Facial Image Retrieval Based on Eigenfaces and Semantic Features

Ahmed Abdu Alattab, Sameem Abdul Kareem
Faculty of Computer Science & Information Technology
University of Malaya
50603 Kuala Lumpur, Malaysia
ahmed_alattab@yahoo.com, sameem@um.edu.my

***Abstract*—In this research ,we develop a facial image retrieval computational model for the problem of facial images retrieval by integrating content-based image retrieval (CBIR) techniques and face recognition techniques(FERET) , with the verbal description of the semantic features of the facial image . Eigenfaces is applied to extract the characteristic feature images** of **the human face images. One hundred participant participated to choose , order and annotate the semantic features of the human face based on the importance of each features to differentiate between human faces . During the retrieval process system use the specific semantic features , of the face that is user looking for , to narrow down the search space . Eigenfaces is then projected onto the narrowed down human faces search space to identify and retrieve the similar faces to the query face from the database .Euclidean distance is used for classification purpose . The database that is used consists of 1500 local facial images database of one hundred and fifty participants from the University of Malaya (UM), Kuala Lumpur,and some of their friends and families outside the UM.The proposed human facial image retrieval is evaluated through several experiments. Precision and Recall are used for results evaluation .The results are encouraging comparing to typical facial image retrieval techniques**.

***Keywords— Face* Retrieval, Semantic , Recognition, Content-Based Image Retrieval, Eigenfaces .**

I. INTRODUCTION

The significant increase in the huge collections of digital images and videos , because the popular of possession image capturing devices such as digital cameras and image scanners, that need to be managed has led to the requirement for efficient methods for the archival and retrieval of these large collections of images.The search for solutions for image retrieval problems is becoming an active area for research and development.

Facial images have gained its importance amongst the digital images due to its use in various aspects of life such as, in airports, law enforcement applications, security systems and automated surveillance applications. Human face is the most significant component of the human body that is people using to recognize each other; So facial images are the most common biometric characteristic used to make a human verification and identification [1]. Much of the works are emerging for various propose of face identification, verification and retrieval used for different application of facial image. Face retrieval problem is concerned with retrieving facial images that are relevant to users' requests from a collection of images . The retrieving is based on the visual contents or/and by information associated with this facial image.

Content-based image retrieval (CBIR), Is an image retrieval technique uses the visual contents of image to find and retrieve the required images from the databases. The basic image retrieval systems mostly use low level visual features such as color, texture and shape features [2] [3]. Visual features are extracted automatically using image processing methods to represent the raw content of the image. Image retrieval based on color usually yields images with similar colors and image retrieval based on shape yield images that have clearly the same shape, etc. From that, such system that is used for the general purpose of image retrieval using the low level features is not effective with facial images ,especially when user's query is a kind of a verbal description, since it does not capture the semantic aspects of a face, while humans in their nature tend to use the verbal description of the semantic features (high level features) for describing what they looking for, and they encounter a difficulty to use language of low-level features. Human beings normally perceive facial images and compare their similarities using high-level features such as gender, race, age and the rating scale of the facial traits, and thus cannot relate these high-level semantic concepts directly to low-level features. Systems use the visual features, actually based on query by example strategy for negating through the image database. If an example image is not available, it is not likely for such systems to perform the task of facial image retrieval efficiently.Generaly facial images are different from other images, because facial images are complex, multidimensional, and similar in overall configuration.

The proposed work is a facial image retrieval model for problem of similar facial images searching and retrieval in the search space of the facial images by integrating content-based image retrieval (CBIR) techniques and face recognition techniques (FERET), with the semantic description of the facial image. The aim is to reduce the semantic gap between high level query requirement and low level facial features of the human face image such that the system can be ready to meet human nature way and needs in description and retrieval of facial image.

I. RELATED WORKS

Some works in face retrieval have been done. Navarrete and Ruiz-Del-Solar[4] Organized the facial images in tree structured of self-organizing map(TS-SOM). principal component analysis projections was used for features representation of the facial image in the images space that is formed the map ,each facial image represent a cluster in the whole images space .The aim is for fast search and retrieval. In [5] an interactive system was proposed as a series of queries and answers between a user and the system .System display a set of images from the database ,a user provide the system by his feedback .The purpose is to retrieve the user target image in his mind from the image database .While the disadvantage of this type of method is the deference between mental matching and feature-based matching. In [6] they tend to extract the semantic features automatically , while there is no a comprehensive algorithms to extract the possible characteristic that exist in the person face, Regardless of the accuracy of the features that is extracted . In [7] they extracts a set of Haar-like features that is a set of rectangle features, and integrates these features with supervised manifold learning to retrieve face image from large database . In [8] a unified framework of structural information and statistical aspects of pattern description is proposed for pattern retrieval based on local feature sets . The method is not limited to faces images.

The main deficiency in most of the retrieval systems is the lack of ability to directly handle and extract the semantic features of the human faces. Where Simple verbal descriptions of a person can do that in addition to narrow down the candidate faces efficiently. The current image retrieval system limitations and challenges were discussed in [9, 10],especially those closely associated with CBIR.

III. FEATURES EXTRACTION

Features extraction task is the basis of the retrieval and recognition systems. It is the process that transfer the content of the images into various content features commonly called a feature vectors. Image content may include visual content that is so called low level features and semantic content that is so called high level features . Semantic content is obtained either by textual annotation or by complex inference procedures based on visual content[11] . Visual content is extracted automatically from the image; it can be classified to general or domain specific. General visual content are an application independent features such as color, texture, shape, and spatial relationship, etc. Domain specific visual content are application dependent features such as human faces , fingerprint[11].In Domain specific, the human facial image features is extracted by two methods : The first method is the information theory concepts, where seeking for a computational model that gives the best description of a face, by extracting the most relevant information contained in that face. Eigenfaces approach is example of such method, where information that is a best description of a face is extracted from the whole facial image. The other method is components based, where deformable templates and active contour models with excessive geometry and mathematics are used to extract the feature vectors of the basic parts of a face such as nose, mouth, eyes, and chin as well as their relationships with each other. All features vectors are stored in a vectors database.

A. Eigenfaces Features

The eigenfaces is one of the most investigated approaches and well known method for face recognition. The method is based on an information theory approach that decomposes face images into a small set of characteristic feature images called eigenfaces.The idea is to find the principal component of the distribution of the set of facial image to extract the information and capture the variation contained in these faces. Sirovich and Kirby[12] represented the human faces using principal component analysis (PCA) ,and Turk and Pentland [13] develop a face recognition technique using eigenfaces. To employ the eigenfaces for facial image retrieval purpose ,eigenfaces are calculated by the means of PCA ,Figure (1) where the following steps based on [13] are applied.

- Suppose the facial images set are $T_1, T_2, \dots T_m$,The mean face of the set is defined by

$$\Psi = \frac{1}{M}\sum T_M \quad (1)$$

- The mean face is subtracted from each original face vector

$$\Phi_i = T_i - \Psi \quad (2)$$

- Covariance matrix is calculated

$$C = \frac{1}{M}\sum_{n-1}^{M} \Phi_n \Phi_n^T = A.A^T \quad (3)$$

Where C is N^2x$N^2$and A is N^2xM

- The eigenvectors and eigenvalues of the covariance matrix are calculated. Consider the eigenvectors v of $A.A^T$ such that

$$A^T A v_i = u_i v_i \quad (4)$$

$$AA^T A v_i = u_i A v_i \quad (5)$$

The Av_i are the eigenvectors of $C = AA^T$

- From these analysis , MxM matrix $L = AA^T$, $L_{mn} = \Phi_m^T \Phi_n$ is constructed, and M eigenvectors v_i of L can be find.

- To form the eigenfaces u_i , fromt M training face images linear combinations, it can be determined by these vectors such that

$$u_i = \sum_{k-1}^{M} v_{lk} \Phi_i \ , l = 1, \dots, M \quad (6)$$

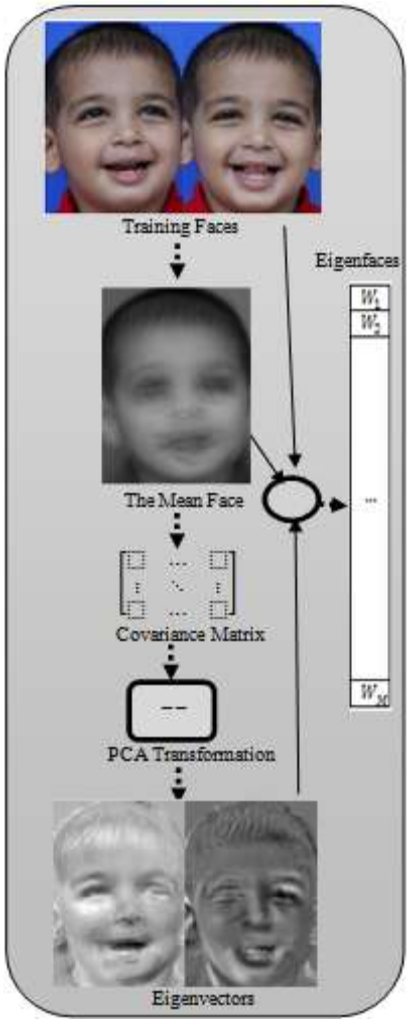

Figure 1.Illustration of eigenfaces calculation

B. Semantic Features

Semantic features are those features that are used to describe the high-level semantic concepts, which appear in images. They play a very important role in facial image recognition and retrieval, because human perceives facial images and measures their similarity using high-level semantic concepts such as the race, gender, age, face shape, face parts size and color, etc. of the described face, which are hard to directly relate to low-level features. From this application have to be ready to meet human nature way and needs. One of the of the best methods used to represent the high-level concepts with a retrieval system is the text-based description. Human face involves many of these semantic features. Some of them consider more important than others, Semantic features that are using in this research were chosen based on one hundred participant participated in case study method. They have given a list of semantic features and asked to order the features based on the capability of each feature to differentiate between the faces. The semantic features that were chosen and used in this research are illustrated in Table(1) with their description .

Table (1).Human Face Semantic Features

Features	Description
Gender	Male ,Female
Age	Infant ,Child, Adolescent ,Young Adult ,Middle Adulthood ,Senior
Race	Malay, Chinese ,Indian, Middle Eastern ,European ,African
Skin Color	Black, Brown, Tan , White
Hair Color	Black, Brown ,Blond ,Red, Gray ,Covering Head
Hair Length	Short ,Medium ,Long, Bald ,Covering Head
Hair Type	Curly, Wavy, Straight , Covering Head
Eye Color	Black, Brown ,Blue, Green
Glasses Shape	Oval ,Circular , Square ,Rectangle
Moustache Size	Short ,Medium , Long
Beard Size	Short ,Medium , Long
Facial Marks	Mole ,Scar , Freckles
Nose Shape	Flat , Rounded ,Straight ,Wide, Convex , Concave
Face Shape	Oval, Round, Long, Square, Heart
Eyebrows Thickness	Normal, Bushy
Mouth Size	Small ,Medium , Big
Lip Thickness	Thin ,Medium, Thick

IV. QUERY AND RETRIEVAL PROCESSES

To conduct our work, prototype system was designed based on the combining a CBIR technique and a face-recognition technique with semantic description features. In query by description features, user picks out specific features of the face he is looking for, and provide the system by these features. System matches the query verbal description with those features description associative the faces stored in the database. The image that achieved the most identical will be retrieved and display on the top. In a query by example, The process will be based on initial face image (instance image) or by picking one image face from the query by the description result pool, this instance image looks close to require facial image. The system will automatically extract the vector feature (eigenfaces) of the query image and will use Euclidian Distance measurement methodology to compute the distance between this query features vector Q and the features vectors D in the database.

$$FacesSimilarityDistance\ (Q\ ,D\ ) = (\sum_{i=1}^{n}(Q_{\ i} - D_{\ i})^2)\ \hat{}\ (1/2) \quad (7)$$

The faces with less distance will be retrieved and displayed in the top. Combining the two methods automatically will improve the accuracy of the retrieval process and reduce the needed time to find the desired faces, because the images that

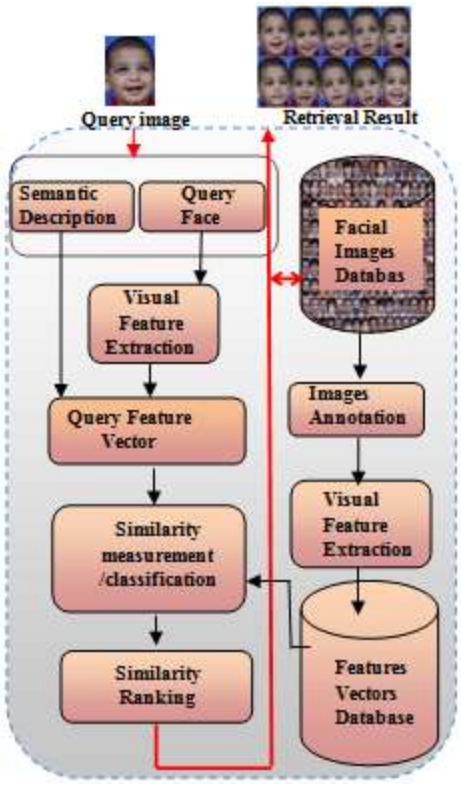

Figure 2. Facial Image Retrieval

will match the verbal description, provide by the user, will nominate to be the narrow pool of faces images for the next matching. The system will compare the extracted features vectors Q of the example image with the features vectors D of the images in the narrow pool of faces images.

V. RESULTS AND DISCUTIONS

Many experiments have been done to evaluate and investigate the proposed method of facial image retrieval. The experiments were implemented on 1500 local facial images database of one hundred and fifty participants from the University of Malaya (UM), Kuala Lumpur .Ten different image were taken for each participant from different race, gender, age, skin color ,etc. .The facial images were taken at different times, facial expressions (happy, sad, smiling, angry etc.) and facial details (glasses, beard, mustache, facial marks). Half of the database, 750 images, was used for training task and the other 750 images were used for testing task. Precision and Recall methods are used to measure the performance efficiency of the retrieval methods. The Recall is the ratio of the relevant facial images of the retrieved facial images to the total number of the relevant facial images in the database .Whilst the Precision is the ratio of the relevant facial images of the retrieved facial images to the total number of the irrelevant and relevant facial image retrieved as define below :

$$\text{Recall} = \frac{\text{Relevant Faces of The Retrieved Faces}}{\text{Total Relevant Faces}} \quad (8)$$

$$\text{Precision} = \frac{\text{Relevant Faces of The Retrieved Faces}}{\text{Total Retrieved Faces}} \quad (9)$$

$$\text{F} - \text{score} = \frac{2 * \text{Precision} * \text{Recall}}{\text{Precision} + \text{Recalll}} \quad (11)$$

Facial image retrieval, system different from the face recognition method, where the system does not look for the identical image only but on the similar images, So during the retrieval process to evaluate the methods' performance, we have not set a threshold to determine the level of retrieval but the number of images that will be retrieved will be subject to a certain number is determined before. Therefore, it was necessary to follow the method of precision and recall cut-off rank. The experiments were curried with various levels of cut-off (10,16,25).In other words the considered images retrieved are those on the top ten, sixteen and twenty-five of the displayed results.The results of the experiments show that, as compared to a typical facial Image recognition and retrieval technique using eigenface features, the proposed methods achieve the best performance. The typical facial retrieval technique using eigenface achieves 78% accuracy, is shown in table (a), while the proposed method achieves 94% accuracy, is shown in table(b), within the top 10 retrieved facial images.

Table 2(a): Retrieval by Eigenfaces

Query Face	Retrieved	Rele-vant	Total Relevant	Recall	Precision	F-score
(Top 16)						
f1	16	10	10	1	0.625	0.7692
f2	16	8	10	0.8	0.5	0.6153
f3	16	10	10	1	0.625	0.7692
f4	16	6	10	0.6	0.375	0.4615
f5	16	7	10	0.7	0.4375	0.5384
Result	80	41	50	0.82	0.5125	0.6307
(Top 10)						
f1	10	10	10	1.0	1.0	1.0000
f2	10	7	10	0.7	0.7	0.7000
f3	10	10	10	1.0	1.0	1.0000
f4	10	6	10	0.6	0.6	0.6000
f5	10	6	10	0.6	0.6	0.6000
Result	50	39	50	0.78	0.78	0.7800

Table 2(b): Retrieval by Proposed Method

Query Face	Retrieved	Rele-vant	Total Relevant	Recall	Precision	F-score
(Top16)						
f1	16	10	10	1	0.625	0.7692
f2	16	10	10	1	0.625	0.7692
f3	16	10	10	1	0.625	0.7692
f4	16	10	10	1	0.625	0.7692
f5	16	8	10	0.8	0.5	0.6153
Results	80	48	50	0.96	0.6	0.7384
(Top10)						
f1	10	10	10	1.0	1.0	1.0000
f2	10	9	10	0.9	0.9	0.9000
f3	10	10	10	1.0	1.0	1.0000
f4	10	10	10	1.0	1.0	1.0000
f5	10	8	10	0.8	0.8	0.8000
Results	50	47	50	0.94	0.94	0.9400

VI. CONCLUSION

Integrated of verbal description of the human face and eigenface feature achieved excellent results in the retrieval of face image compared to retrieval by image content to reduce the semantic gap between high level query requirement represented by user verbal description and low level facial features represented by image content features. Combining the two methods of query by description and query by image example automatically improve the accuracy of the retrieval process and reduce the needed time to find the desired faces .The idea is based on matching the user verbal description of the query face with the annotated description of the faces in the database, the candidate facial image from the whole database will narrow down .The system then uses eigenfaces features to further searches on narrowed down search space of the pruned set facial images ,obtaining more accurate results. Where the comparative will be with relative images so retrieval of non relative image will reduced.

The proposed system can help for suspect identification using semantic features which is generally the kind of verbal descriptions given by witnesses.

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