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Face Photo Sketch Recognition using Rule Based Fuzzy

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Abstract:In today's digital era, face recognition has found a lot of importance in biometrics technology. Face is an important part of a person which can be used to verify one's identity. In forensics science, face sketch recognition is used to identify criminal or suspects. In this paper, an approach has been proposed for face sketch recognition using rule based fuzzy. A forensic sketch is to be matched with mug-shot photos stored in database. The proposed approach converts the original face photos into synthesized sketches to reduce the modality differences between the original photo and the forensic sketch. Faces are extracted from synthesized sketches and features are extracted from these synthesized sketches i.e. the face portion is separated from background and stored in database. Method used for extracting features is blob feature extraction and the extracted features are intensity, area and equivalent diameter of the faces. Features of forensic sketches to be matched are extracted and given to fuzzy rule based approach has been used to find possible matches between forensic sketch and mug-shot photos stored in the database. The possible matches are compared with the forensic sketch using a correlation coefficient to find the best match.

Keywords: face sketch recognition, photo sketch synthesis, Rule based fuzzy, 2-D correlation coefficient

I. INTRODUCTION

An important part of humans through which a person can be identified is face. A person's face can be easily used to detect the identity of the person .Homogeneous face recognition systems focus on comparing an image to another image taken in visible spectrum. Focus has shifted from homogeneous to heterogeneous systems [1] where the images to be recognized may not be havingsame modality i.e. images have different modalities. One of the most important application that has evolved over recent time is the use of sketch images to recognize faces. Image forensics or law enforcement agencies make use of this image retrieval system by comparing image of criminal with mug-shot images stored in their database. But in most of crimes, the image of criminal may not be available rather some eyewitness of the crime is available. A sketch is drawn by taking the details from the eyewitness. Features are extracted from these sketches and the person is identified use these features. Artificial Intelligence is used to develop such algorithms which can compare features of images having different modalities. Machine is trained on a training set and then tested for a test set of images. The objective is to develop such algorithm that can be used to compare images of different modalities and recognize faces. Traditional algorithms for face photo sketch recognition are classified by two approaches: intra- modality approaches [2] and inter- modality approaches [3], [4]. The main aim of intra-modality approach is to convert a photo (sketch) into a sketch (photo) so that a homogeneous face recognition may be used to match the sketch (photo) to synthesized photo (sketch). The reason behind this transformation is to reduce the modality gap between the sketch and the photo so as to make the recognition task easier for the machine. Inter-modality approaches reduce the modality gap by extracting the modality invariant features form the sketch and photo. The main reason behind this is to maximize the inter-class separability while still maintaining the inter-class differences.Some authors have used a combination of inter and intra modality approaches for this face sketch identification [5].

II. RELATED WORK

Many researchers in recent times used either of the two face sketch recognition. The literature for face sketch recognition is available from different sources. Many sources have contributed regarding this topic of research which include research papers, articles, journals and books. Some of the important research papers based on sketch photo image recognition that have been reviewed are defined in this section. [6] The method is based on extracting Multi-scale Local Binary Pattern (MLBP) descriptors. For each photo and sketch the descriptors are taken out from patches of log-Gabor-filtered images. For matching and comparing the two templates, the author has used The Spearman Rank-Order Correlation Coefficient (SROCC). Global texture information is provided by Log-Gabor filtering and local texture information is extracted by Multi-scale Local Binary Pattern (MLBP). Combination of Log-Gabor filtering and by Multi-scale Local Binary Pattern (MLBP) has proven to be useful for beneficial for face-photo sketch recognition.[7] Author here laid prime focus on the Eigen transformation method and Local feature-based discriminant analysis (LFDA). The gross characteristics of face such as shape and skin color are measured using Eigen transformation method. The structures in face that are relevant to face recognition are measured using Local feature-based discriminant analysis (LFDA). [8] Author used a different modality invariant face descriptor known as Gabor Shape inspired by the fact that the modality gap between face photo and sketch is caused by fine texture not coarse texture. PushpaGopalAmbhore et.al**.** [9] used a robust framework called local feature-based discriminant analysis (LFDA) for matching sketch images against police mug-shot image database. Scale invariant feature transform (SIFT) and multi scale local binary pattern (MLBP) method is used to extract features of sketches and digital photos. Scale-invariant feature transform (SIFT) is an algorithm to extract local

features in images.SouravPramanik et.al.[10]in this paper, brought face photo and face sketch images in a new dimension using 2D Discrete Haar wavelet .Then Principal Component Analysis (PCA) was used to extract features from the transformed images. Thereafter, SVM classifier and K-NN classifier were used on the extracted features for classification. Their proposed method experimentally proved to be robust against faces that are captured in a good lighting condition and in a frontal pose. An intra-modality approach algorithm, known as Face Hallucination (FH) technique which uses face super-resolution and face-sketch synthesis has been proposed in [11]. A Scale Invariant Feature Transform (SIFT) approach that matches sketches and photos directly using the gradient magnitude andorientation within a local region has been proposed by [12]. [13] Further used Local Feature Discriminant Analysis (LFDA) as an extension to their previous research for matching forensic sketches. In [14] the author has used geometrical relationships between facial features .PCA has been used followed by a Feed Forward Neural Network (PCA-NN).

III. METHODOLOGY

A. Overview of proposed methodology

The proposed work for face sketch recognition has been divided into three phases.

In phase1, original face image of each individual subject is converted into synthesized sketch image for face feature extraction based on blob feature extraction method based on blob features. The extracted features are stored in database.

Phase 2 works as a filtering stage based on rule based fuzzy. In this phase, features of a forensic sketch image of an individual probe are compared with the features of synthesized sketches using rule based fuzzy logic system. The output of this phase is a set of images that match the forensic sketch. We call this set as suspect set.

In phase 3, the best match between the forensic sketch and the images in suspect set is determined using correlation coefficient. A brief overview of proposed methodoogy is shown in figure 1.

B. Synthesizing Sketches

A synthesized sketch is one that is prepared artificially by the computer system using some synthesizing process. The process of converting an image into a sketch is called synthesizing. This process is based on Markov Random Fields model. A training pair dataset consists of face photos and their corresponding sketch made by an artist. To synthesize a sketch from a face photo, a similar photo patch is taken from the training set and its corresponding sketchpatch in the training set is used to approximate the new synthesized sketch. In this process, an image whose sketch is to be made is broken down into patches. Similar patches are looked for in the training dataset. Patches from the training set that are similar to the patch of the image to be synthesizedare taken. Then corresponding sketch patches of sketch images of the selected images are organized using Markov Random Fields to form a synthesized sketch. It is assumed that if two patches in colored images are similar to each other, then their corresponding sketches will also be similar to each other. The sketch synthesizing algorithm is derived from [15], which uses an algorithm to synthesize both images as well as sketches. The result of this step is a synthesized sketch which is shown in figure 2.

C. Face Extraction

Face extraction is an important part of this problem because the features are to be extracted from the extracted face. Face from the synthesized sketch is extracted using cascade object detector system available in matlab [16]. Viola-Jones algorithm is used by cascade object detector to detect people's faces, noses, eyes, mouth, or upper body. For our purpose, only face has been detected and extracted. The face extracted from a sample images is shown in figure 3.

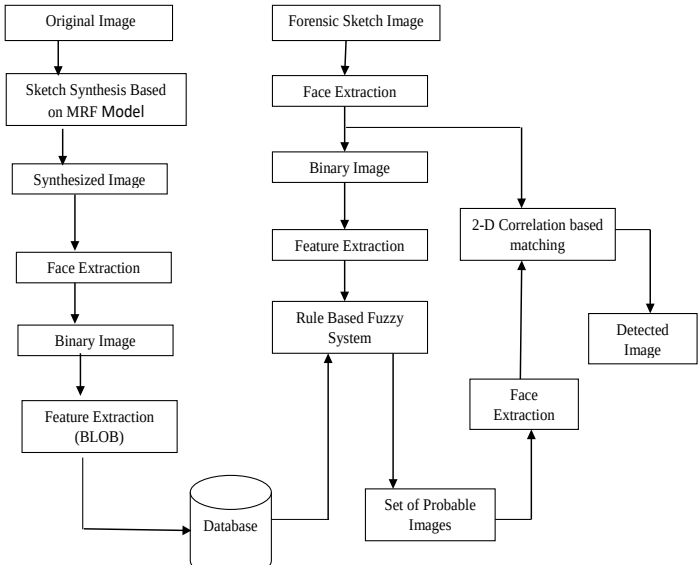

Figure 1. Proposed Methodology

D. Blob formation and feature extraction

The synthesized sketch so obtained is converted into binary image. The whole image is considered to be a single blob. The features that are extracted from the synthesized sketch are its mean intensity, area and diameter. For finding mean intensity of the blob, we find all the pixels in the blob and then find the mean of all the intensity values. For finding areawe estimate the area of the objects in binary image.

(a) (b) (c)

Figure 2. Sample of original photo, sketch and synthesized sketch [20].(a) original photo (b) forensic sketch (c) synthesized sketch

Area is a scalar value and roughly equals the total number of pixels in the image that are on. The algorithm for finding

the area of a blob finds the area by adding the areas of each on pixel in the binary image. Area of each pixel is determined by examining its 2-by-2 neighborhood. Six different patterns for each individual pixel, each representing a different area are:
Patterns having zero on pixels (area = 0)
Patterns having one on pixel (area = 1/4)
Patterns having two adjacent on pixels (area = 1/2)
Patterns having two diagonal on pixels (area = 3/4)
Patterns having three on pixels (area = 7/8)
Patterns having all four on pixels (area = 1)
This algorithm is implemented in matlab using [17] which is used to find the properties of a blob. Equivalent diameter specifies the value of diameter of a circle having equal area as that of the region in the image. It is computed as :

$$diameter = sqrt(4 * \frac{area}{pi}) \qquad (1)$$

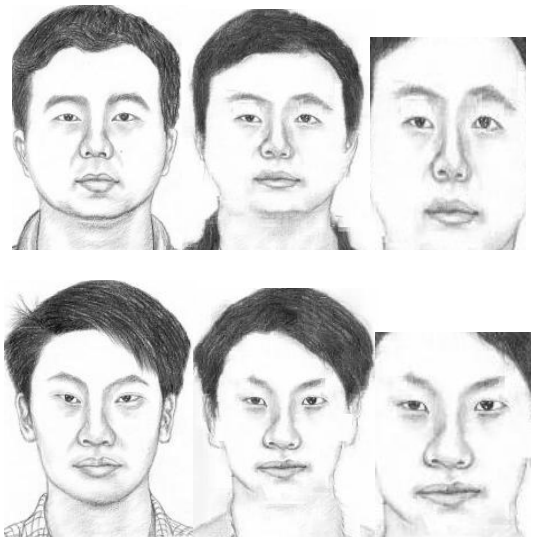

Figure 3. Face extraction process [20]
(a) Forensic sketch (b) Synthesized sketch (c) Face Extracted

The features so obtained are intensity, area and diameter for each image. The features of all the synthesized images are stored in database.
Thus for each face image, a synthesized sketch is obtained and features extracted from these sketches are stored in the database. This is first part of the approach used.

E. **Testing a forensic sketch**

A forensic sketch is one that has been made by an artist on the basis of details provided to him by a witness. This forensic sketch has to be compared to the faces already stored in the database. Face is extracted from the sketch and it is converted to a binary image to be represented as the blob. Features are extracted from the forensic face sketch.

F. **Rule Based Fuzzy Logic System**

Fuzzy logic is a logic operations method which instead of being based on two valued (true/false) logic is based on many valued logic.Fuzzy Logic Toolbox in matlab provides functions for analyzing, designing, and simulating systems based on fuzzy logic. A Fuzzy Inference System is built using Fuzzy logic system toolbox. Fuzzy Inference system takes the features of the forensic sketch as an input vector .It uses set of rules and a membership function to produce an output value. Fuzzy system gives us a degree of truthfulness of a system instead of true or false values.

The membership function used in our model is trapezoidal membership function.

$$f(x;p,q,r,s) = \begin{Bmatrix} 0, x \le p \\ \frac{x-p}{q-p}, p \le x \le q \\ 1, q \le x \le r \\ \frac{s-x}{s-r}, r \le x \le s \\ 0, s \le x \end{Bmatrix} \qquad (2)$$

A trapezoid-shaped membership function[18] is shown in figure 4

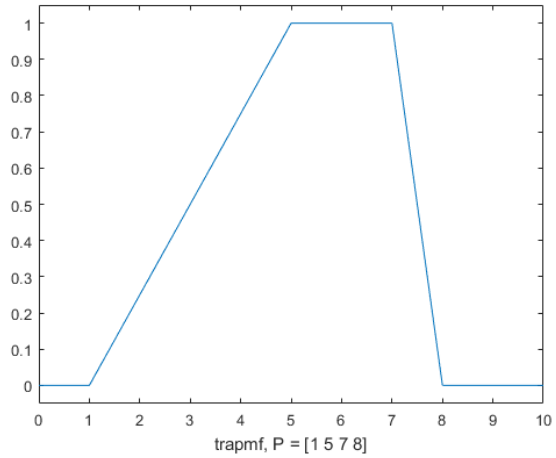

Figure 4. Representation of a trapezoid-shaped membership function. Parameters p and s represent the feet of the trapezium while q and r represent the shoulders of the trapezium

The result of fuzzy system for a forensic sketch compared with those of synthesized sketches shows the degree to which the forensic sketch is expected to be similar to those of synthesized sketches. A forensic sketch is compared with synthesized sketches using fuzzy logic system. For each synthesized sketch, fuzzy logic provides us a scalar value of degree of relationship with the forensic sketch. The output of this function is a vector having the values of degree of relation between each individual synthesized sketch and the forensic sketch. A set is obtained from this output vector which contains the synthesized images having high degree of relationships with the forensic sketch. A sample matching of a forensic sketch and synthesized sketch is shown in figure 5.

G. **2-D Correlation coefficient**

2-D correlation coefficient is used to find the degree of relationship between two images. Higher the degree of this coefficient, more will be the images related to each other. It is calculated as-

$$\text{cor} = \frac{\sum_p \sum_q (A_{pq} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left(\sum_p \sum q (A_{pq} - \bar{A})^2\right)\left(\sum_p \sum_q (B_{pq} - \bar{B})^2\right)}} \qquad ..(3)$$

$\bar{A}$= mean of matrix A
$\bar{B}$= mean of matrix B
A and B are matrices of the two images of size m*n

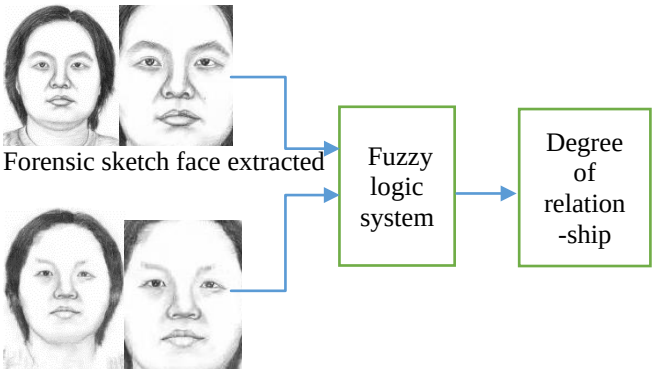

Figure 5. Matching a forensic sketch with a synthesized sketch

Our proposed approach uses both fuzzy system and correlation coefficient to match the forensic sketch to the available synthesized sketches. The output of fuzzy system acts as an input to the next step. The result of fuzzy inference system is vector consisting of degrees of relationship between the forensic sketch and each synthesized sketch. Out of this vector, top images are taken out having maximum degree of relationship with the forensic sketch. These top images are the synthesized sketches having maximum degree of matching with the forensic sketch. These top images are matched with the forensic sketch using 2-D correlation coefficient. The synthesized sketch having maximum correlation value with the forensic sketch is considered to be the match of the forensic sketch. A brief explanation of correlation coefficient is may be read from [19]

IV. EXPERIMENTAL RESULTS

We conducted our experiment on CUHK dataset and IIIT-D face sketch database [22]. CUHK Face Sketch database (CUFS)comprises of 188 faces from the CUHK student database. For each face, there is a sketch drawn by an artist based on a photo.It is assumed that photos are taken in a frontal pose, under normal lighting condition, and with a neutral expression. It consists of CUHK student data set having 88 training pairs and 100 testing pairs. Another dataset that has been used is IIIT-D Sketch Database. It consists of a large number face sketch pairs that are meant for research purpose in this field only. We have worked on 72 sketch-digital image pairs from the IIIT-D student & staff database for training purpose and 190 forensic images for testing purpose. It contains a combination of92, 37 and 61 forensic sketch digital image pairs from Lois Gibson, Karen Taylor and other internet sources respectively. CUHK dataset is openly available at [20]. IIIT-D dataset is available at [21]. Thus a total combination of 460 images were used in the experiments. Results of fuzzy logic system act as input to the correlation coefficient. Output of fuzzy logic is vector having degree of relationship of stored images with the forensic sketch to be identified. This vector is then sorted to obtain the top degrees of relationship. The images having maximum degree of relationship were identified. We performed our experiment by taking three different levels of output from the fuzzy output stage. In these different levels, a small size vector containing images having maximum degree of relationship with the forensic sketch were taken. Then faces of synthesized sketches were taken and compared with the face of forensic sketch using 2-D correlation coefficient. In first level, top 10 images from the fuzzy output stage were taken. The sketch recognition accuracy came out to be 82% which is quite good as compared to other algorithms in the initial stage. When the top 15 images were taken from the fuzzy output stage, accuracy came out be near 90%. However when top 20 images from the fuzzy output were taken, we got an accuracy of 95% which is quite good. This model is a two-step verification process where a forensic sketch is verified by fuzzy in the first step and then correlation coefficient verified the result by showing high degree of relationship between the detected image and the forensic sketch. The results of experiments have been drawn using bar chart in figure 6.

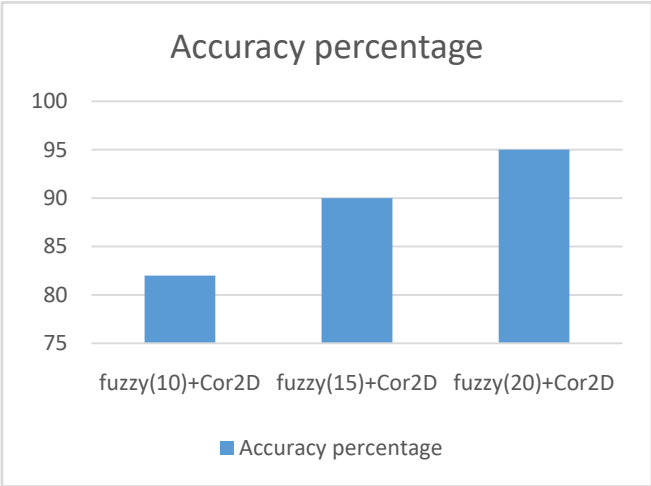

Figure 6. Graph showing accuracy rate in percentage
Fuzzy(10) means 10 images taken from fuzzy output stage
Fuzzy(15) means 15 images taken from fuzzy output stage
Fuzzy(20) means 20 images taken from fuzzy output stage
cor2D means 2D correlation coefficient.

The following table represents the results of our experiments.

Table 1. Identification accuracy in percentage:

Method	Accuracy percentage
Fuzzy(10) +cor2D	82
Fuzzy(15) +cor2D	90
Fuzzy(20) +cor2D	95

V. CONCLUSION

The main conclusions of the study is that the accuracy of every face sketch recognition algorithm depends on many factors. In our case, it depends on the sketch synthesizing process which gives us the synthesized sketch from which the features are extracted. Various methods and state of art approaches have been used to solve the problem of synthesizing sketches. But its accuracy mainly depends on the accuracy of the artist who makes the forensic sketch and the witness who describes the face of the person. Despite all this, we have achieved a quite good accuracy compared to some existing face sketch detection algorithms. In future we would like to use some other methods to improve the

accuracy of fuzzy by extracting some more distinctive features. In future we would like to compare the results with other existing sketch recognition algorithms in terms of time and accuracy. We would like to use some other membership functions in fuzzy logic to see if accuracy of fuzzy can be improved by other membership functions. In the end we would like to urge other researchers of this field to use this new methodology to check if more improvements can be made to our proposed algorithm

VI. ACKNOWLEDGMENT

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VII. REFERENCES

[1] B. F. Klare and A. K. Jain, “Heterogeneous face recognition using kernel prototype similarities,” IEEE Trans. Pattern Anal. Mach. Intell., vol. 35,no. 6, pp. 1410–1422, June 2013.

[2] N. Wang, D. Tao, X. Gao, X. Li, and J. Li, “A comprehensive survey to face hallucination,” Int. J. Comput. Vision, vol. 106, no. 1, pp. 9–30,Jan. 2014.

[3] H. Galoogahi and T. Sim, “Inter-modality face sketch recognition,” in IEEE Int. Conf. Multimedia and Expo, July 2012, pp. 224–229.

[4] H. Han, B. F. Klare, K. Bonnen, and A. K. Jain, “Matching composite sketches to face photos: A component-based approach,” IEEE Trans. Inf. Forensics Security, vol. 8, no. 1, pp. 191–204, 2013.

[5] C. Galea and R. A. Farrugia, “Fusion of intra- and inter-modality algorithms for face-sketch recognition,” in Proc. Int. Computer Analysis of Images and Patterns, 2015, vol. 9257, pp. 700–711.

[6] C. Galea and R. A. Farrugia, "Face photo-sketch recognition using local and global texture descriptors," 24th European Signal Processing Conference (EUSIPCO), Budapest, 2016, pp. 2240-2244.

[7] M. A. A. Silva and G. Cámara-Chávez, "Face sketch-photo recognition," DECOMFederal University of Ouro Preto, UFOPOuro Preto, MG, Brazil

[8] H. K. Galoogahi and T. Sim, "Face photo retrieval by sketch example," Proceedings of the 20th ACM international conference on Multimedia - MM ’12, 2012,pp. 949-952

[9] P. G. Ambhore and L. Bijole, "Face sketch to photo matching using LFDA and Pre-Processing," International Journal of Science and Research (IJSR), vol. 358, No. 5, 2014.

[10] S. Pramanik and D. D. Bhattacharjee, "An approach: Modality reduction and face-sketch recognition,"International Journal of Computational Intelligence and Informatics, Vol.1: No. 2, July-September 2011

[11] N. Wang, D. Tao, X. Gao, X. Li, and J. Li, “A comprehensive surveyto face hallucination,” Int. J. Comput. Vision, vol. 106, no. 1, pp. 9–30,Jan. 2014

[12] B. Klare and A. Jain,“Sketch-to-photo matching: a feature-based approach,”Society of Photo-Optical Instrumentation Engineers*(SPIE) Conference Series*, volume 7667,pp 597-602, 2010.

[13] Klare, Brendan, Zhifeng Li and Anil K. Jain. “Matching Forensic Sketches to Mug Shot Photos.” IEEE Transactions on Pattern Analysis and Machine Intelligence 33 (2011): pp639-646, 2011.

[14] Amit R Sharma and Prakash R Devale. Article: Face Photo-Sketch Synthesis and Recognition. International Journal of Applied Information Systems 1(6):46-52, February 2012.

[15] X. Wang and X. Tang, "Face Photo-Sketch Synthesis and Recognition," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 31, no. 11, pp. 1955-1967, Nov.2009.

[16] https://in.mathworks.com/help/vision/ref/vision.cascadeobjectdetector-class.html as accessed on 10/2/2017

[17] https://in.mathworks.com/help/images/ref/bwarea.htmlas accessed on 10/2/2017

[18] https://in.mathworks.com/help/fuzzy/trapmf.htmls accessed on 10/2/2017

[19] https://in.mathworks.com/help/images/ref/corr2.html as accessed on 12/3/2017

[20] http://mmlab.ie.cuhk.edu.hk/archive/facesketch.htmlas accessed on 19/2/2017

[21] http://www.iabrubric.org/resources/sketchDatabase.htmlas accessed on 10/2/2017

[22] H.S. Bhatt, S. Bharadwaj, R. Singh, and M. Vatsa, “Memetic Approach for Matching Sketches with Digital Face Images,” IIITD-TR-2011-006, October 2011.