SELF-SIMILARITY MEASURMENT USING PERCENTAGE OF ANGLE SIMILARITY ON CORRELATIONS OF FACE OBJECTS

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Abstract: A 2D face image can be used to search the self-similar images in the criminal database. This self-similar search can assist the human user to make the final decision among the retrieved images. In previous self-similar search, a 2D face image comprises of objects and object correlations. The attribute values of objects and their correlations are measured and stored in the face image database. The similarity percentage is specified to retrieve the self-similar images from the database. The problem of previous self-similar search is that the percentage of the angle differentiation among the objects in different part is different although their angle differentiation is exactly the same. The proposed model is introduced to improve the stability of the similarity percentage by reducing the number of face objects, object correlations, and the degree calculation. After testing over 100 samples, the proposed method illustrated that the stability of similarity percentage is improved especially for the left side objects of the face image.

1 INTRODUCTION

The face image is two dimensional, vertical and horizontal. For each image, there are 10 objects – Face, Right Eyebrow, Left Eyebrow, Right Eye, Left Eye, Right Ear, Left Ear, Nose, Mouth, and Scar that are identified and the size from the center toward the 0, 90, 180, and 270 degrees of each object are recorded in the database. The Face object is used as the reference object. There are 9 object correlations – Face against Right Eyebrow, Face against Left Eyebrow, Face against Right Eye, Face against Left Eye, Face against Right Ear, Face against Left Ear, Face against Nose, Face against Mouth, and Face against Scar – in which their distance and angle toward the Face object are recorded in the database as well. The self-similar images in which all the attribute values of objects and object correlations are not exceed the specified similarity percentage will be retrieved from the database by using the following formula (P. Porntrakoon, 1999; V. Srisarkun, 2001 & 2002).

$$angle\_similarity\_percentage \geq \frac{|q_i - r_i|}{\max(q, r)} \times 100 \quad (1)$$

where q is an attribute value of the object of the key image and r is an attribute value of the object of stored image.

It is obvious that the degree calculation of each object – in different part of the face – toward the reference object is unstable. Therefore the percentage of the angle differentiation among the objects in different part will be different although their angle differentiation is exactly the same – e.g., 2 degrees on the face.

The proposed mothod reduces the number of objects to 8 objects, reduces number of object correlations to 7 correlations, and introduces the new calculations of the object correlations. The proposed method presents a more stable ratio of angle similarity among objects in different part of the face although their angle differentiation is exactly the same. Moreover, the proposed method requires less attributes to represent the content of the face image. The attribute number is adequate to retrieve the similar face images from the database. The space required to store the attribute values is less and the search time is much improved.

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2 PROPOSED METHOD

2.1 Face Image Conversion

The face image is segmented into closed contours corresponding to the dominant image objects. Each object contains its object correlation and attributes (I. Kapouleas, 1990; S. Dellepiane, 1992; A.V. Ramen, 1993). In the proposed method, 8 objects – Nose, Right Eyebrow, Left Eyebrow, Right Eye, Left Eye, Right Ear, Left Ear, and Mouth are detected by specifying the top, bottom, leftmost, and rightmost positions of each object. Nose will be used as the reference object that has the correlation with the remaining objects.

Therefore, a face image has 7 object correlations and each correlation (Right Eyebrow versus Nose, Left Eyebrow versus Nose, Right Eye versus Nose, Left Eye versus Nose, Right Ear versus Nose, Left Ear versus Nose, Mouth versus Nose).

Each correlation has angular direction and distance to the center of the reference object. The distance is measured in pixel while the direction is measured in degrees.

In this paper, the object and the object correlation are estimated prior to the storing. The attributes include size, distance, and angle.

2.2 Specify the Positions of Objects on the Face Image and Calculate the Object's Center Coordinate (x, y)

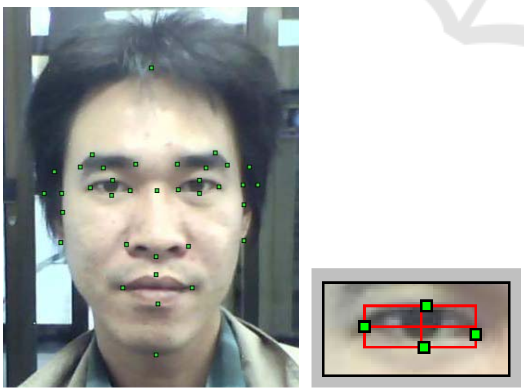

Figure 1: Specified positions of the top, bottom, leftmost, and rightmost of each object.

For each object, the coordinate (x, y) position of the top, bottom, leftmost, and rightmost are specified as shown in Figure 1. Then the coordinate (x, y) of each object's center is calculated as follows:

$$OCx = (OLx + ORx) / 2 \tag{2}$$

$$OCy = (OTx + OWx) / 2 \tag{3}$$

where *OCx,y* is the center, *OLx,y* is the leftmost, *ORx,y* is the rightmost, *OTx,y* is the top, and *OWx,y* is the bottom coordinate (x, y) of the object.

2.3 Calculate the Distance of Each Face Object based on the Reference Object

After the boundary and the center of each object are identified, the distances and angles from the center of reference object toward the remaining objects are calculated as follows:

$$\text{Distance} = (OCy - Oy) / \ \text{TAN}((OCy - Oy) / (OCx - Ox))^{-1} \tag{4}$$

Where *OCx* and *OCy* are the center coordinate (x, y) of the reference object, *Ox* and *Oy* are the center coordinate (x, y) of the correlated object.

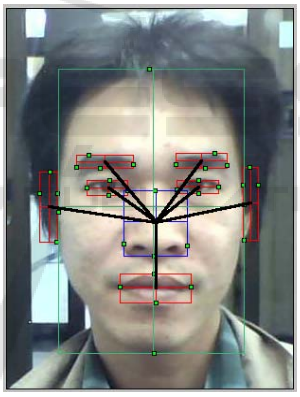

Figure 2: Distance of each object based on the reference object.

2.4 Calculate the Angle of Each Face Object based on the Reference Object

In the angle calculation, the direction of each object except the nose is measured – in degrees – from its center coordinated (x, y) to the center coordinated (x, y) of the reference object (Nose). This model considers the widest range of each object to the center object based on the location of that object toward the reference object as shown in Figure 3.

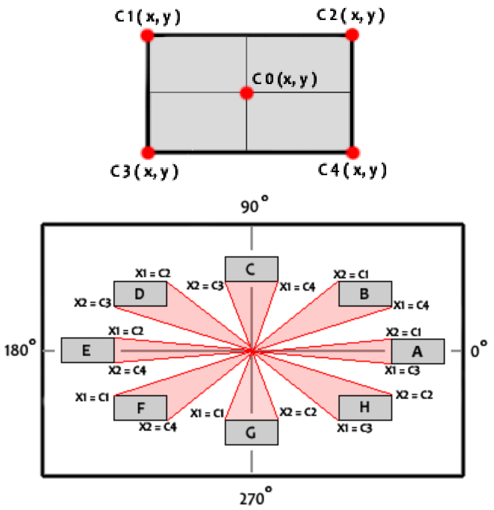

Figure 3: Distance of each object based on the reference object.

The object in different location from the center object will use the different coordinate positions (x, y) to calculate the Minimum and Maximum degrees toward the reference object.

Then, the widest position of each object toward the reference object is used to calculate the maximum and minimum degrees as shown in Figure 4 and is calculated as follows:

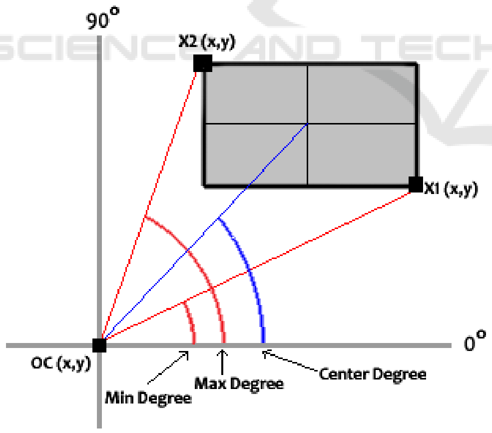

Figure 4: Maximum and Minimum degrees of each object toward the reference object.

$$\text{Min} = \text{ATAN}((OCy - X1y) / (OCx - X1x)) \quad (5)$$

$$\text{Max} = \text{ATAN}((OCy - X2y) / (OCx - X2x)) \quad (6)$$

Where X1x, X1y, X2x, and X2y are the widest positions – coordinate (x, y) – of the correlated object.

3 EXPERIMENTS

The experiments were performed to test the stability of similarity percentage by testing over 100 samples of front face image (640*480 resolution) which consider the object correlation one by one (Right Eyebrow, Left Eyebrow, Right Eye, Left Eye, Right Ear, Left Ear, and Mouth) toward the reference object (Nose). Then compare the similarity percentage of its objects by simulating that the object is compared with the same object size when it is simulated to locate at different degree (range from ± 1-10 degrees) from its own original position to prove that the percent of the similarity from the proposed method is more stable than the old method “A Model for Similarity Searching in 2D Face Image Data” (P. Porntrakoon, 1999), “A model for Self-Similar Searching in Face Image Data Processing” (V. Srisarkun, 2001), “Self-Similar Searching in Image Database for crime Investigation” (V. Srisarkun, 2001), “A model for Self-Similar Search in Image Database with Scar” (V. Srisarkun, 2002), and “Face Recognition Using a Similarity-based Distance Measure for Image Database” (V. Srisarkun, 2002).

Then the processes used to perform the experiments are as follows.

3.1 Resize the Position and Proportion of the Face Objects

To avoid the problem of the different object size caused by the distance of the captured images, the position and proportion of the objects are resized by adjusting the width of the reference object (Nose) in the captured images to have the same width. Then recalculate the top, bottom, leftmost, rightmost, and center coordinate (x,y) positions of each object based on the new proportion of the reference object as follows:

$$NOx = (iw + (100 / ((NLx - NRx) / iw * 100) * (dw - (NLx - NRx)))) / iw * Ox \quad (7)$$

$$NOy = (iw + (100 / ((NLx - NRx) / iw * 100) * (dw - (NLx - NRx)))) / iw * Oy \quad (8)$$

Where NOx is the new x coordinate after resizing, NOy is the new y coordinate after resizing, NLx is the leftmost, NRx is the rightmost x coordinate of the reference object (Nose), iw is the original image width in pixel, and dw is the default width value in pixel for resizing.

3.2 Calculate the Similarity Percentage of Angle of Each Object between Faces

According to the Maximum and Minimum degrees of each correlated object toward the reference object in each face image, this model will use the minimum and maximum degrees of the correlated object toward the reference object from the same object correlation number in different face images to calculate the similarity percentage of as shown in Figure 5 and is calculated as follows:

$$\text{Percent of similarity} = ((\text{Min1}, \text{Max1}) \cap (\text{Min2}, \text{Max2})) * 2 / ((\text{Max1} - \text{Min1}) + (\text{Max2} - \text{Min2})) * 100 \quad (9)$$

Where Min1, Max1, Min2, and Max2 are the Minimum and Maximum degrees of the same correlated object toward the reference object in different face images.

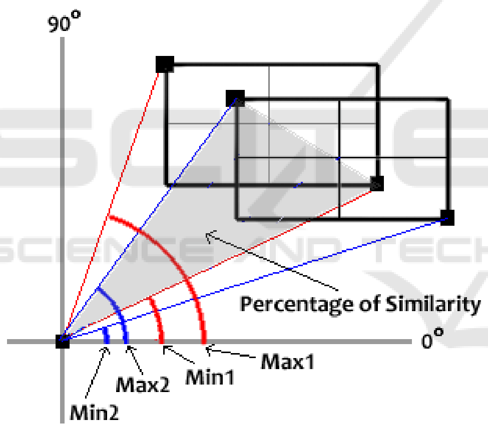

Figure 5: Percentage of Similarity.

4 EXPERIMENT RESULTS

From the experiment, we have summarized the results in average of percentage of angle similarity among object correlations on the face and standard deviations that compares the proposed method with the old one. The results are shown in Table 1, Figure 6 and Figure 7.

Table 1: Average Percentage of Angle Similarity result and standard deviation of the proposed method and the old method (P. Porntrakoon, 1999; V. Srisarkun, 2001&2002).

Degree Different	Average Similarity (%)		Average STD	
	Propose	Old	Propose	Old
1	97.7895	96.8704	0.43391	5.32916
2	95.5776	94.4426	0.86811	8.91565
3	93.3558	93.0225	1.30500	9.97539
4	91.1348	91.2665	1.74134	11.9929
5	88.9097	90.0068	2.17840	12.8165
6	86.6606	88.7411	2.62243	13.7332
7	84.2427	87.8864	3.15865	13.6906
8	81.9148	86.8308	3.65496	14.2223
9	79.6666	85.8518	4.08442	14.6272
10	77.6822	85.0452	4.38132	14.6733

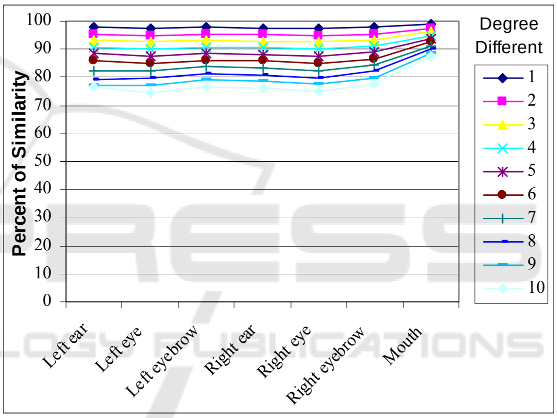

Figure 6: Average Similarity Percentage of the proposed method.

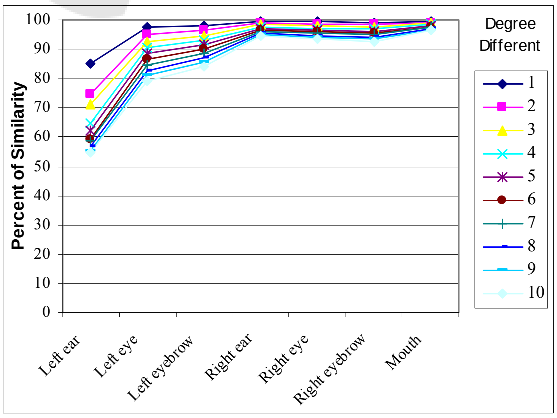

Figure 7: Average Similarity Percentage of the Old method (P. Porntrakoon, 1999; V. Srisarkun, 2001&2002).

We found that the proposed method provides more stable of the angle similarity percentage among object correlations compared to the old method that presents unstable (reference from the result of standard deviation value in Table 1) especially the left side object correlation that presents high deviation from the other correlated objects. Moreover, the old method still presents a little deviation when the actual different in degrees is increased which presents unstable result of the method.

5 CONCLUSIONS

In this paper, we proposed a method to handle approximate searching by image content in an image database. Older method, such as 2D string (S.-K. Change, 1987), giving binary answer is slow and not scaleable (S.-Y. Lee 1992). In addition, image content representation methods based on strings have been proven to be ineffective in capturing image content and may yield inaccurate retrieval (Petrakis, 1997). Our method allows querying the image database with the degree of similarity. And we do propose the method which considers the stability of the angle similarity percentage among object correlations. Older method, (P. Porntrakoon, 1999; V. Srisarkun, 2001&2002) also gave the unstable results.

The proposed method can reduce the instability in the angle similarity percentage for a better subsequent decision making process in similarity searching and reduce the number of object correlations which fasten the searching time.

6 FUTURE WORK

We plan to continue our research work by replace the proposed model which provided more stable result in percentage of angle similarity among object correlations over the full sequence reference from the old model (P. Porntrakoon, 1999; V. Srisarkun, 2001&2002) under the sample images of the same person which are taken at different time (approximately 2 -20 weeks). We believe that the front face photos that are taken from the same person at different time are not exactly the same .We will perform the experiments to prove the overall result of similarity between the future model and the old model.

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