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Color Based Face Recognition Using Template Based Approach

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Abstract. Face recognition has gained an extensive attention from research point of view. This area is still remained with many challenging problems in day to day application. Many face ientification algorithms have been implemented during past two decades. This paper provides a template based technique for face recognition. Performance of the method considered in the paper is improved by considering preprocessing steps such as image restoration, using Wiener filter to minimize noise and smoothing the degraded input images. Next face detection step using skin color based segmentation for selecting only facial skin areas inorder to execute face recognition process. A template image database is used as traning set. Algorithm is tested over FERET database images. Experimental results showed that our algorithm is invariant to illumination change, change in pose, presence of salt pepper noise up to 0.05 density, inplane rotated images up to ±55 degrees. Accuracy of our algorithm is 100% in almost all input image cases.

Keywords: face recognition, image restoration, wiener filter, skin color based face detection, template based face recognition.

1 Introduction

Image based face identification is a very interesting and demanding area even after two decades of research. There are many number of security, commercial and forensic applications, there is a need for the use of face recogniton technologies. A face recognition or identification approach is use to match human faces stored in an image database and videos automatically. It can be performed in two ways, face verification and face identification. Face verification or authentication performs a one-to-one identity that verifies a query image with a template face image whose identity is being claimed. Face identification or recognition[1][2][3][16] is an one-to-many matching process that verifies a query face image with all the template image in the database to determine the identity of query face or image. Face recognition is mostly used in biometric systems for personal verrification or identification in case of passports, driving license, virtual reality, human computer interaction, surviellance, database retrieval, law enforcement like investigation etc. Steps in the process of face recognition are image acquisiton, image restoration, face detection and face recognition shown in figure-1.

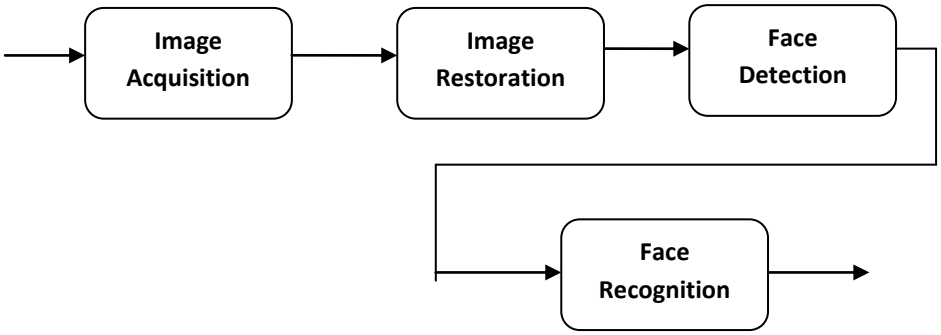

Figure-1. Process of Face Recognition System

Image acquisition is the process of acquiring an digital image from number of source, generally a hardware, so that it is used for further processing. Image restoration[7][8][9] is a method of compensation or undoing the defects or noise from a degraded image. Degradation can be because of noise, motion blur and camera misfocus. Face detection[10][11][12][13][14] is a technique used in the process of face recognition for identfying human faces areas in the digital images.

Face recognition approachess[1][2][3][16][17] can be categorized into four types. They include holistic, feature based, template based and part based approaches. Holistic method considers entire face area as an input data for face identification approach. It calculates some transformation on the input data to obtain a compact representation for face recognition. Principal Component Analysis(PCA), Independent Component Analysis(ICA), Linear Discriminate Analysis(LDA) are some of examples. Feature based methods make use of more information from domain knowledge of human face, computer vision and image processing. They deduce the facial features or features from considered complete face and next aquired features are used to compare in face recognition system. Local binary pattern, Gabor wavelet feature are some example methods. Template based tecniques[4][5][6] check the query input image with stored templates of human faces. Part based approaches locate the necessary area from the face image and combine this area with machine learning tools for face recognition process. Support Vector Machine is a part based approach. Templates are obtained by deleting unnecessary parts in the image.

Inplane rotation, immune to noise, illumination change, head pose, expression change, aging, occlusion are some of the challeges in face recognition system. A face identification system must be uniform or same to these challenges, based on which the capability of the approach is calculated. This paper includes a template based method that is uniform to head pose, inplane rotation, illumination and immune to noise. The algorithm is able to recognize the images both in single and multiple face images.

The paper is arranged in the following order: section -2 deals with proposed steps of face recognition algorithm, section-3 discusses about performance evaluation of the approach specified, section-4 deals with conclusion.

2 Steps of Proposed Face Recogniton Algorithm

2.1 Image Acquisition

A way of obtaining or capturing the image from physical source like imaging hardware such as digital cameras, scanners, faxed pictures , digital videos etc and modifying it into manageable image data is called as image acquisition.

2.2 Image Restoration by Wiener Filter

Image restoration[7][8][9] is a method used for considering a noisy or corrupted or degraded image and estimating the clean, actual image. Image restoration is used to remove the noise and get back thw resolution loss. It is an undo operation to reduce the noise from a corrupted image. A degradation or corrupted model/restoration method is shown in figure-2.

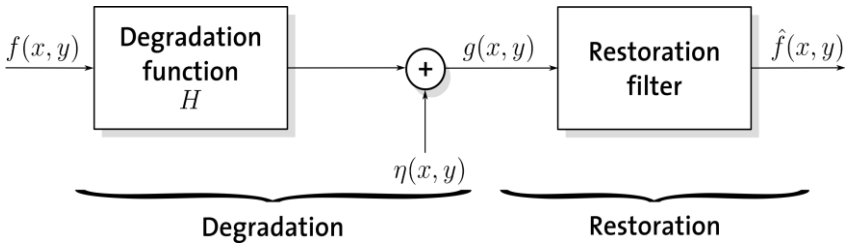

Figure-2. Image Degradatin/Restoration process

Where f(x,y) is original image, g(x,y) is degraded image, H or h(x,y) is blurring function, η(x,y) is noise.

Restoration is a process of getting back of original image f^(x,y) from the degraded image. Recovering is performed by using filtering operation. This is done by deriving or estimating the degradation operation and apply the reverse function of degradation to restore the actual image f^(x,y).

Degradation or corruption of an image may be because of noise, blur, camera-mis focus etc. Recovering from noise is done by noticing and assesing the noise type and parameters, apply and check the result otherwise adjust filter type and parameter. Restoration from bluring can be done by using inverse filter, wiener filter and Blind convolution.

Algorithm considered in the paper uses Wiener filtering for restoration. Wiener filter performs an best tradeoff within inverse filtering and noise smoothing. Wiener fiter carry both reducing of noise and removing blurring effect. It minimizes the overall mean square error. Optimal Wiener filter W(x,y) with minmum Mean Square Error is given by

$$W(x,y)= h(x,y) / (|h(x,y)|^2 + s_{\eta\eta}(x,y)/s_{ff}(x,y))$$

where $s_{ff}(x,y)$ is power spectra of the original image, $s_{\eta\eta}(x,y)$ is additive noise and h(x,y) is blurring function.

2.3 Skin Color Based Segmentation for face detection

Face detection[10][11][12][13][14] is an required step in the process of face recognition. Face detection is a way to detach human faces area from the background and find its location in the given input image, regardless of their position, scale, pose, plane rotation, noise, illumination change etc. Face detection approaches can be grouped into four types. They include knowledge based approaches, feature invariant approaches, appearance based approaches and template based approaches. Knowledge based type rely up on group of rules about human face knowledge for detecting human face areas in a query image. In case of feature based or feature invariant approaches faces are obtained from the structural features of a faces. A classifier is used for classifying non-facial and facial parts. Appearanace or image based types employ a group of alternate training faces for detecting human face areas. In case of template based methods a predefined or parmeterized face template is used to detect the position of faces in a given input image. Every type of methods have their own benefits and disadvantages in view of accuracy, efficiency, complexity, speed etc.

Our algorithm make use of feature invariant face detection method to detect the skin areas in group image or single image. Skin color based segmentation[10][11][12][13][14] is a feature invariant face detection approach. This method make use of color information to seperate the skin areas and non-skin areas. Our face detection

approach use YCbCr color model for this purpose.

First the color features are aquired to characterize the skin areas from the background details in the given image. Next background subtraction is performed to remove the skin colored pixels in the background area. Thresholding is performed to convert U32 represented image into a binary image inorder to perform morphological operation. Then dilation followed by an erosion is applied to remove skin areas other than face part. Next to morphological operations smoothing filtering is applied to face detection operation efficient and to avoid false detections. Further particle analysis is performed. Particles of the face skin area are analyzed to generate the parameters like area ,width to height ratio and number of holes to identify only face area in given input image. A rectangle is overlaid on the face area by using overlaying operation. This face detection method is invariant to illumination change, inplane rotation, presence of noise, change in pose.

2.4 Construction of training set

Trainging database consists of templates constructed from FERET database. Algorithm for the construction of templates is as follows:

1. Pattern matching mask is defined and unwanted regions in the templates are removed.
2. Curve parameters like extraction mode, edge threshold, edge filter size, minimum length are specified to make the facial features clear. If necessary additional curves are drawn to enhance the operation of face template matching.
3. Normal curves and extra additional curves are modified and unwanted regions are removed in the template and offsets like angle x and y are set.

After the template database is ready, we can run the face recognition task.

2.5 Template Based Face Recognition

Template based method[4][5][6] compares the input image with stored set of templates of faces. When an input image is submitted to the system, image is passed through restoration process to remove the noise and smoothing it, if any. This step is performed to enhance the face recognition process. Then the face detection step is performed which detects the face area and draws a rectangle for face area indicating that face is detected in the given input image. Pattern matching algorithm of vision module is used to compare query image and template image. If a match of query image with one of template is found then number is overlaid on the face or faces(in case of multiple face image) to indicate that the face is recognized.

3 Performance Evaluation

Our template based face recognition is a new approach for face recognition. Algorithm is tested over the input images from FERET database. Experimental results conducted in Lab View showed that algorithm is able to recognize the faces under various factors such as change in illumination, presence of salt and pepper noise up to density of 0.02 to 0.05 , inplane rotation up to ±55 and pose change. Efficiency of our algorithm is 100% in almost all the cases. Below are shown some sample output images recognized under various cases for both single as well as multiple image inputs. Rectangular box in the output indicate the face areas are detected in the face detection step. Figure-3 shows the query images. Figure-4 shows the recognized images with various cases of illumination change, pose change, presence of salt and pepper noise and inplane rotation ane with

number overlaid on the face area and not recognized image(as they are not available in the database) without number.

Figure-3. Sample Input Images

Figure-4. Recognized And Not Recognized Query Images

4 Conclusion

In this paper we presented a template based face recognition approach with dimensionality reduction, for increasing the computational efficiency of the face recognition algorithm. We also considered the preprocessing steps such as image acquisition, image restroration and face detection. Image restoration is used to reduce the noise and smoothing the input image such that we can create the templates in further steps with more clear details and also increasing the computational efficiency. Face detection using skin color based segmentation is a feature invariant approach which effciently detects the face areas both in single and multiple images. Dimensionality reduction performed by creating the templates, for improving the efficiency or computational speed has been used. In the final step template based pattern matching is used to see whether the query image is present in the stored template database or not. Our algorithm is invariant to recognize the input images with change in pose, change in illumination, inplane rotation and presence of salt and pepper noise. Efficiency of the algorithm is 100%.

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