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FACE RECOGNITION USING PCA AND WAVELET TRANSFORM

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Abstract

Building an automated system for recognition of Human Face with quite good accuracy and speed as similar to human brain's ability is quite a challenging task. Principal Component Analysis (PCA) is Eigen face method for the recognition of facial expressions and makes use of statistical variance, which can remove the correlation between the statistical variables and keep all or most of the information. The system functions by projecting face images onto a feature space that spans the significant variations among known face images. This paper presents a method which improves face Recognition speed combining Principal Component Analysis (PCA) and Wavelet Transform at preprocessing stage. Preprocessing by Wavelets transform will reduce the storage space and computational time which will enhance the speed over simple PCA technique. The recognition speed improved up to 18.03% at two level Wavelet Transform by using proposed algorithm.

1. Introduction

Human have been using body features such as voice, face, gait, etc. for millions of years to distinguish between them. There are a number of issues in a practical biometric system for personal recognition that must be accounted, are Performance, Acceptability, and Circumvention [1]. Biometric-based techniques includes identification which is based on various physiological characteristics (such as face, hand geometry, hand veins, palm, retina, iris, voice) and behavioral characteristics (such as signature, gait, and

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keystroke dynamics) [2]. Face recognition seems to offer several benefits over other biometric technologies. Some or the other voluntary measures are required to all these technologies by the users, i.e., the users are required to keep his or her hand on the device for finger printing or hand geometry scanning and also required to stand in front of the camera in stationary position for retinal or iris scanning. However, face recognition does not require any explicit measure and can be done passively even without need of participation of the user as cameras can capture the images from distance. This is useful especially for surveillance and security purposes where images from surveillance cameras may be used for detection [3]. Eventually, technologies in which large number of crowd use the same device to take images of their biological features possibly expose the users to transmit the germs, viruses and impurities from one user to another. Nevertheless, face identification is absolutely non-invasive and do not carry any such type of health related.

The human face plays a key role in identification and individuality of a person from the rest of the people in the human society. Regardless of so countless faces in the human society, human eye can recognize each faces distinguishly even at a glance. Human face recognition is a topic of research with the aim of developing a computer based program for recognizing faces similar to ability of human eye combined with its brain. The studies were carried out by researchers over so many years which shows that some facial characteristics were used by human beings to identify faces. The early systems was using comparison of features like eyes, nose, ears and mouths based on distances and ratios. Takeo Kanade (1973) developed the idea of picture processing system based on the manual properties detection [4]. M. Turk and A. Pentland [5] done commanding work in development of basic essential steps of Principal Component Analysis (PCA) algorithm to authorize the face [5]. Majority of after research work was followed by basics developed by M. Turk. They gave idea of using PCA algorithm and developing a vector space and Eigen face. Ningthoujam Sunita Devi, K. Hemachandran [6] Ramandeep Kaur, Er. Himanshi [7], Erwin, M Azriansyah, N Hartuti, Muhammad Fachrurrozi, Bayu Adhi Tama [8], Louis Asiedu, Felix O. Mettle, and Joseph A. Mensah [9] Dinariyah and Alamsyah [10], all worked on face recognition using PCA on various datasets. They have also highlighted

tradeoff between complexity, computational time, storage space and recognition accuracy.

PCA have many advantages like storage and computational effectiveness, and less complexion implementation. It does not require manual selection, supervision at every step and it is free from localization accuracy issues. PCA does not classifies faces utilizing geometrical dissimilarities. On the contrary, a group of faces are examined using it to identify which "variables" report for the discrepancy of faces. In face recognition technique, these variables are known as Eigen faces because when it is plotted it showcase a weird face similar to human faces. As stated by Johnson and Wichern [11], "principal component analysis (PCA) helps in clarifying the variance-covariance structure with the help of several linear combinations of original variables."

From literature review, it was figured out that the focus area of earlier research by using PCA was mainly focusing Recognition Rate Accuracy (RRA) and precision. Also, work was done in the direction of detecting the face image under different type of poor image like scaling, non-frontal image, presence of shadow, illumination etc. The missing area was improvement in Time Taken in Recognition (TTR) and storage space used. These two areas are of much importance to our modern life when resolution of captured images, videos either from Mobile phones, cameras or whatever device is being used, is increasing day by day which is need of current hour [12]. In the time of big data, artificial intelligence and machine learning the image resolution and space taken by each image for storage is also increasing. The PCA technique calculations takes time on basis of number of image and the size of each image. In this paper, a method has been demonstrated for improving Time Taken in Recognition of a face image without compromising the recognition rate.

After introduction in Section 1, Section 2 describes the proposed method of combining PCA with Wavelet Transform. Section 3 discusses about experimental results. Section 4 concludes the paper including future work.

2. Proposed Method

The method proposed in this paper is based on combining PCA and Discrete Wavelets Transform (DWT). The combined algorithm will have all

the advantages of PCA as well as DWT. First the face image is preprocessed by using 2-D DWT which provides three benefits: (1) Dimensionality Reduction. (2) Multi-resolution Data approximation, and (3) Insensitive Feature extraction.

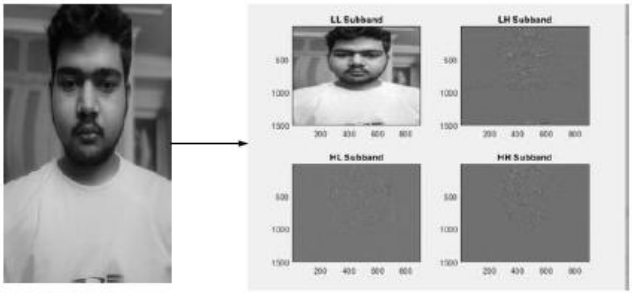

Figure 1. Sub-bend LL, LH, HL and HH after one level DWT of a face image.

After application of DWT a face image is decomposed into four different sub-bands having equal size which is 25% of the original face image as shown in Figure 1. The LL, HH, LH, HL sub-bands, corresponding to approximate, Diagonal, vertical and horizontal features respectively. The LL is corresponding to the low frequency components in horizontal as well as vertical directions. HH corresponds to high frequency in both directions. The present description was about one-level decomposition after applying DWT. LL sub-band represents the image as it contains most useful information.

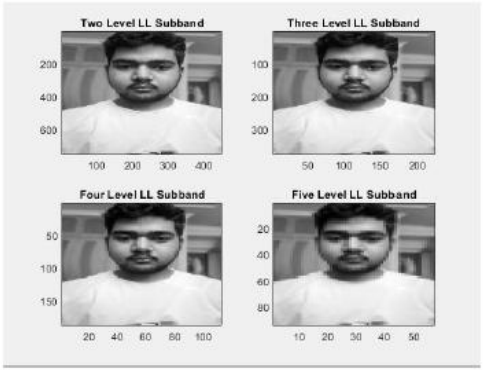

Figure 2. LL sub-bend after Two, Three, Four and Five level DWT.

The higher levels of decomposition on LL sub-bend as per the requirement may be performed, like four or five or any other level

decomposition as represented in figure 2.

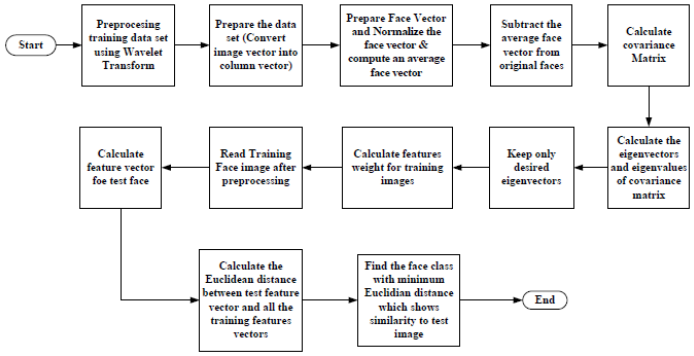

Figure 3. Proposed Algorithm.

After application of DWT on face image, the images are simply fetch to PCA system where the normal PCA operations like calculation of mean face, average face, covariance matrix, Eigen vector, Euclidean distance and identification of face images takes place as shown in figure 3. Here, it is important to notice that at application of one level of DWT at LL sub-bend, the size of resultant LL sub-bend at next level is 25%.

3. Experiment and Result

For the experiment Yale dataset have been used which is a set of 165 grayscale face image of 320 X 243 pixels. Yale dataset consists of face images in different styles of 15 subject each having 11 images with attributes like w/glasses, center-light, happy, left-light, normal, w/no glasses, right-light, sleepy, surprised, sad and wink. The results are shown in the Table 1 and 2. In the table 1 and 2, Training dataset % indicates how many images were used as training and testing dataset out of total image. Wavelet type used at each stage is “haar”.

From the results it can be seen that the wavelet transform improves the speed of recognition up to 18.03%. Also, it was observed (Table 2) that when no of images in the training datasets reduces beyond 60% or less, the speed improves but the recognition rate deteriorates. It was also observed that at higher no of levels of wavelet use, the testing time does not significantly reduce as the number of eigenvalues plays important role than the size of the

each image. Since images of Yale Dataset is having only size of 320 X 243 pixels for which at higher level of wavelet transformation the size of image reduction does not plays important role in speed of recognition but the number of eigenvalues plays important role. The higher level of Wavelet is effective for higher resolution images for which each level of wavelet transform reduces a significant amount of data for calculation which improves the recognition speed.

Table 1. Performance comparison in terms of speed.

Training Dataset %	Without DWT	One level DWT		Two level DWT		Three level DWT		Four level DWT	
	TTR	TTR	SI (in %)	TTR	SI (in %)	TTR	SI (in %)	TTR	SI (in %)
100	17.25	15.44	10.49	14.14	18.03	14.33	16.93	14.54	15.71
90	17.09	15.08	11.76	14.02	17.96	15.05	11.94	14.53	14.98
80	15.59	14.89	4.49	14.83	4.87	14.30	8.27	14.60	6.35
70	15.09	15.58	-3.25	14.27	5.43	14.26	5.50	15.81	-4.77
60	15.09	14.91	1.19	14.72	2.45	14.23	5.70	15.13	-0.27

*TTR = Time Taken for Recognition of each image in milli second.

SI = Speed Improved in comparison to method without DWT.

* Time Taken for Recognition (TTR) of each image may vary machine/computer to machine/computer as per its capacity. Here the purpose is to only show % recognition time reduction in computed/recognized time taken by a machine/computer.

Table 2. Performance comparison in terms of Recognition rate accuracy.

Recognition Rate Accuracy (RRA)(in %)					
Training Dataset %	Without DWT	One level DWT	Two level DWT	Three level DWT	Four level DWT
100	99.39	99.39	98.79	98.18	98.18
90	98.79	98.79	97.58	96.97	96.97
80	97.58	97.58	96.97	93.94	95.15
70	96.97	96.97	93.94	91.52	93.33
60	93.94	93.94	91.52	91.52	92.12

The above analysis reflects that over 70% of images are uses for training datasets, then accuracy of results is better compared to results obtained using less than 70% images for training datasets. Here, it is interesting to mention

that a few images which were having effect of dual faces present in the face image were mostly unrecognized every time.

For re-verifying the accuracy of proposed method, a dataset have been created where the result may be seen in figure 4 where the tested images are satisfactorily matches the faces from training datasets.

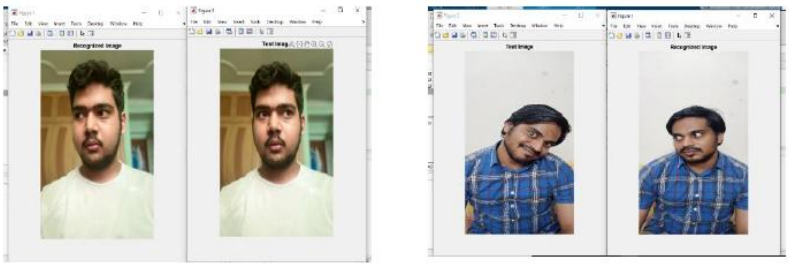

Figure 4. Results.

4. Conclusion and Future Work

The proposed algorithm was tested and implemented using MATLAB which works well with almost all type of images. This technology is rapid and comparatively easy that can exhibit well in almost all constrained environment. Use of wavelet transform has resulted in speed improvement upto 18.03% without any significant change in the recognition rate. Although the algorithm is quite easy to implement and less expensive computationally but has certain limitation where it requires proper centered faces and a fix dimension of all image. This is also sensitive to shadows, lightening and scale of image. The proposed method may be used in automatic recognizing high resolution faces images captured from surveillance systems based on which further decisions may be taken. In future work, other wavelet types or combinations may also be used for improvement in the performance. From the real world environment data, techniques may be designed without need of image and size tuning.

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