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A Novel System for Face Recognition to Identify Occlusions and Restoration of Image

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Abstract. Face recognition system has emerged as an important field in case of surveillance systems. Since three dimensional imaging systems have reached a notable growth, we consider 3D image for face recognition. Occlusions(extraneous objects that hinder face recognition e.g., scarf, glass, beard etc.,) are one of the greatest challenges in face recognition systems. Other issues are illumination, pose, scale etc., Aninnovative three dimensional occlusion detection and restoration strategy for the recognition of three dimensional faces partially occluded by unforeseen objects is presented. One of the main motivations of 3D face recognition is to overcome the problems in 2D recognition methods resulting from illumination, expression or pose variations. An efficient method is used for detection of occlusions, which specifies themissing information in the occluded face. A restoration method then eliminates occlusion and renders restored facial image. It exploits the information provided by the non-occluded part of the face to recover the original face. Restored faces are then applied to a suitable face recognition system. The proposed system will provide better accuracy to eliminate the occlusion and restoration method is independent of the face recognition method.

Keywords: 3D face detection, 3D face recognition, face occlusion, face restoration.

1. Introduction

Facial recognition is a method for automatically identifying or verifying a personfrom digital image or a video frame from a video source. This can be achieved by comparing selected facial features from the image with facial database. Face recognition is one of the most relevant applications of image analysis. The growing availability of three dimensional imaging systems has paved the way to the use of 3D face models for face recognition. A face recognition system has to be robust to occlusion in order to guarantee reliable real-world operation[11].It involves a number of pre-processing steps prior to recognition such as localization, normalization, feature extraction etc., Several issues complicate the task of face recognition which includes pose, illumination, expression, occlusion etc.,2D face recognition systems are sensitive to conditions such as illumination, head orientation and facial expression and variation in scale can be overcome by geometric normalization[4]. Hence, to overcome these issues and improve the efficiency in achieving the results, the problem of occlusions is handled using 3D images.

2. Related Work

Generally, when the type of occlusion is known, a specific strategy can be used to eliminate the occlusion and a suitable face recognition strategy can be used. For example, park et al. [1] proposed a method which could eliminate the occlusion caused by glasses in the frontal face. Kim et al. [2] have proposed a part-based local representation method called Locally Salient Independent Component Analysis

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(LS-ICA) that works for specific occlusions. The problem of detecting occlusions in 2D faces has been investigated by Lin and Tang [8]. They derived a Bayesian formulation unifying the occlusion detection and recovery stages. Colombo et al. [3] proposed a fully automated system for face detection and recognition which are occluded by unknown objects where the occluded regions are first detected by considering their effects on the projections of the faces in a suitable face space. A different approach has been investigated by Tarres and Rama [9]. Instead of searching for local non-occluded features, they try to eliminate some features which may hinder recognition accuracy in the presence of occlusions or changes in expression. De Smet et al. [10] proposed an algorithm which iteratively estimates the parameters of a 3D morphable face model to approximate the appearance of a face in a 2D image. Simultaneously, a visibility map is computed which segments the image into visible and occluded regions. Zhang et al. [12] proposed a method based on local Gabor Binary patterns where the face is divided into rectangular region and, on the basis of their graylevel histograms, the probability of occlusion is estimated.

This paper is organised as follows. Section 3 deals with the concept of occlusions. Section 4 deals with the system design and Section 5 deals with the methodology used in the paper.

3. Occlusions

Face recognition system contains an image with facial data given as an input to the system. It is accompanied with feature extraction which involves obtaining relevant facial features from the data. In the face recognition context, occlusions involves that some parts of the face cannot be obtained. There are objects that can occlude facial features such as glasses, hats, beards, haircuts etc.This leads to the absence of some parts of the face which may result in bad classification. Thus Partial face occlusion is one of the most challenging problems in face recognition. Therefore, the face recognition system has to be robust to occlusion in order to guarantee reliable real-world operation[11].Since 2D image does not provide sufficient information about the features in the face, 3Dimages are considered [4]. The work can be done with both real occluded faces or occlusions can be generated in a non-occluded face by acquiring a facial image and occluding object separately and applying the objects over the face to generate a real occlusion. This enables comparison of the efficiency of the non-occluded part of the face with the restored faces.

3.1. Artificial occlusions

Artificially occluded sample images used in the work have several advantages over real acquisition of occluded faces that can be listed as follows [4]

- A great variety of occlusions may be generated, varying in shape, position, and size, allowing for an in-depth evaluation under different conditions
- Since the mask of occluded regions is immediately available (without manual annotation) we can accurately measure the precision in detecting occlusions
- The accuracy of the non-occluded faces provided by the restoration module can be compared with the information provided by the non-occluded faces.

Generation of artificial occlusion is a common task. Typically occlusions are generated by corrupting the original image by introducing a patch of some fixed value or blobs of noisy pixels [4]. Working with real occlusions of faces is a problematic task since annotation of ground truth is not possible. In the artificial occlusion generation the same device is used to generate both the facial image and the occluding object.

4. System Design

A practical face recognition system needs to work under different imaging conditions, such as different face poses andillumination conditions. Hence before the face is subjected to any face recognition system pre-processing steps such as normalization, feature extraction has to be carried out in order obtain efficient face recognition results. This paper involves obtaining a 3D facial image and the occluding object separately. A patch of the occluding object is applied over the face to generate the occlusion. We generate this type of occlusion because the acquisition of a large number of occluded faces and their annotation with a ground truth are costly and time intensive operations. Moreover, several in-depth analyses may not be possible because information about the regions covered by the occlusions is not available. Since we used only 3D information, it is possible to produce artificially occluded faces which are hard to distinguish from faces with real occlusions even by a human observer. Original samples of the occluded facial images are also made available since the recognition performance of the occluded image is to be calculated with regard to the non-occluded samples of the images.

Occluded images have to be normalized in order to overcome any pose and orientation variation with respect to the sample image. Since the final face recognition system is an application of any identity verification system, frontal face images are to be considered in this case. Normalization is the process by which contrast enhancement of the image could be achieved. Normalized images are generally robust to rotation, translation and scaling. So subjects can be easily identified using normalized image, since variance of the normalized image of the same subject is lower than the variance of the original image of that subject. Here, since the image has to be scaled and rotated to the frontal view, the occluded test image, irrespective of its position has to be normalized to obtain the frontal position. Contrast enhancement can be used when pose and illumination variations co-exist. Contrast enhancement, in general, is achieved by utilizing the entire brightness range in a given image. Once images are normalized to obtain the frontal view, next feature extraction is carried out for efficient face restoration.

In this paper, we are dealing the problem of occlusions in facial images. Since not all the facial features will be available, features have to be extracted prior to the restoration module. The method used here finds the edges of the feature points. The skin colour map is used if the eye region is not available. The face restoration process which follows the feature extraction used here considers the available information provided by the feature extraction. Only the regions which are considered to be uncovered as the result of this step, helps in the restoration method. This varies with respect to the type of the occlusion and the amount of the regions covered due to the occlusion. For efficient face restoration to be carried out, at least two facial features must be available. The feature extraction method to be used prior to the face restoration should be invariant to pose and orientation.

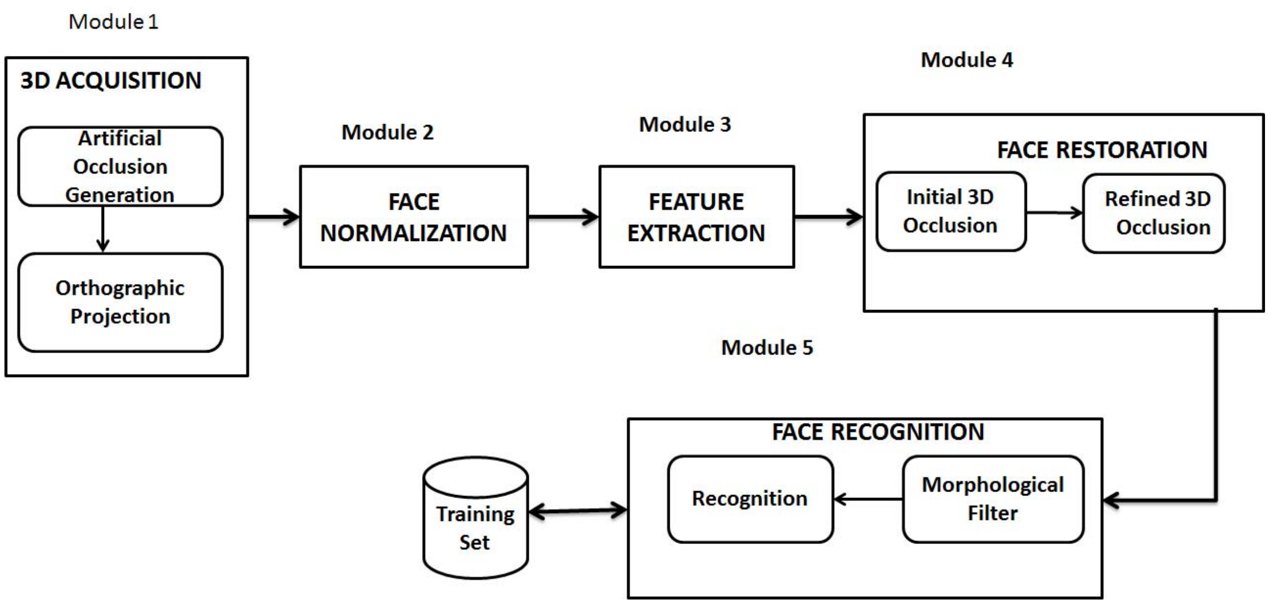

Fig. 1: System Design

5. Methodology

Occluded faces are obtained by applying an object over the normal 3D facial image. The three dimensional faces are encoded as range images, images whose pixels are labelled with the coordinates of a point in 3D space. The range images have been obtained by an orthographic projection of the acquired images on a plane. This is because for surfaces like human faces, the orthographic projection retains almost all the information about three dimensional shapes [4]. We consider any part of the acquired 3D scene that does not look like part of a face and lies between the acquisition device and the acquired face to be a generic occlusion (occluding objects may not touch the face). In other words, sets of points which do not fit the model of a non-occluded 3D face are classified as occlusions.

5.1. Normalization

The feature extraction module finds the possible facial features which presents the occluded regions. Once the artificial occlusion is generated, the Next step normalization is carried out. Wavelet Normalization is used for this purpose. This method is efficient for illumination and pose conditions. It first decomposes the image into its low frequency and high frequency components.In the two-band multi-resolution wavelet transform, signal can be expressed by wavelet and scaling basis functions at different scale, in a hierarchical manner.

$$f(x) = \sum_k a_{0,k}\, \emptyset_{0,k}(x) + \sum_j \sum_k d_{j.k}\, \varphi_{j.k}\,(x)$$

$\emptyset_{0,k}$ arescaling functions at scale j and $\varphi_{j.k}$ arewavelet functions at scale $j.\, a_{0,k}$, $d_{j.k}$ are scaling coefficients and wavelet coefficients. Contrast enhancement can be done by histogram equalization of the approximation coefficients and meanwhile edge enhancement can be achieved by multiplying the detail coefficients with a scalar (>1). Histogram Equalization is applied to the approximation coefficients and at the same time accentuates the detail (high frequency) coefficients by multiplying by a scalar so as to enhance edges. A normalized image is obtained from the modified coefficients by inverse wavelet transform [5]. The resultant image has not only enhanced contrast but also enhanced edges and details that will facilitate the further face recognition task.

5.2. Feature extraction

TheFacial features are extracted from the Normalized facial image. This is done by the dual tree complex wavelet transform. This provides a direct multiresolution decomposition of a given image. This method works well for the direct upright frontal images. Frontal images are already obtained by the wavelet normalization method which is already described. The desirable characteristics of the DT-DWT(S) such as spatial locality, orientation selectivity and excellent noise cleaning performance provides a framework which renders the extraction of facial features almost invariant to such disturbances. The norm of complex directional wavelet sub band coefficients is used to create a test statistics for enhancing the facial feature edge points. The Rayleigh distribution of the derived statistics matches very closely with the true coefficient distribution in the 6 directional sub bands. The use of the complex wavelet transform helps to detect more facial feature edge points due to its improved directionality. Additionally, it eliminates the effects of non-uniform illumination very effectively [6]. By combining the edge information obtained by using DT-DWT(S) and the non-skin areas obtained from the skin color statistics, the facial features can be extracted.

5.3. Face restoration

Thefacial feature extraction provides the necessary information for subsequent face restoration and recognition process. The key idea in restoration is to use the available information provided by the facial feature extraction. For this a preliminary mask is computed by calculating Distance From Feature Space (DFFS), by thresholding vector ‘e’. This results in the preliminary mask calculation.

$$M_i = \begin{Bmatrix} 1 & if\ e^i > \tau \\ 0 & if\ e^i < \tau \end{Bmatrix}$$

$\tau$is the threshold that takes into account the resolution of the imaging device, acquisition noise and the accuracy achieved in normalization. After the mask calculation,the occluded regions are restored by having the information provided by the feature extraction.

5.4. Face recognition

Therestored face isfinallyused for face recognition. The method used for face recognition is Average Regional Model (ARM). The aim of the method is to find regional correspondences between any two face. It consists of the following steps, i) coarse and dense ARM-based registration, ii) region-based matching, and iii) classifier fusion. Global coarse registration is carried out to roughly align a given 3D face image to the AFM. ARMs are constructed on the AFM by determining the semantic regions manually. The whole facial model is divided into four parts: eye-forehead, nose, cheeks, and mouth-chin regions. Dense registration [7]is carried out by aligning local regions with ARMs using the ICP algorithm. Each region over the test face is registered to its corresponding average regional model separately. Registered regions are then regularly resampled. Therefore, after local dense registration, facial components are automatically determined over the given facial surface.

This recognition method provides efficient results for faces with occlusions and expressions.

6. Results and Discussions

An innovative face recognition method for occluded faces which is one of the applications of the identity verification system is developed. This system can also be applied for faces with varied expressions.Normalization provides facial image with sharper details even under occlusion. Feature extraction is carried out prior to restoration, which accentuate finer details for face recognition. Restored faces are recognized using a method which divides the face into individual regions by fusing all independent regions and automatically detecting/removing occluded regions. The recognition method used is independent of restoration and can be applied for restoration of faces even with noise and self-occlusion.

7. Conclusion

An efficient face recognition system which is robust to occlusions and expressions is proposed. This System provides better results for face restoration and face recognition and handles three dimensional images. The efficiency of the proposed work will be compared with the existing system and the performance will be highlighted.

8. References

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