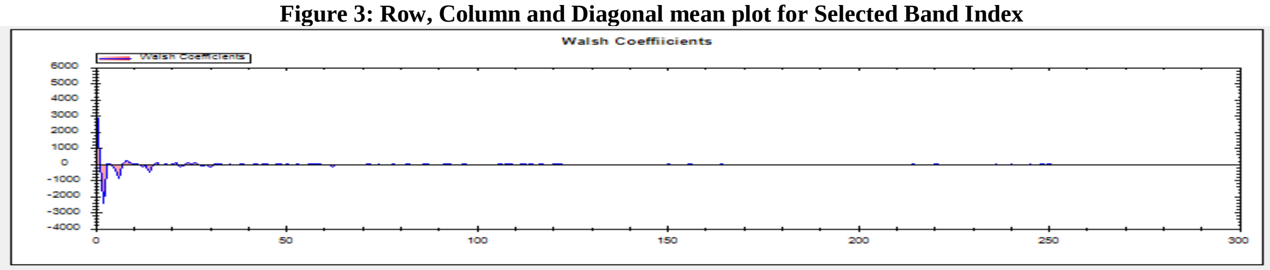

Figure 4: Walsh Coefficient Plot for Row Mean Feature Vectors

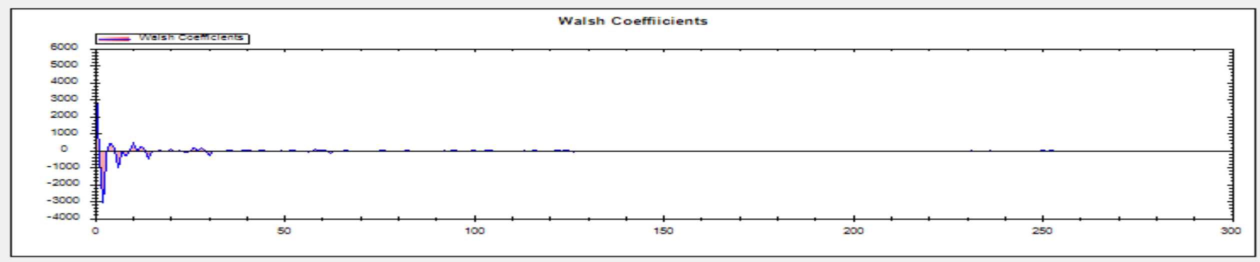

Figure 5: Walsh Coefficient Plot for Column Mean Feature Vector.

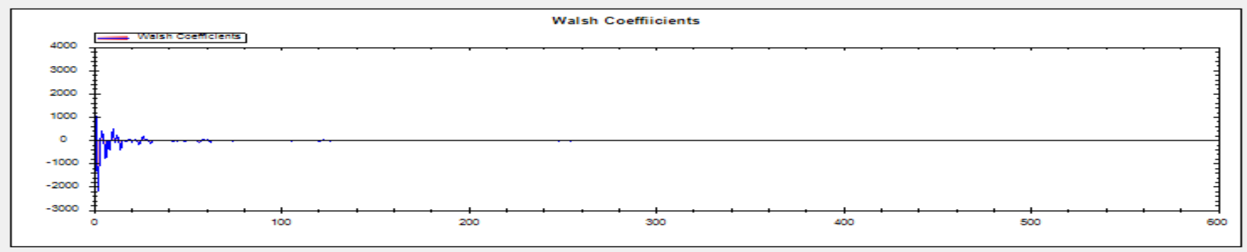

Figure 6: Walsh Coefficient Plot for Forward Diagonal Mean Feature Vectors

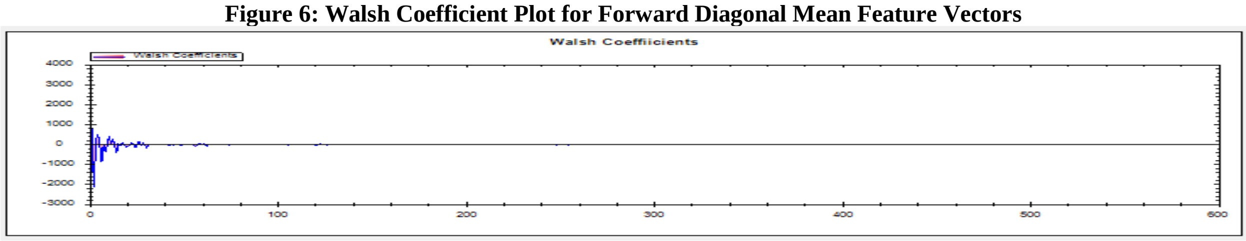

Figure 7: Walsh Coefficient Plot for Backward Diagonal Mean Feature Vector

4. RESULTS AND DISCUSSION

The testing for the proposed system was performed by comparing the coefficients generated for standard image as well as the test sample. Both the standard image and the test image were extracted from the PolyU database. The row, column and diagonal mean values for both the images were obtained for each band. These obtained values were then stacked onto a 2D array , each for row , column, forward and backward diagonal on which transforms such as Walsh Transform was applied. The generated coefficients are plotted and the coefficients of both the images were compared during testing. For this purpose Euclidian based distance measure is used. The formula for Euclidian Distance is given as:

Say P (1…n) and Q (1…n).

$$ED = \sqrt{\sum (P_i - Q_i)^2} \quad \text{for } i = n.$$

4.1 Intra-class Testing

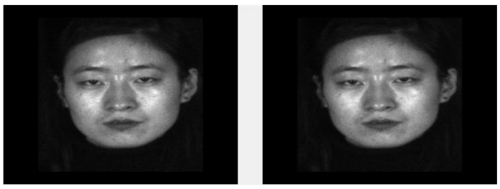

Figure 8: Intra-class Front Samples of User

The sample image of same user is used for intra-class testing. The distance measure is computed for the same. The different image samples of the same user are also used for intra-class testing. It is expected that the same images will give minimum distance. The image with minimum distance is considered to be best match. Table 1 shows the results for distance measures generated when User 1 samples were compared with same sample and also with different images of User 1 samples.

Table 1: Intra class testing for User No: 1

1.1	1.1	1.2	1.3	1.4
Row	0	76.0907	96.8075	77.6032
Column	0	57.7872	88.5244	42.7818
Forward	0	51.8923	69.5269	64.0926
Backward	0	53.1280	71.2351	55.0966
1.2	**1.1**	**1.2**	**1.3**	**1.4**
Row	76.0907	0	43.1499	60.7868
Column	57.7872	0	53.3315	54.7023
Forward	51.8923	0	44.9622	54.3994
Backward	53.1280	0	41.3833	37.5051
1.3	**1.1**	**1.2**	**1.3**	**1.4**
Row	96.8075	43.1499	0	81.2342
Column	88.5244	53.3315	0	77.6946
Forward	69.5269	44.9622	0	66.7857

Backward	71.2351	41.3833	0	55.9228
1.4	**1.1**	**1.2**	**1.3**	**1.4**
Row	77.6032	60.7868	81.2342	0
Column	42.7818	54.7023	77.6946	0
Forward	64.0926	54.3994	66.7857	0
Backward	55.0966	37.5051	55.9228	0

4.2 Inter-class Testing

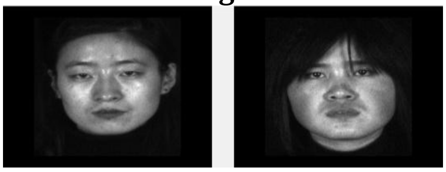

Figure 9: Inter-class Front Samples of User 1 and User 2

Table 2: Inter class testing for User No: 1 with User No: 2

1.1	**2.1**	**2.2**	**2.3**	**2.4**
Row	79.8336	136.392	101.987	85.6819
Column	67.4445	129.938	37.6746	45.1993
Forward	79.0094	100.293	76.1575	67.8460
Backward	42.0099	106.273	80.4843	57.3394
1.2	**2.1**	**2.2**	**2.3**	**2.4**
Row	78.7149	91.9453	93.4447	89.4909
Column	83.4256	97.4063	68.2682	72.2034
Forward	69.1617	73.0286	69.7527	65.1186
Backward	46.0700	74.0607	69.5846	53.1027
1.3	**2.1**	**2.2**	**2.3**	**2.4**
Row	101.8954	87.7067	115.587	110.457
Column	98.3299	99.2879	97.8668	92.6207
Forward	76.9132	68.1976	81.9646	78.7556
Backward	67.7298	69.4487	81.1458	72.1970
1.4	**2.1**	**2.2**	**2.3**	**2.4**
Row	44.1152	105.532	58.0733	46.4832
Column	53.9350	120.470	50.1339	34.5834
Forward	35.6698	82.7088	35.4185	21.5273
Backward	36.2581	81.302	81.302	32.4891

The sample images of different users are used for inter-class testing. The distance measure is also computed for the same. It is expected that the most dissimilar image is likely to give the maximum distance value. The image with minimum distance is considered to be best match. Table 2 and Table 3 shows the results for distance measures generated when User 1 samples were compared with sample of User 2 and User 3 respectively

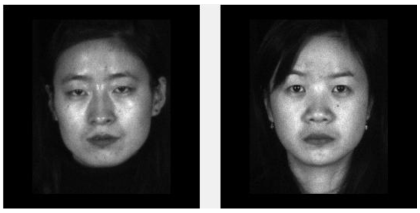

Figure 10: Inter-class Front Samples of User 1 and User 3

Table 3. Inter class testing for User No: 1 with User No: 3

1.1	**3.1**	**3.2**	**3.3**	**3.4**
Row	49.2875	120.755	90.6954	96.3410
Column	85.6990	109.118	44.6491	67.2559
Forward	54.2438	83.6313	70.2853	77.6868
Backward	42.8744	81.9626	57.7720	63.5258
1.2	**3.1**	**3.2**	**3.3**	**3.4**
Row	83.9781	75.4982	89.3895	103.642
Column	118.614	86.7780	84.2827	110.705
Forward	71.7483	61.1547	72.2341	86.3571
Backward	77.1458	61.0368	55.9369	73.0878
1.3	**3.1**	**3.2**	**3.3**	**3.4**
Row	107.974	58.5770	110.471	125.327
Column	129.710	74.2183	108.355	131.336
Forward	86.0181	48.9335	86.3650	99.3548
Backward	89.2094	52.2119	76.5547	90.9986
1.4	**3.1**	**3.2**	**3.3**	**3.4**
Row	74.7392	104.808	44.8206	69.6334
Column	79.9336	102.957	50.7250	78.5734
Forward	55.6844	80.3815	37.1322	55.5460
Backward	66.5002	76.0469	37.0966	55.3995

The results evidently shows that the intra class images i.e. the images from the same user has minimum distance values highlighted with green color and highest distance value is highlighted with red color whereas the inter class images i.e. the images of different users were found to have a higher distance value i.e. maximum values have a higher distance as highlighted by red color as compared to intra class distances, which can be used to correctly identify the face samples. The results obtained so far were using only the Front face images. The same method can be extended for Left and Right face images as well.

5. CONCLUSION

The proposed system was implemented to perform the analysis of texture feature extraction based on Fast Walsh transform coefficients of row, column and diagonal mean for Hyperspectral face recognition. The feature vectors were generated by applying Walsh transform along row, column, forward and backward direction. The feature vectors are generated for mean values computed for the image rather than for entire image which reduced the computational complexity and also reduced the processing time extracted feature were then compared for different samples by generating Euclidean Distance measure. If was found that the intra class results are much lower as compared to the inter class results. i.e. the images from the same user has minimum distance values highlighted with green color whereas the inter class images i.e. the images of different users were found to have a higher distance value highlighted by red color as compared to intra class distances. As this method is found to give satisfactory results, it can be further used as classification system for hyperspectral face recognition. The research can be extended to support composite feature vector generation using Front, Left and Right face images and also combination of different instances of face image for different transform. A cloud based system can enhance the performance and scalability of the system.

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