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A Varied Efficient Approach on Sketch Based Image Retrieval System

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Abstract: Especially with the vogue of touch screen devices, retrieval of images that match with a hand-drawn query sketch became a highly desirable feature. Since 1990s, query-by sketch has been an extensive study. Due to the lack of effective and efficient matching solutions they are still very challenging. Compared to face recognition, face photo recognition using face sketch is relatively a younger area. The exceptional triumph of search techniques have encouraged to revisit the problem and focused at solving the problem of sketch based image retrieval. To this end, a novel method is presented here which is as follows: for each image in the database feature extraction is carried out and edge correspondence metric is computed which will be stored. Similarly for the query sketch the same steps are repeated. For each value the query sketch searches for a match score. The database image with highest match score is the retrieved match against the query sketch from the face photo database. An optimized algorithm is also incorporated for images that are corrupted by various types of noises. This method can handle non-facial factors such as such as hair style, hairpins, and glasses. During investigation results show that the proposed method outperforms several state of-the-arts in terms of accuracy and running time.

Index Terms: Face sketch synthesis, Feature vector, Edge correspondence metric, Sketch based image retrieval.

I. INTRODUCTION

In determining the identity of criminals biometric technology has improved a lot in the case of law enforcement. Some of the biometric traits include fingerprint, face and iris. Out of which fingerprint and iris are considered as a more mature and accurate biometric technology. In recent years the research community is showing significant interest in face recognition [1]. By capturing faces in a covert way, it is also considered as an extremely valuable biometric for surveillance applications. While digital cameras are capturing data in public areas, a robust and accurate face recognition method is critical to apprehend suspects and prevent crimes. Thus solving unconstrained face recognition requires a significant amount of research in face modelling, feature extraction and matching. A new problem of interest in face recognition that has emerged deals in retrieving facial photos from gallery that match a query sketch has received great attention from research community, security agencies, crime investigators etc.

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Sketch-based image retrieval (SBIR) methods use a hand drawn sketch composed of simple strokes or lines to fulfil the image retrieval task [2]. One of the prominent applications is in the field of law enforcement [3], [4]. While doing an offence, the photo image of the suspect will generally be not available. The offenders are sensitive that they do not leave behind any trace of their individuality in the form of fingerprint or any other biometric. In such situations a recollected verbal description of eyewitnesses is used by forensic artist to recreate an estimate sketch of the culprit. For automatically retrieving the photos of potential suspects from the criminal photo database, the law enforcement team need assistance based on the query sketch. It is really difficult to match real-time sketches with their corresponding photos, since the sketch is not an exact portrayal of the culprit. Additional problems are posed due to the difference in style of sketches and photos. With these challenges, criminal investigators are commonly interested in the first N retrieved results because of low probability of finding an exact match and relatively higher possibility of finding a correct match from these retrieved photos. Thus reducing the manual searching time for finding an exact match of the sketch from the whole database and saves crucial time. It also helps the witness and artist to alter the sketch drawing of the suspect based on retrieved results. Based on sketches identified by citizens many criminals have got arrested till date.

Turk and Pentland introduced holistic Eigenface matching algorithm [5] which served as the precedent for modern face recognition engines. Introduction of Eigenface algorithm has been 20 years, since then the face recognition accuracy has increased by orders of magnitude [6], to the point where the face recognition rates under controlled imaging conditions (good lighting, frontal pose, neutral expression and uniform background) are comparable to fingerprint and iris matching rates. But considering real world face recognition scenarios, such controlled conditions will not be satisfied. That triggered researchers to target their research in face recognition with more difficult problems such as varying illumination [6], non-frontal pose [7] and occlusion [8]. A novel method is generated for matching a sketch to a photo. The proposed method varies significantly from earlier approaches [9-11] where local feature-based representations are used to compare sketches and photos. Previous works are performed in holistic matching on sketches that were transformed to photographs (or vice-versa) using a linear transformation directly on the intensity image [9,10] or by generating a synthetic photograph [11,12].

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1.1 Issues in Face Recognition

In recognizing faces, humans do not encounter an issue as compared to face recognition systems. Since faces are complex in structure it has got many challenges due to the variations in facial expression, illumination, pose, hair style, aging etc. Illumination is an important issue which occurs due to variations in lighting conditions. For the same person with same facial expression can look entirely different in different lighting conditions. Lighting conditions could change based on the intensity of light, its direction and number of sources of light. Identifying face from a single image is a crucial task due to various factors such as one to one match problem for sketch verification or authentication and one too many problems for face sketch identification or recognition.

II. OBJECTIVE OF SKETCH BASED IMAGE RETRIEVAL SYSTEM

An individual can be identified using face which is an important part of human body. It plays a major role in bearing identity and emotions of an individual. Except identical twins each individual has distinctive facial features. The true identity of an individual is his/her face. While the average person has no qualms with their identity being published; a collection of individuals would prefer to keep such knowledge hidden rather the negative impact it may cause on the population at large. The ultimate aim of the face recognition and face sketch recognition systems are in enabling fast identity matching in the areas of surveillance, authentication and investigation purpose. Some of the prominent applications are in the field of entertainment, authentication, information security and law enforcement sectors. Face sketch recognition is a very tough research problem and relatively a younger research area compared to face recognition. For more than twenty years human face recognition has been studying. Since faces are complex, multi-dimensional visual stimuli developing a computational model of face recognition is very difficult. Face recognition is a computer vision task, in which many early vision techniques can be involved.

The remainder of the paper is organized as follows. In Section 3 a review through the previous research that has been conducted in sketch/photo matching is done. Proposed method for sketch/photo matching is then detailed in Section 4. The results of our experiments using this method can be found in Section 5, followed by concluding remarks in Section 6.

III. RELATED WORKS

Many researches are going in sketch based image retrieval systems of which much of the existing works are performed by Tang et al. [9-12]. Some related articles on edge-based face recognition methods [13-15] can also be found. Global linear transformation is used by Tang and Wang [9,10] to convert a sketch to a photograph in their initial works. Here projecting the eigenspace representation of image pixels in the whole image is done in the sketch domain to the eigenspace of photo domain [9]. Later this method got extended by separating the shape and texture of the image and further transformations were applied to it separately.

By first breaking the sketch into a set of overlapping patches Liu et al.[11] produced a synthetic photograph. For each sketch patch, the adjoining k local sketch patches (based on Euclidean pixel distance) from a training set of sketch/photo correspondences are selected as candidates. All patches is then converted from the sketch domain to the photo domain by first solving the set of weights for the k candidate patches which will minimize the reconstruction error from the sketch patch being converted. The weights obtained are applied to the equivalent photo patch of the sketch candidate to construct a photo estimate of the sketch patch.

Wang and Tang [12] improved the photo synthesis algorithm of Liu et al. [11] by modelling the faces with a Markov random field (MRF). Here also the sketch to be converted into a photo was broken into a set of overlapping patches. These patches were then modelled as the observed nodes in the MRF, and each node is connected to a hidden photo node twin to be estimated. The feasible states for the hidden photo nodes were the photo twin of the k nearest training sketch patches of the observed sketch patch. The solution to the MRF was estimated using the belief propagation algorithm,[6] and solution patches were stitched together to yield a synthetic photograph representation. In order to match the synthetic photograph with the gallery of photos global face matching algorithms are used.

Li et al.[7] matched sketches and photos using a method similar to the eigen-transform presented by Tang and Wang [9] focusing on converting sketches to photos (as opposed to converting photos to sketches). Zhang et al. [8] compared the performance of human sketch recognition to automated sketch recognition and showed the benefit of using multiple sketches drawn by different artists.

IV. PROPOSED SYSTEM

In this section, a detailed explanation of the new approach to retrieve photos based on probe sketch is described. The framework of the proposed system is shown in Fig. 1. For visualising the concept the system can be broadly categorised into three parts consisting of processing and extraction of information from the image database, extraction of information from the query sketch, search for an accurate match score.

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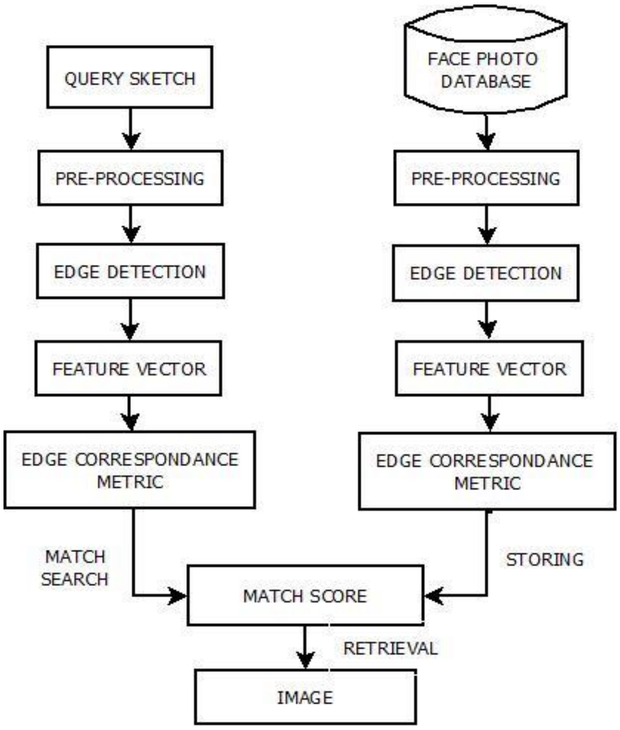

Fig. 1 Overview of proposed architecture

4.1 Information retrieval from image database

a. Pre-processing

For all the set of face photos in the database as an initial step some pre-processing tasks are carried out such as converting an RGB to gray scale, noise removal, scaling etc. By converting an image which is in RGB to greyscale image, each pixel information will carry only intensity information. They are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. Image noise is random variation of brightness or colour information in images. The magnitude of image noise can range from almost imperceptible specks on a digital photograph taken in good light are almost entirely noise. Scaling Enlarges or reduces the physical size of the image by changing the number of pixels it contains.

b. Feature extraction

After pre-processing next step is the feature extraction. Here this is done using the edge detection algorithms Fig. 2 (Canny and optimised edge detection algorithm). An edge is generally defined as the boundary or contour at which a significant change occurs in some physical aspect of the image. Optimised algorithm is used in order to retrieve the boundary information that is obtained while using a noisy image. This technique is used for finding the boundaries of objects within images. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.

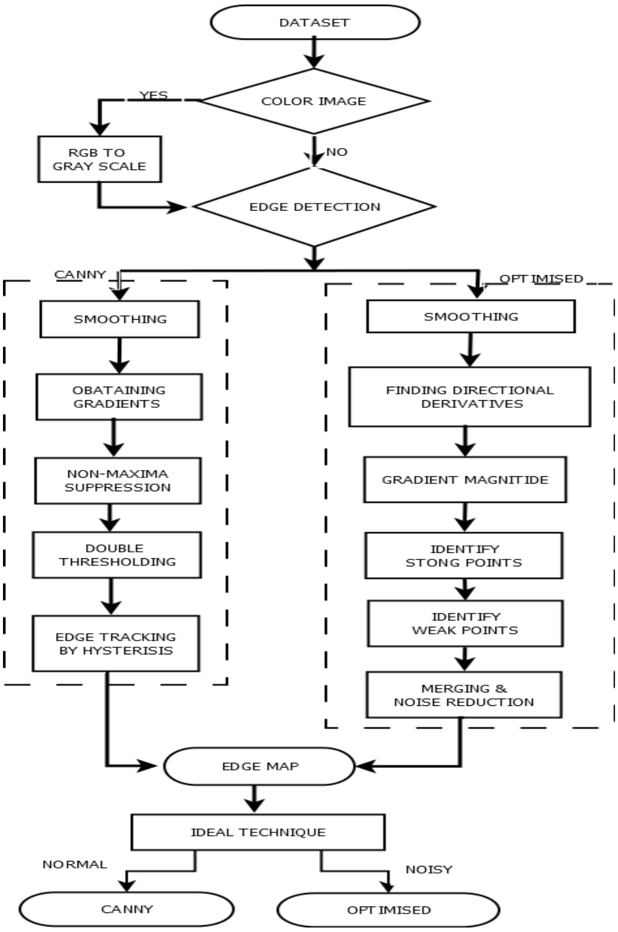

Fig. 2 Architecture of Edge detection

i. Canny Edge detection

It is one of the most popular edge detection algorithms. The performance of the algorithm depends on number of parameters such as standard deviation for the Gaussian filter and lower and upper threshold values. Larger the scale of the Gaussian filter, lesser the accuracy of localization of the edges. Whereas smaller values of standard deviation imply a smaller Gaussian filter which limits the amount of blurring, maintaining finer edges in the image [16, 17]. They are computationally more expensive compared to other edge detection techniques. Major drawback is it generates lots of spurious edges corresponding to weak edge points in the image.

ii. Optimized Edge Detection Algorithm

Robustness to noise and scalability are two other features of edge detection techniques. An image can be corrupted by several types of noise such as Gaussian, Speckle, Poisson and Salt and Pepper noise. The performance of existing edge detection algorithm reduces significantly when the input image is corrupted by noise. The visibility of the edge features is greatly reduced in a noisy image. One of the primary focuses of our research is to enhance the performance of the system even under noisy conditions. This can be achieved by using weighted wide convolution kernels and low pass Gaussian filtering [18]. The steps involved is shown in Algorithm 1.

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Algorithm 1: Improved Edge Detection
Input: Greyscale Image
1. Filter the image using Gaussian low pass filter. 2. Compute gradient of image i. Compute 1D gradient along horizontal and vertical directions ii. Compute gradient as sqrt($I_x^2+I_y^2$) 3. Compute composite gradient variation along horizontal and vertical directions. 4. Determine local maxima, local minima along horizontal and vertical directions. 5. Compare composite gradient variation, local maxima and minima to determine strong and weak edge points. 6. Perform morphological operation to remove isolated pixels.
Output: Binary Image

iii. Morphological operation

This step is the post-processing of edge detection. It removes small objects (connected components) from binary image. This operation is also known as an area opening. The default connectivity is 8 for two dimensions, 26 for three dimensions.

c. Feature vector

Feature vectors are generated from the edge detection output image. The edge image is scanned in the raster order and the origin is marked as a fixed point at the centre of the face image. This approach makes sense since all images are of the same size after the pre-processing steps. If the centroid is evaluated from edges available on the edge image, then the centroid point will vary for the reference and test image (based on the edges that are obtained after edge detection). To find the angle (1) in the polar coordinate representation, a horizontal line that is passing through the origin point is taken as the reference line.

$$\theta\alpha = \tan^{-1}\left(\frac{y_1-y_2}{x_1-x_2}\right) \quad (1)$$

Here (x_1, y_1) is the Cartesian coordinate of the origin and (x_2, y_2) is the Cartesian coordinates of the edge pixel under consideration. '$\theta\alpha$' is the angle corresponding to the pixel α.

d. Edge correspondence metric

Similarly, the distance from the image centroid to the edge pixel obtained using the edge detection techniques is computed using (2).

$$d = sqrt((x_1 - x_2)^2 + (y_1 - y_2)^2) \quad (2)$$

In this approach, the Feature vector and the Edge correspondence metric are the two features that are of interest which are stored for later purpose.

1.2 Information retrieval from Query Sketch

Here sketch drawn by an artist is given as input. For this query sketch also there are three different procedures that are very similar to the procedures done to the images in the database such as pre-processing, feature extraction, feature vector and obtaining edge correspondence metric. The values obtained in feature vector and edge correspondence metric for each query sketch pixel is noted.

1.3 Search for match score

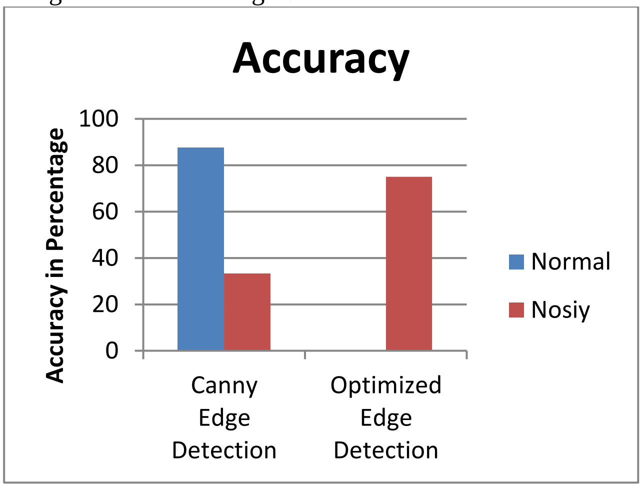
The last and final step of the system where the values of feature vector and edge correspondence metric for each query sketch pixel is searched for a relative very similar or nearby values of each image pixel's feature extraction and edge correspondence metric in image database. The image that has got the highest match score is the image for retrieval.

V. RESULTS AND DISCUSSION

In this section, to evaluate the proposed algorithm and framework two tasks are done: Accuracy and execution time. In order to validate the effectiveness of the proposed sketch synthesis method, the CUHK student database (including 134 males) as the training set while the test set contains the CUHK student database (including 54 females) are taken.

a. Accuracy

The following graph shows the accuracy measure of various edge detection algorithms. From the analysis; accuracy measures of edge detection algorithms is concluded in a way such that, Canny edge detection algorithm performs well when compared to optimised edge detection algorithm under normal condition. But when looking onto noisy images Optimized edge detector is much stronger to detect the edges.



Graph 1: Accuracy measure

From the Graph 1, it is observed that Canny edge detection algorithm attains high percentage of accuracy and out performs well when compared to optimised edge detection algorithm.

b. Execution time

The execution time for the Canny edge detector is relatively high when compared to the optimised algorithm in normal image retrieval case. But when applied to the noisy image the performance and as well as execution time of canny dropped abruptly as shown in the graph.

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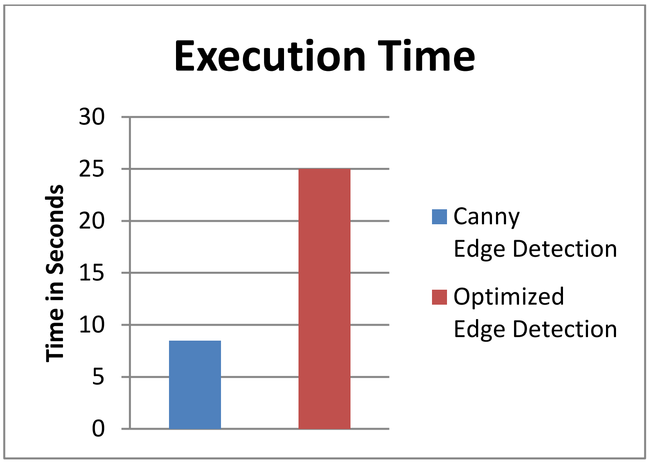

Graph 2: Execution time for edge detection algorithms

VI. CONCLUSION

Here presented a method that relies on edge features for face photo and face sketch recognition. The effectiveness of this approach for face sketch recognition is shown in the previous section on the CUHK student dataset. The use of feature vector and edge correspondence metric for sketch recognition is a novel contribution. This method can be further improved by incorporating learning rules to extract other commonalities between the photo and sketch images. Future work includes modification and testing the proposed algorithm on other face sketch databases such as CUFSF (CUHK Face Sketch FERET Database). Further analysis has to be performed to see the tolerance of this method with difference in artist rendering styles. The method fails if the face photo/ sketch images involve pose variations. Pose variation is a major challenge in face photo/ face sketch recognition. To handle this, the method can be combined with other state of the art methods that are used for pose invariant face recognition.

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