FACE AUTHENTICATION /RECOGNITION SYSTEM FOR FORENSIC APPLICATION USING SKETCH BASED ON THE SIFT FEATURES APPROACH

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Abstract- In this paper, an efficient algorithm for human face detection and facial feature extraction is devised.In the domain of face recognition, the SIFT feature [1] is known to be a very successful local invariant feature. The performance of the recognition task using SIFT features is very robust and also can be done in real-time. This project present an approach that adopt the SIFT feature for the task of face recognition. A feature database is created for the detection of generic face features and a model fitting algorithm is used to resolve the scale, orientation and position of the faces in images. Because of the advantages brought by the SIFT features, the system can easily detect faces of any scale and rotation. Furthermore, in order to improve the level of detection reliability in our approach, the lighting eject and orientation of the faces are considered and solved. The challenge of face recognition is that the performance is mainly constrained by the variations of illumination, expression, pose and accessory. And most algorithms which were proposed in recent years focused on how to conquest these constraints.

Keywords- Face recognition, Feature Selection, ,SIFT Features, Graphic User Interface, SIFT, SIFT descriptor.

I. INTRODUCTION

Yang et al. [2] classified the existing approaches into four categories: knowledge-based methods, feature invariant approaches, template matching methods and appearance-based methods. The first and third categories share some similar disadvantages because it is very difficult to enumerate all the possible rules or templates to describe and model the faces because of the countless variations of face poses and expressions. Different from the previous two approaches, feature invariant approaches use local features to represent the faces. For example, color and texture. The appearance-based approaches emphasize the global appearance of the faces and use statistical models, learned from a large training database, to describe faces .There are many different kinds of features used in different approaches. For example, wavelet is used by Papageorgiou and Poggio [3]; features similar to Harr-like basis function is used by Viola and Jones [4]. SIFT feature, by David Lowe [1], is a robust invariant local feature that have the property of scale and rotation invariance.

Detecting the location of human faces and then extracting the facial features in an image is an important ability with a wide range of applications, such as human face recognition, surveillance systems, human computer interfacing, video-conferencing, etc. In an automatic face recognition system [14], the "first step is to segment the face in an image or video irrespective of whether the background is simple or cluttered. For model-based video coding [15], the synthesis performance is quite dependent on the accuracy of the facial feature extractionprocess. In other words, a reliable method for detecting the face regions and locating the facial features is indispensable to such applications. This paper presents an efficient method for face detection and facial feature extraction in a cluttered image. Our approaches extend the successful method based on the Scale Invariant Feature Transform (SIFT). The authors have prepared a Matlab based GUI (graphical user interface) application for experimental testing of face detection and recognition effectiveness. Our programs are based on standard solutions. The face recognition system is based on the eigenfaces approach.

II. FACE RECOGNITION SYSTEMS

In general, an automatic face recognition systems are comprised of three steps. Their basic flowchart is given in Figure 1. Among them, detection may include face edge detection, segmentation and localization, namely obtaining a pre-processed intensity face image from an input scene, either simple or cluttered, locating its position and segmenting the image out of the background. Feature extraction may denote the acquirement of the image features from the image such as visual features, statistical pixel features, transform coefficient features, and algebraic features, with emphasis on the algebraic features, which represent the intrinsic attributes of an image. Face recognition may represent to perform the classification to the above image features in terms of a certain criterion.

Segmentation among three steps is considered. Previous work on the evaluations provides insights into how the evaluation of recognition algorithms and systems can be performed efficiently.

Figure 1. The basic flowchart of a face recognition.

III. FACE DETECTION METHODS OVERVIEW

Face detection in a picture is the preliminary step for the face recognition. By detection we understand location of the face in the image or determination of its position. There are many programs for face detection [19, 21,22]. An example of web application is faint (The Face Annotation Interface) [24].

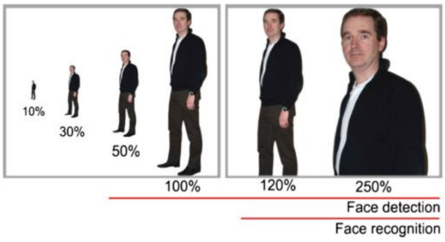


Figure 1. Scheme of the recommended minimum size of the observed object.

Typically, the detection is realized in two stages. The first stage is the reduction of impact of interfering factors with the use of histogram equalization and noise reduction. The next stage is determination of areas with high probability where a face can be placed. At a later stage verification of the previously selected areas is performed. Finally, the face is detected and marked [18].

There are several common approaches for face detection The first one consists in a face location based on the color of the human skin. The human skin color is different in terms of lighting intensity (luminance) but has the same chroma. Thanks to that other elements in the image, which do not correspond to the skin, can be effectively removed. Then, using mathematical morphology operations in the selected ROI (Region of Interest) further features can be isolated, which indicate the presence of a face in the picture [21]. Examples of the face detection in different conditions obtained with the Face Detection in Color Images algorithm are shown in Fig. 2. As we can see in this figure, the algorithm generally properly detects faces, but has significant disadvantages.As the method finds the skin, together with the face detection the neck and sometimes even the blond hair can also be detected, increasing the ROI. This method does not deal with images with low lighting and intensive side illumination.

Next technique for finding face location is the use of geometric models.This method is based on comparing the location of the selected models of the test face with the processed image. An advantage of such detection is an opportunity of working with static images in grayscale. This method is based on the knowledge of geometry of a typical human face and on dependencies between them—position, distance, etc.This method is based on the use of the Hausdorff distance [20, 23].

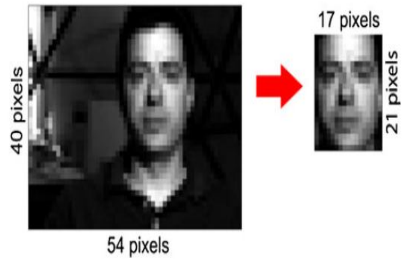


Figure 2. Example of face detection in image with low resolution of 54 × 40 taken from Yale database.

IV. USING SIFT FEATURE FOR DETECTION

The basic idea is to create a feature database that contains sufficient number of both face features and non-face features so that any feature from a random image can be classified as face features or nonface features according to the class of its nearest neighbor in the database.

Figure 1. Sample images from ORL Face Database[5]

As is seen in fig. 1, the face features extracted from face database can be very different. Among those features, some might be very typical face features while the other might be just from one specific face and not representative at all. So, it is better to associate some weight to each face feature in the database to evaluate how typical the feature is. The weight of each face features is simply computed as follows:

$$\omega = \alpha(N_{face} - N_{nonface})$$

where α is a normalization constant. In this project, it is empirically set to 1.

V. VERIFICATION OF FACE REGIONS AND FACIAL FEATURE EXTRACTION

Moreover, facial feature extraction is a time-consuming process due to the lack of constraint on the number, location, size, and orientation of faces in an image or a video scene. Recently, human face detection algorithms based on color information have been reported [6,8]. The face regions are initially segmented based on the characteristic of skin tone colors. The color signal is usually separated into its luminance and chrominance components in an image or video.

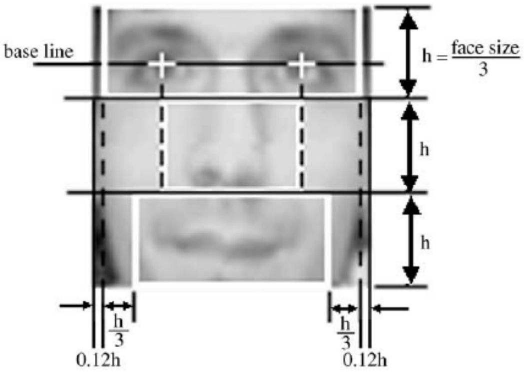


Figure 1. Windows for facial feature extraction.

However, human face detection and facial feature extraction in gray-level images may be more difficult because the characteristics of skin tone color are not available. Sung et al. [9] proposed an example-based learning approach for locating vertical frontal views of human faces in complex scenes. A decision-making procedure is trained based on a sequence of `face and `non-face examples. Yang et al. [10] proposed a hierarchical knowledge- based method consisting of three levels for detecting the face region and then locating facial components in an unknown picture. Extraction of facial features by evaluating the topographic gray-level relief has been introduced [6,11,12]. Since the intensity is low for the facial components, the position of the facial features can be determined by checking the mean gray-level in each row and then in each column. In [12,13], facial feature detection based on the geometrical face model was proposed. The model is constructed based on the relationships among facial organs such as nose, eyes, and mouth.

VI. RELATED WORK

A. Scale Invariant Feature Transform

SIFT is an algorithm that has the ability to detect and describe local features in images. It was proposed by David Lowe in [17]. The features are invariant to image scaling, translation and rotation. It was originally developed for matching an object in images with different views of the object. The first step of the detection is determination of extrema in the image filtered by the Difference of Gaussian (DoG) filter. The filtering is performed in several scales. After this step, the "best" points are identified. Only points with high enough contrast are used. An orientation is assigned to each of these points. The resulting set of points is then used for creation of feature vectors (descriptors).

B. SIFT For Face Recognition/SIFT Features Extraction

The SIFT algorithm has basically four steps: extrema detection, removal of key- points with low contrast, orientation assignment and descriptor calculation [16]. To determine the key-point locations, an image pyramid with re-sampling between each level is created. It ensures the scale invariance. Each pixel is compared with its neighbours. Neighbours in its level as well as in the two neighbouring (lower and higher) levels are examined. If the pixel is maximum or minimum of all the neighbouring pixels, it is considered to be a potential key-point. For the resulting set of key-points their stability is determined. Locations with low contrast and unstable locations along edges are discarded. Further, the orientation of each key-point is computed. The computation is based upon gradient orientations in the neighbourhood of the pixel. The values are weighted by the magnitudes of the gradient. The final step is the creation of the descriptors. The computation involves the 16×16 neighbourhood of the pixel. Gradient magnitudes and orientations are computed in each point of the neighbourhood. Their values are weighted by a Gaussian. For each sub-region of size 4×4 (16 regions), the orientation histograms are created. Finally, a vector containing 128 (16×8) values is created. The algorithm is described in detail in [17, 1] and [16].

VII. SIFT FEATURE

SIFT features are developed by Lowe [1] for extracting distinctive scale and orientation invariant features from images that can be used to perform reliable matching between different images of the same object or scene. It firstly uses scale-space extrema to efficiently detect the location of those stable keypoints in the scale space. Then, an orientation histogram based on the gradient in different directions is formed around the keypoint and the dominant orientation is used to represent the keypoint's orientation. Finally, a gradient histogram is created as a very distinctive descriptor of that keypoint. Thus, each keypoint is represented by the scale, orientation, location and the gradient descriptor so that it can achieve scale and orientation invariance. Also, the descriptor is so distinctive that it can have high probability to find the exact match under certain extent of illumination changes and 6D affine transform. All these characteristics, especially the scale and orientation invariance, perfectly fulfills the basic requirements of the detection task. Morever, the SIFT features can also be computed very efficiently so that it makes it possible to have real-time detection.

VIII. THE PROCEDURE OF FACE/FEATURE MATCHING

Our proposed matching strategy is similar to [26] with a different global similarity. After the sub-regions are determined, the local similarity and the global similarity are calculated and integrated to classify the face image. The procedure of matching is illustrated as Figure 1.

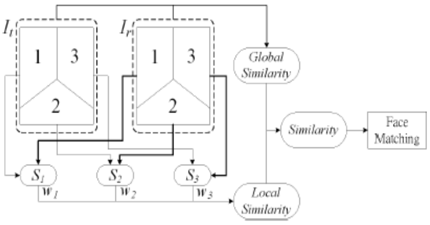


Figure 1. The procedure of the face matching

Before calculating the local similarity, the weight of each sub-region must be set. That each sub-region is assigned a different weight can emphasize the sub-region with important features and conduce to the recognition rate. A set of 200 face images is used to determine the weights of the sub-regions, and the algorithm for choosing the weights is similar to [27]. Assuming a face image In is represented as the PCA-SIFT features localized in k sub-regions and it is denoted as (3), where f_{nk}^{j} means the j^{th} PCA-SIFT descriptor in the k^{th} sub-region of image In.

$$I_n = \left(f_{n_1}^1, \ldots, f_{n_1}^{m_1}, f_{n_2}^1, \ldots, f_{n_2}^{m_2}, \ldots, f_{n_k}^{m_k}\right) \quad (3)$$

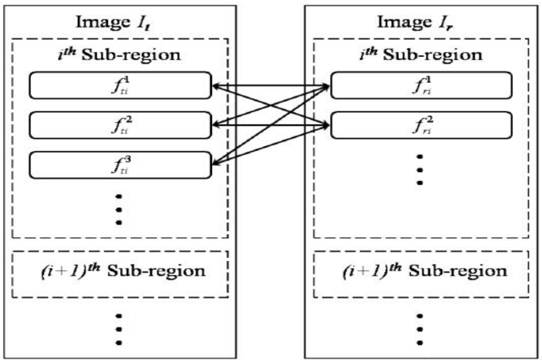


Figure 2. Computation of the similarities in the i^{th} sub-region of two images.

At first, the local similarity SL between a testing image It and a registered image Ir is calculated as the following. Firstly, the similarities between each pair of the features in the i^{th} sub-region of two images are computed as (4). Figure 2 illustrates this step. Secondly, by (5), the maximum of these similarities in the i^{th} sub-region is chosen as the similarity of the i^{th} sub-region, Si. Finally, the local similarity between two images is defined as the average of Si multiplies the weight of the i^{th} sub-region, w_i, in (6).

$$d\left(f_{ti}^{x}, f_{ri}^{y}\right) = \frac{\langle f_{ti}^{x}, f_{ri}^{y} \rangle}{\|f_{ti}^{x}\| \cdot \|f_{ri}^{y}\|} \quad (4)$$

$$S_i(I_t, I_r) = \max\left(d\left(f_{ti}^1, f_{ri}^1\right), \ldots, d\left(f_{ti}^1, f_{ri}^y\right), \ldots, d\left(f_{ti}^x, f_{ri}^y\right)\right) \quad (5)$$

$$S_L(I_t, I_r) = \frac{1}{k}\sum_{i=1}^{k}\left(S_i(I_t, I_r) \times w_i\right) \quad (6)$$

In (5), S_i is chosen as the maximum of the similarities rather than the average. Forneach feature in the sub-region of I_t, only few features in the same sub-region of I_r are validly matched. Because most matches are invalid and the similarity values of these matches are small, choosing the average of the similarities as S_i will greatly lower the local similarities of the correct match and the wrong matches, and therefore induce the poor discrimination between the sub-regions of I_t and I_r.Then the global similarity SG between a testing image It and a registered image Ir is computed as (7), where match(It,Ir) is the number of validly matched features of two images and the feature matching method is the same as [25].

$$S_G(I_t, I_r) = match(I_t, I_r) \quad (7)$$

At last, the local similarity SL and the global similarity SG are integrated to avoid the wrong classification caused by the situation that only some local regions of two subjects are very similar. And the final similarity Sall is computed by (8) for face recognition.

$$S_{all} = S_L \times S_G \quad (8)$$

IX. GRAPHIC USER INTERFACE (GUI)

This program uses an algorithm based on PCA (principal component analysis), called also eigenfaces (eigenvectors determined by PCA are called eigenfaces, when the PCA is used to analyze the face image) [29, 30]. Face recognition is based on the distance from the nearest class, according to the numbering assigned at the beginning to individual photographs (indicating a person in the class).

Our software is equipped with GUI (graphical user interface) (Fig. given below) and allows for operation in two modes: continuous and batch processing [31]. A Graphic User Interface (GUI) is a program interface item that allows people to interact with the programs in more ways than just typing commands. It offers graphical icons, and a visual indicator, as opposed to text-based interfaces, typed command labels, or text navigation, to fully represent the information and actions available to users. The GUI is introduced in reaction to the steep learning curve of command-line interfaces.

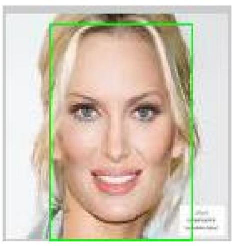
When comparing command-line interfaces, a GUI is used to enhance the efficiency and ease of user. Well-designed graphical user interfaces can free the user from understanding intricate theories, learning complex command languages, and implementing complicated algorithms. In other words, user-friendliness and usefulness for the user can help to achieve the transparency necessary to understand the program.

Figure. Graphical User Interface developed for image face authentication application(in the case of sketch image).

X. RESULT AND EXPERIMENTAL EVALUATION

In this section, we present our experiments and our inferences based on the results we obtain. Here face recognition algorithms are applied. The first experiment is face detection algorithm based. The source image and the result by different algorithm are shown from fig.1 to fig.8. Fig. 1, fig 3 and fig.5 are the original test image. Whereas, fig.7 is the original test image. Fig. 2 shows the detected face image, fig .4 shoes the extracted face image feature vector, whereas fig. 6 and fig.8 shows the generated face.

1(a). Input Image



1(b). Output Image

Fig.1 Face Detection

Fig 2(a). Input Image

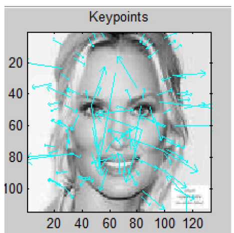


Fig 2(b). Output Image

Fig.2 Feature Extraction

Fig 3(a). Input Image

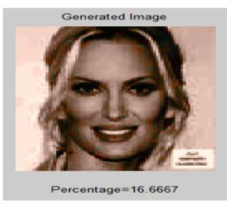


Fig 3(b). Output Image

Fig 3. Face Generation(original image)

CONCLUSION AND FUTURE WORK

In the paper, after giving the definitions for face recognition approach; a SIFT algorithm has been suggested to select the most useful features of the face. Recently, SIFT features and their distances have been used in [28] for the face recognition problem. For our future work, we are planning to apply the genetic algorithm on a number of interest points of some faces and determine the best features for face. Then using only these selected features, same tests as in [28] will be done for performance and accuracy analysis.

In this paper an adaptation of the SIFT algorithm for face recognition was presented.Another problem to be investigated in the future is the possibility of using SIFT to solve the registration problem. There will be a scope for a problem of face authentication in multifaces image.

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