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Recognition Algorithm by Face Sketch Segmentation

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Abstract— *this paper proposes a separate learning algorithm by segmenting them to compare the generated sketch with the base sketches. Three types of distances were used to test the identification probability of the algorithm. The test results are presented at the end of the paper. This article further discusses architecture, design, and policy through observations and recommendations for improving access management maturity in an organization.*

Keywords— Sketch, Eigen faces, eigenvector, weighting factor, details, key points, distance

1. Introduction

As sketch-based recognition systems are uses in forensic investigations, they require high accuracy, although their speed is low. Therefore, using recognition methods based on traditional methods is highly efficient. The recognition accuracy of methods based on geometric features and eigenvalues is high. It was also found that the recognition accuracy of sketches created using special software is relatively higher than that of hand-drawn sketches. On this basis, the recognition is based on the use of methods based on geometric features and principal components.

The model of facial recognition consists of 3 processes:

1. Formation of its face sketch based on facial images.

2. Implementation of identification based on the photo-robot.

3. Using the capabilities of parallel computing to increase the recognition speed.

To recognize a face sketch through a face sketch, we first need to create a face sketch from a face image.

METHODOLOGY

The geometric features of the image or pixel coefficients are studied in the recognition of face sketches.

Initially, the sketch was used to identify the eyes, eyebrows, nose, lips and other key points of the face and measure the distance between them. Three different schemes are used to recognize the sketch:

- Comparison of the sketch with the sketch;
- Comparing a facial image to a facial image;
- Comparing a face image to a sketch or vice versa.

In the first method, listed above, the sketch is generated from the face image and the incoming and baseline sketches are compared. In the next method, the inverse of the above method is performed, that is, the sketch is converted into a face image and the generated and base face images are compared.

The last method, although less accurate in most cases, is used in urgent cases and can help the forensic field at least a little. In this paper, the first method creates and stores a sketch in a database. This sketch is then used in comparison with sketches drawn by an expert or created with special programs. The sketch recognition algorithm uses principal component algorithms and calculation of the difference between the two images. Its scheme is shown in Figure 1.

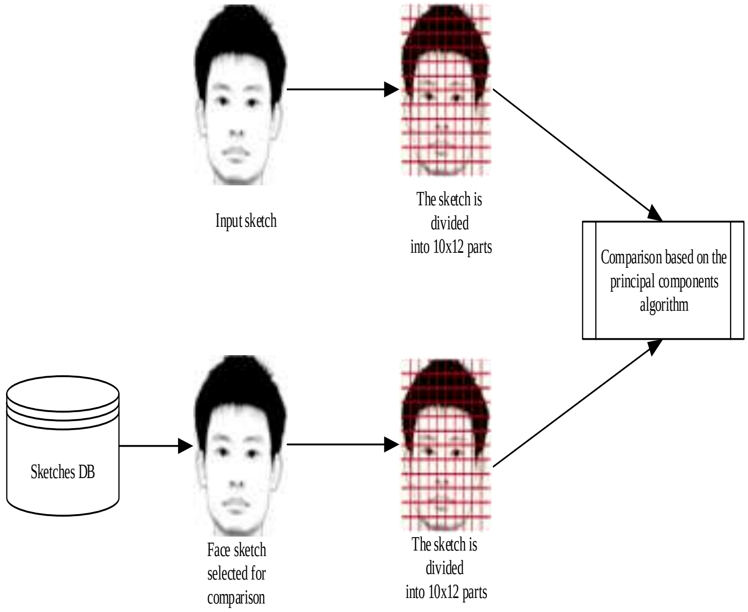

Fig. 1. *Algorithm of face sketch recognition*

Using [1], the sketch is divided into 12x10 parts. In the analysis of each part of the sketch (of 120 parts), it is processed on the basis of the algorithm for the individual principal components [2], weighting factors are calculated and the algorithm for calculating the difference between the two pixels is used.

The algorithm uses two types of labeling:

b_r - basic face sketch features.
k_r - incoming face sketch features.

Each part of the base and incoming face sketch is taken as a separate image and examined based on the principal component algorithm. On the basis of the received characteristics the difference between them is calculated, and the belonging and the degree of similarity between them is determined.

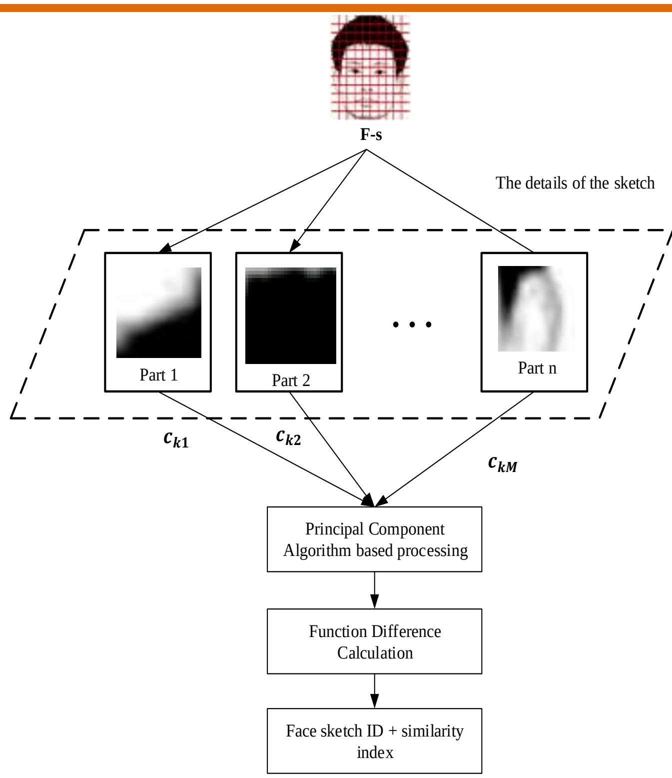

Fig. 2. *Recognition scheme based on the principal component algorithm, splitting the sketch into parts*

The algorithm consists of the following steps:
Step 1. $\boldsymbol{A_{br}}$ (in base) using sketch details, $\boldsymbol{U_{br}}$ is a special domain.
Step 2. $\boldsymbol{A_{kr}}$ (incoming) using parts of the face sketch, $\boldsymbol{U_{kr}}$ - special domain.
Step 3. Random part of the face sketch $\boldsymbol{U_{br}}$ is selected through the generated characteristic field $\boldsymbol{S_r}$
Step 4. The face sketch part $\boldsymbol{U_{kr}}$ is randomly selected from the characteristic field by projection from the incoming parts of the face sketch $\boldsymbol{S_r}$ Based on the values obtained, the weight vector is calculated using the following formula [3].

$$\boldsymbol{b_r} = \boldsymbol{U_{kr}^T S_r} \tag{1}$$

Here U_{kr}^T is the transformation of the characteristic field.

Step 5. As above, the part of the sketch $\boldsymbol{U_{kr}}$ is selected from a particular test region by projecting from the incoming parts of the sketch $\boldsymbol{S_{kr}}$, and the weight vector is calculated based on the following formula.

$$b_{kr} = U_{kr}^T S_{kr} \tag{2}$$

To calculate the recognition accuracy, the difference between the two vectors (b_r and b_{kr}) is calculated. The minimum distance between them means that its accuracy is high.

Both of the mentioned algorithms use principal component algorithms, in which the coefficients c_{br} and c_{kr} are of great importance

Here c_{br} is the weight coefficient of the base sketch generated from a face image based on the principal component algorithm.

c_{kr} is the weight coefficient of the sketch created on the basis of the description of the witness.

The weighting coefficients of the base and incoming sketches are calculated according to the following formula.

$$c_{br} = V_{br}\Lambda_{br}{}^{-(1/2)} b_{br} \tag{3}$$

$$c_{kr} = V_{kr}\Lambda_{kr}{}^{-(1/2)} b_{kr} \tag{4}$$

There are 3 different methods of measuring distance (respectively $\boldsymbol{d_1},\ \boldsymbol{d_2},\ \boldsymbol{d_3}$) used for the recognition of the sketches.

When the algorithm is implemented in the software, calculating its accuracy through these three-dimensional distances increases the chances of forensic investigators to identify the suspect.

For example, the first distance gives a 90% similarity and the second a 50% similarity, which would lead to the conclusion that this detection is incorrect.

First distance. Based on the coefficients. c_{br} and c_{kr}, the first distance is calculated using the following formula.

$$\boldsymbol{d_1 = ||c_{br} - c_{kr}||} \tag{5}$$

Second distance. The difference between the random and included in the base sketches - the second distance is calculated by the following formula.

$$d_2 = ||b_r - b_{kr}|| \tag{6}$$

Here b_r is the weight vector after projecting on the own area of the random sketch in the base generated face image.

b_{kr} is the weight vector after projection of the sketch to a specific area, based on the description of the witness.

The weight vector of a randomized sketch is calculated as follows.

$$b_r = U_{kr}^T S_r \tag{7}$$

Here U_{kr} and S_r are calculated by the following formulas.

$$U_{kr} = A_{kr} V_{kr} \boldsymbol{\Lambda}_{kr}{}^{-(1/2)} \tag{8}$$

$$S_r = A_{kr} c_{br} \tag{9}$$

Taking into account the above formulas, the weight vector of a randomized face sketch is calculated as follows.

$$b_r = A_{kr} A_{kr}{}^T V_{kr}{}^T \boldsymbol{\Lambda}_{kr}{}^{-(1/2)} c_{br} \tag{10}$$

To simplify it, the following expression is introduced.

$$\boldsymbol{\Lambda}_{kr} = A_{kr} A_{kr}{}^T V_{kr}{}^T V_{kr} \tag{11}$$

$$\boldsymbol{\Lambda}_{kr} = A_{kr} A_{kr}{}^T V_{kr}{}^T V_{kr} \tag{12}$$

So, the weight vector of a random combo box is expressed as follows.

$$b_r = \boldsymbol{\Lambda}_{kr}{}^{(1/2)} V_{kr}{}^T c_{br} \tag{13}$$

The weight vector of the arriving sketch after projecting into the characteristic field is calculated as follows.

$$c_{kr} = V_{kr} \boldsymbol{\Lambda}_{kr}{}^{-(1/2)} b_{kr} \tag{14}$$

From this formula b_{kr} is obtained as follows.

$$\boldsymbol{b_{kr} = \Lambda_{kr}{}^{(1/2)} V_{kr}{}^T c_{kr}} \tag{15}$$

As a result, the second distance is calculated by the following formula.

$$\boldsymbol{d_2 = ||b_r - b_{kr} = ||\Lambda_{kr}{}^{(1/2)} V_{kr}{}^T c_{br} - \Lambda_{kr}{}^{(1/2)} V_{kr}{}^T c_{kr}|| = ||\Lambda_{kr}{}^{(1/2)} V_{kr}{}^T (c_{br} - c_{kr})||} \tag{16}$$

The third distance. This distance is similar to the second distance, where the incoming sketches are randomly selected. It is calculated as follows.

$$\boldsymbol{d_3 = ||b_r - b_{br}|| = ||\Lambda_{br}{}^{(1/2)} V_{br}{}^T c_{kr} - \Lambda_{br}{}^{(1/2)} V_{br}{}^T c_{br}|| = ||\Lambda_{br}{}^{(1/2)} V_{br}{}^T (c_{br} - c_{kr})||} \tag{17}$$

It is noteworthy that the calculation is performed using the weights of the base and incoming sketches at all three distances. At the second distance, the characteristics of the approaching sketch were prioritized, and at the third distance, the base sketches were considered.

The FERET database [4] of the sketches and pairs of facial images was used to perform the initial testing at the three distances listed above. Facial images of 188 people and their sketches were created in this database. Half of them are recommended to be used for training and the other half for testing.

Table 1: Experiment Result by component types

Testing level / The method	1	2	3	4	5	6	7	8	9	10
Geometric method	30	37	45	48	53	59	62	66	67	70
Principal Components Method	31	43	48	55	61	63	65	65	67	67
Tang and Wang method	71	78	81	84	88	90	94	94	95	96
Proposed algorithm	76	83	85	86,5	90	92,6	95	95	96,8	97,9

Table 1 shows the results obtained using the geometric method [5], the method of principal components [6], the transformation method proposed by Tang and Wang [7], and the proposed algorithm.

The results of the three distances in the recognition accuracy test are as follows.

Table 2: Experiment Result by coordinate distance

Testing level / Difference	1	2	3	4	5	6	7	8	9	10
1st distance	30	51	62	65	71	73,6	76	80	82	82,5
2nd distance	76	83	85	86,5	90	92,6	95	95	96,8	97,9
3rd distance	59	71	77,2	80	84	87	86	88	88,3	88

It can be seen that the recognition accuracy is higher at the second distance. also, as a proof of the above statement, the first and third distances should not be considered. Since the second distance is recognized, so to speak, by a random sketch in the base, its accuracy is relatively high.

2. CONCLUSION

Researchers are currently using face sketch databases to evaluate the effectiveness of face sketch -based recognition methods and algorithms. These databases consist of an image of a face and its face sketch pair drawn under normal conditions, from the front, manually or in a program. Also, the results obtained in the test form may be partially different from the real results. Since the proposed algorithm divides the face sketches into parts and examines each part separately, its accuracy is relatively improved. In the test case, the algorithm, which showed 97.9% accuracy at the second distance, is expected to record a high result in the real case.

3. REFERENCES

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