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AUTOMATIC EXAM ATTENDANCE SYSTEM BASED ON ILLUMINATION INVARIANT FACE RECOGNITION

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ABSTRACT: Security systems are used in several ways. In the developing technology, the computer systems are employed to solve different kinds of problems whereas they can be also used for security purposes. Application of the computer-aided security systems are one of the applicable technologies today especially in the crowded places such as entrance gates where high security measure is requested. On the other hand, automatic face recognition is useful in the applications where the recognition of the authorized people should be completed in a limited time. An application, that is the identification of the students for exam security is one of the important issues in universities where crowded exams take place. Unidentified people other than one's own examinations can be defined as problematic in terms of exam assessment. The paper proposes a new automatic class attendance system based on illumination invariant face recognition. System consists of three stages which are the face detection, facial feature extraction and classification. A known method will be employed for face detection part. For the facial feature extraction stage, non-subsampled Contourlet transform is used. The classification is done by the use of a known method which is the correlation coefficient. The system is currently under test and expected to run at acceptable recognition rates to be used in an automatic class attendance system.

Key words: Automatic attendance, face recognition, non-subsampled contourlet transform (NSCT), exam security, student authorization.

INTRODUCTION

Recent developments in the areas of image processing and computer vision make real time authorization systems applicable. There are several biometrics to authorize a person like fingerprint or iris recognition. On the other hand, a biometric to be chosen for a classroom attendance system should be adapted to the classroom constraints like limited time. Thus, real time face recognition is the most applicable method of person identification to be used in an automatic attendance system.

We recommend the automatic face recognition system primarily to provide the safety of the university exam halls, which will be used for detecting the identity of the students participating in the exam. In this way, computer assisted system will help invigilators to report the attendance in a limited time. The proposed system will be able to recognize the human faces, and then matching operation through the database of the university will be made by performing the analysis. The faces are to be captured in the classroom environment. Firstly, a known face detection method will be applied to detect faces in the images. Then, by using non-subsampled contourlet transform (NSCT), obtained images are then to be transformed into multiscale and multidirectional contour information for face recognition where the intrinsic geometrical structures are used for characterizing feature vectors. Finally, a correlation matching procedure will recognize the unknown face by comparing with the database of the classroom.

There are recent studies about the implementation of classroom attendance system based on face recognition. N. Kar et al. (2012) implemented a classroom attendance system based on face recognition. Their face recognition method is based on Principal Component Analysis (PCA) algorithm. Patil and Shukla (2014) proposed a face recognition based classroom attendance system in which a hybrid method of PCA and Linear Discriminant Analysis (LDA) with Viola and Jones face detector.

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The organization of the paper is as follows. First, the face recognition methodology is presented in three sub sections which are face detection, facial feature extraction and classification. Then the Results section presents the preliminary performance tests. Finally, the article concludes with a summary of the next directions.

METHODS

The methodology can be analyzed in three parts: Face detection, facial feature extraction and classification. The block diagram of the overall system is given in Figure 1.

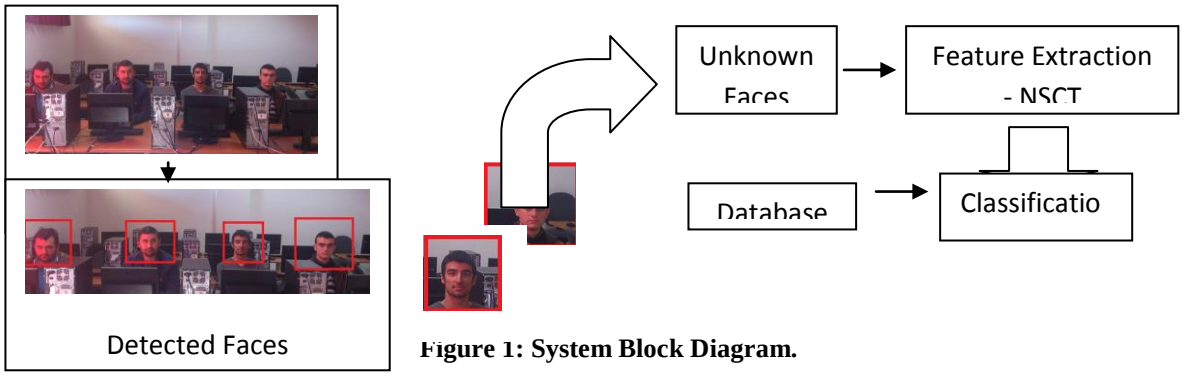

Figure 1: System Block Diagram.

Face Detection

The face detection part is a vital stage for a face recognition system. A false detection decreases the overall recognition performance. A known successful face detector which is the algorithm of Viola and Jones is planned to be used as the face detector (Viola P., Jones J. (2004)).

Facial Feature Extraction Using NSCT

NSCT method is employed for facial feature extraction. The main reason for the choice of NSCT is based on its effectiveness to capture the smooth contours and geometrical structures in the image. Different and flexible number of directions at each scale can be provided by contourlet transform, while achieving anisotropy and shift invariance properties compared with other multi-scale directional systems. NSCT obtains a sparse image representation due to its properties such as directionality and shift invariance by first applying a multiscale transform and then applying a local directional transform to gather the nearby basis functions at the same scale into linear structures. The multiscale transform essentially performs an edge detection operation, and the local directional transform performs contour segment detection. Extracted facial geometric properties from the detected human face will be assumed to be facial features. After that, classification depending on the face geometry could be applied.

Do and Vetterli (2005) proposed contourlet transform (CT) to represent two dimensional singularities, which is composed of Laplacian pyramid and directional filter bank. Due to its directionality and anisotropy, the transform can represent curve more sparsely. Non-subsampled contourlet transform (NSCT) presented in (A.L. da Cunha, Jianping Zhou, and M.N. Do (2006)) based on the theory of CT, and is a kind of multiscale, multidirectional computation framework of discrete images. The whole course of NSCT is still composed of two stages, including multiscale analysis and multidirectional analysis, which are similar to those of CT. The NSCT is also shift-invariant so that each pixel of the transform subbands corresponds to that of the original image in the same spatial location. Therefore, we gather the geometrical information pixel by pixel from the NSCT coefficients. Furthermore, Cheng et al. (2010) reported that feature extraction based on contour analysis is an effective way for face recognition under varying lighting conditions. All directional contour subbands can be expressed by

$$\{C_{m,d}\}, m = 1,2,...,k; d = 1,2,...,l_m; \\ k \in (1,2,...,N), l_m = 2^N \quad (1)$$

where m and d are the scale and direction of the decomposition respectively, k is the number of contour decomposition scale, l_m is the number of contour decomposition directions of m^{th} scale and {Cm, d}is the coefficient at the d^{th} directional subband of the m^{th} scale.

Directional contour subbands of NSCT only include spectrum information and keeping the most significant coefficients will directly lead to improvement in feature extraction (Po et al. (2006)). Thus in this letter, we propose to represent images under varying lighting conditions by using the directional coefficients having the maximum spectral norm.

$$P(x,y) = \max_{\{C_{i,j}(x,y)\}} \left(\left\| C_{i,j}(x,y) \right\|_2 \right), \quad i = 1,2,...,m; \; j = 1,2,...,d \tag{2}$$

where $\|\square\|_2$ is the spectral norm and P(x, y) is the coefficient point (x, y) at the jth directional subband of i^{th} scale. We observe that in the NSCT domain, the illumination component corresponds to those pixels with positive coefficient points and the reflectance component mainly corresponds with negative coefficient points. Since the reflectance component is considered as the intrinsic facial features, it can be directly used for face recognition. Based on this observation, Binary-NSCT, B(x, y), of an image is defined as

$$B(x,y) = \begin{cases} 1, & \text{if } P(x,y) > 0 \\ 0, & \text{if } P(x,y) \le 0 \end{cases} \tag{3}$$

After extracting the intrinsic geometrical information by this simple binarization process, the illumination invariant representation can be reconstructed from the Binary-NSCT coefficients by inverse NSCT. Figure 2 shows an example of constructing Binary-NSCT by using contourlet transform with three scales and four directional subbands in each scale.

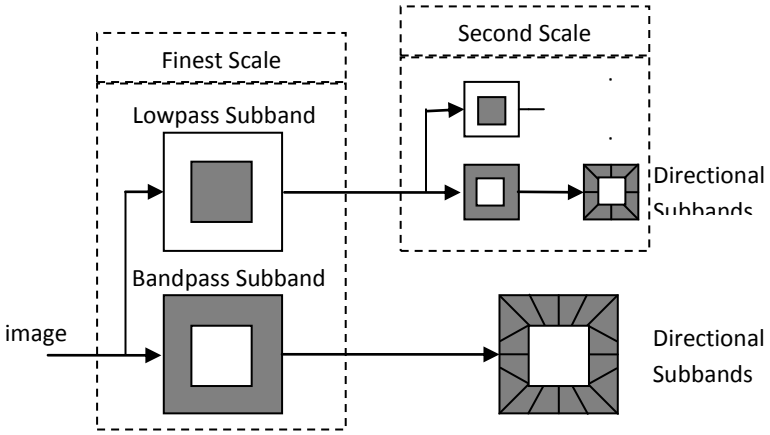

Figure 2: Structure of the Non-subsampled Counterlet Transform with Two Levels of Decompositions.

Face Classification

The last stage of the face recognition based attendance system is the face classification where an unknown face is to be classified with one of the known faces in class database. Currently, a correlation coefficient based classifier is employed in order to be a base for future classification method.

The correlation coefficient used r, is given in Equation 4 where A and B are two matrices. $\overline{A}$ and $\overline{B}$ represent corresponding mean values, m and n represent image dimensions.

$$r = \frac{\sum_m \sum_n (A_{mn} - \overline{A})(B_{mn} - \overline{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \overline{A})^2 \right) \left(\sum_m \sum_n (B_{mn} - \overline{B})^2 \right)}} \tag{4}$$

The inputs to the classifier are the output images supplied by NSCT algorithm. Each unknown face in NSCT form undergoes a matching procedure using Equation (4) where A is the unknown face and B varies among the registered known faces which are planned to be in the database of each classroom. Then, the maximum correlated face image will be selected as the classified face. Figure 3 shows examples of input images to the classifier.

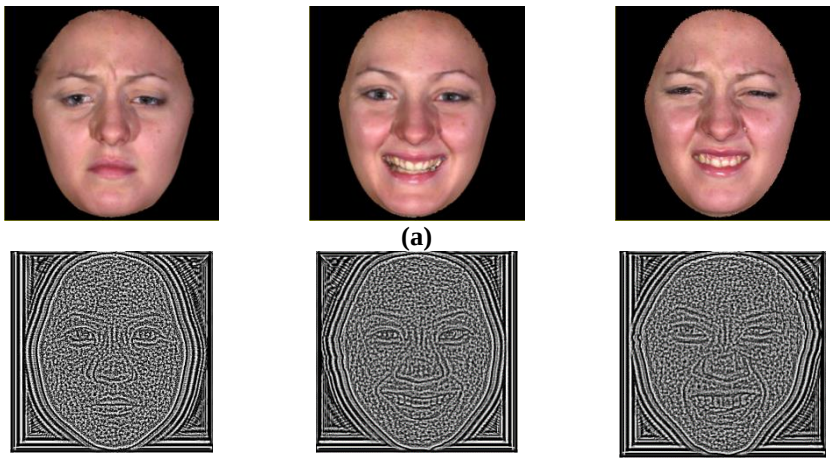

Figure 3: Input Face Images (a) and Their Corresponding Illumination Invariant NSCT Representations (b).

RESULTS

The system is currently being tested with two different databases which are Yale database and BU-3DFE database. NSCT based face recognition algorithm already performed at high rates on Yale database reported in H.Soyel, B.Ozmen and P.McOwan (2012). However, in their study, the facial expression constraint was not tested. Differently, in this study, we are testing the system on BU-3DFE database (proposed in Yin et al. (2006)) in order to evaluate the performance under different facial expressions. BU-3DFE is a facial expression database that includes 6 different expressions of the face, anger, disgust, fear, happiness, sadness and surprise in four degrees. Obviously, a face can be in different expressions and in the classroom environment facial expressions should be considered as constraints to the system. Therefore the system performance on both databases, with or without facial expressions, will set the overall system performance.

CONCLUSION

The paper proposes an automatic class attendance system based on illumination invariant face recognition. The contribution of the paper is that it is proposing to employ NSCT transform for expression independent illumination invariant face recognition. The system is currently being tested on two different databases which are Yale and BU-3DFE face databases. The future works are the creation of sample classroom database, completion of offline tests on two databases and the real time tests in the classroom. It is expected to provide expression and illumination invariant robust face recognition system to be used in classroom environment for automatic attendance application. Furthermore, automatic attendance system will be useful in examination halls where there is a limited time to authorize the participants of the exam.

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