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ADC

Adaptive Computation
LLC

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Whitepaper

**[Statistical study for Partial Sketch-Face Recognition Based on ADC Bio-
Inspired Visual Recognition Software]**

Background

Sketch-object recognition plays an important role in security arena to future advertisement product market, to enable the recognition of the suspects or desired products based on the visual sketch characteristics.

In security perspective, criminals without being identified, tracked and captured would evade justice and wait for their chance to strike again. We would live in chaos and terror. Sketch-face recognition, which allows identifying and tracking suspects based on their visual characteristics, has been a crucial tool for law-enforcements from ancient time. However, obtaining a complete sketch-face of criminals is idealistic and challenging, but the *crucial partial* of it is often well-recalled. In addition, their appearance often changes intentionally such as disguise or naturally such as aging. In most cases, partial sketch-face search is practical and realistic approach. To help law-enforcements overcome this challenge, Adaptive Computation (ADC) had developed partial sketch-face recognition.

In commercial arena, desired products from memory or imagination may be in the wish-list now, but will be realistic in the future from ADC sketch-object search and recognition.

This is a bio-inspired visual recognition software that integrates state-of-the-art computational theories with current knowledge of the mammalian visual system to automatically analyzes and extracts unique features of the sketch, and then search in the databases for most probable matches. ADC algorithms has successfully demonstrated that it is capable, with 100 statistical trials, to perform 100% correct of partial sketch-face search within the best 5 candidates in no scaling resolution and 90% correct of it within the best 5 candidates in random scaling resolution for practical real world applications. The results are so substantial that this algorithm is not only ready for security applications, but is heading to pave the way in commercial applications via sketch recognition and integration of photo and sketch recognition of desired products.

Experimental set-up

In this experiment, we collected a database consisting of face pictures from 533 individuals and 188 of their face sketches¹. For input, we took the first 100 face-sketches and randomly selected different parts on the faces with no scaling or scaling to emulate the search along random scaling values from 0.5-1.0, as shown in Figure 1 and Figure 3 respectively. The resolution of the raw images in the databases is the same of that of the non-scaling images, but is different from that of the scaling ones. For scaling data set, this discrepancy resolution between sketch-face input and images in database incorporates one of the real world features for practical applications and it is more focused in this study.

Simulations

In this section, ADC bio-inspired visual algorithms were used to execute automatically two major tasks:

¹<http://mmlab.ie.cuhk.edu.hk/archive/facesketch.html>

a) *Alignment*: Finding matching partial of face in the face database from given crucial partial input as detection step. In this step ADC algorithms self provides the alignment for partial of region interest in test image.

b) *Recognition*: Comparing between two partial faces (input and matching partial) to rank and recognize them.

Partial sketch face with no scaling(resolution)

From 100 out of 188 sketch images, we randomly selected a portion of each sketch-image as input for searching the recognition of correct face in the 533-face database. Hence the resolution of sketch and raw image can be close as sketched. A part of input image array is shown in Figure 1 and the results are shown in Table I.

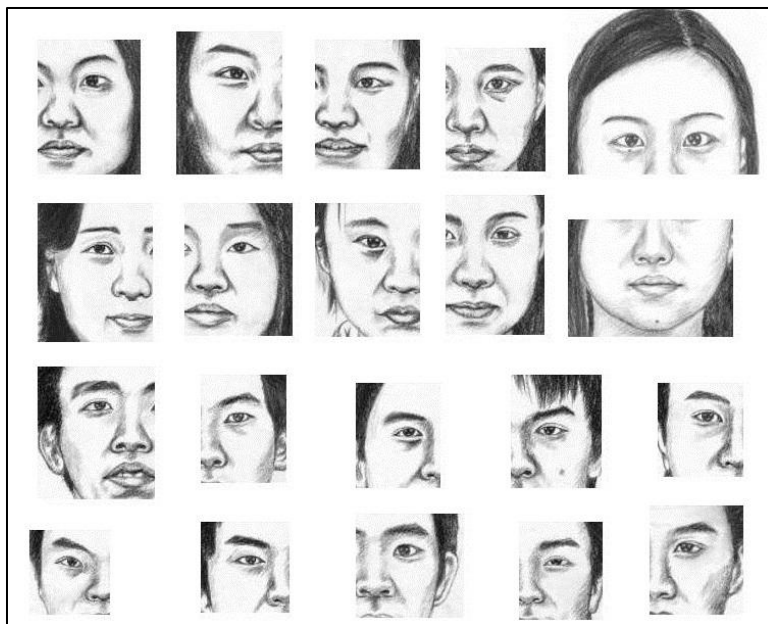


Figure1: A portion of sampled input image without scaling

Simulation Results

ADC validated 100 random partial sketch-image samples and the results are provided in Table I.

Table I: Simulation recognition results

Total sample	100 trials with <i>no scaling</i> image with 533 different faces database	Comments
Best 1 results	72	72 cases were reported to be the best (best 1) match
Best 2 results	87	15 cases were reported to fall in the second best match.
Best 3	97	10 cases were reported to be in the

		third best match
Best 4	98	
Best 5	100	
Out of the best 5	0	

Based on this simulation results, ADC bio-inspired visual recognition software is capable to get about 97% correct identification within the best 3 and completely correct within the best 5.

This is a substantial result for partial sketch face recognition and up to this point, we never aware of any other technique which can achieve like this.

Partial sketch face with random scaling size (resolution)

In reality, the sketch and database images are independent and their resolutions have no correlation from each other; hence it may introduce one of the biggest obstacles for recognition. In emulation of the reality, we randomly generate scaling values shown in Figure 2, to scaling the original sketch-image resolution before selecting partial portion of images. A portion of random scaling input array are shown in Figure 3 and each image input with different size (resolution) is used as input search to evaluate our algorithms.

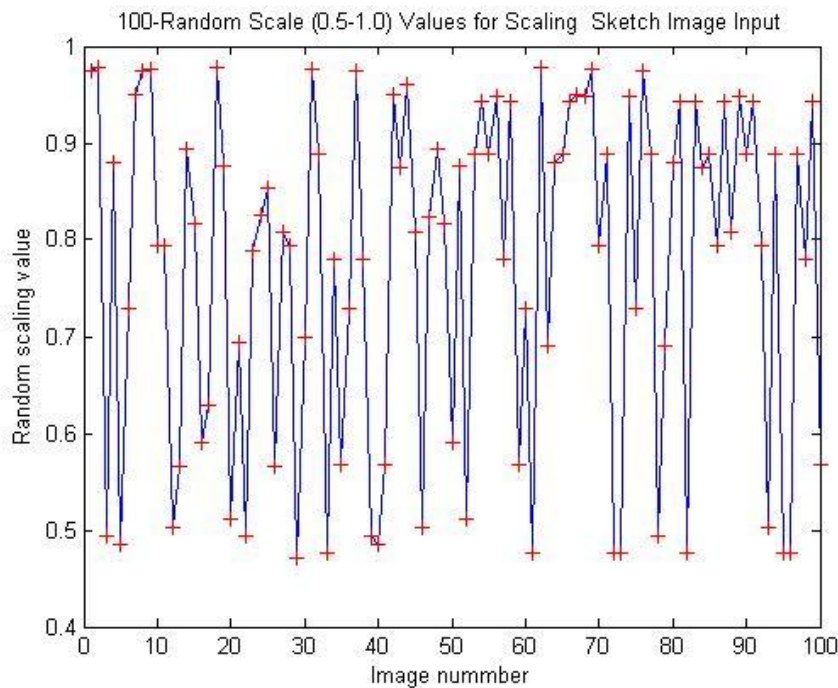


Figure 2: Random value array for scaling image resolution

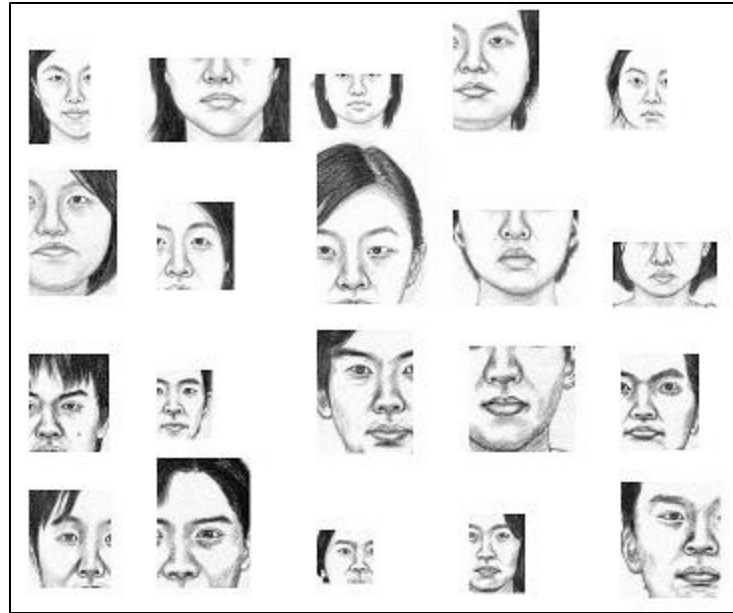
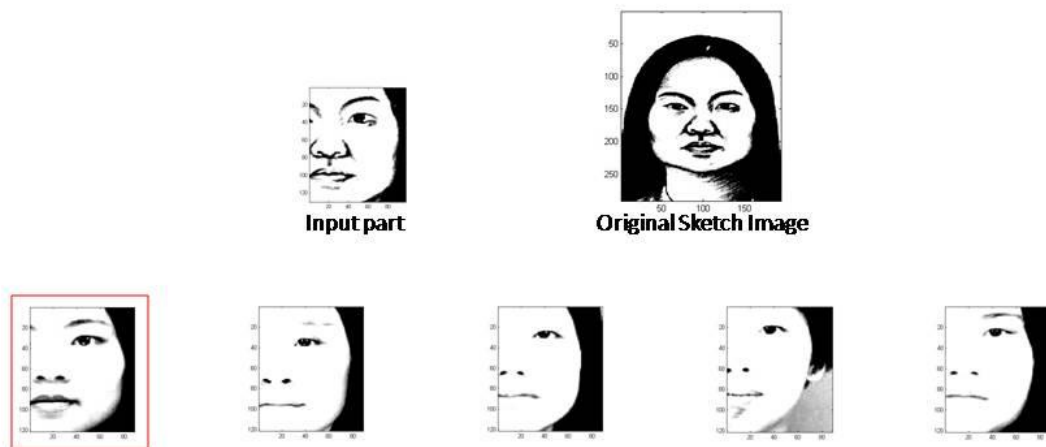
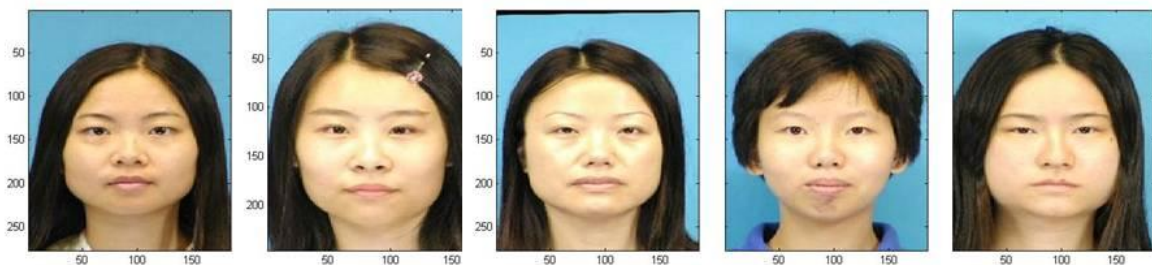


Figure 3: A portion of random scaling partial image input array

Simulation Results



Detection (Alignment): Found Matches part (Best, second, third, fourth and fifth Match in sequence order)



Recognition: Found Matches (Best, second, third, fourth and fifth Match in sequence order) in Database

Figure 4: Sequent steps and the best and correct match

In Figure 4, input part as input search is extracted from original sketch image in the first row, to validate our algorithms. ADC software provided the best five match parts with alignments (second row) and red frame indicates the best and correct match and the third row is corresponding faces of the matches in database.

With 100 random selected partial sketch-face image and 100 random scaling values, the simulation results are reported in Table II.

Table II: Simulation results with randomly scaling image resolution (0.5-1.0)

Total sample	100 trials with <i>random scaling image</i> with 533 different faces database	
Best 1 results	67	67% is the best mach and 3% is off from no scaling image
Best 2 results	79	12 cases were reported to fall in the second best match and 8% is off from no scaling image
Best 3	84	5 cases were reported to be in the third best match and 13% is off from no scaling image
Best 4	88	4 cases were reported in the fourth best match and 10% is off from no scaling image
Best 5	90	2 cases were reported in the fifth best match and 10% is off from no scaling image
Out of the best 5	10	There are 10% discrepancy between scaling and no scaling ketch image input.

Discussions

In sketch-image, the features are not complete accuracy and short of true gradient information as compared to the raw image; hence it may pose more challenges in recognition. Specially partial image may carry much less feature information of the correct one and it may introduce more errors. In order to compensate this shortness, we used more features e.g., an eye, half mouth, half nose in this study as compared with the previous white paper (ADC White paper, 2012) and this assessment suggests that the experienced operator (with more experiments) can be substantially effective to select optimal feature for highly successful rate of recognition.

To understand the algorithms' capability better, we provide the results of the best 2 and the best 3 to understand further.

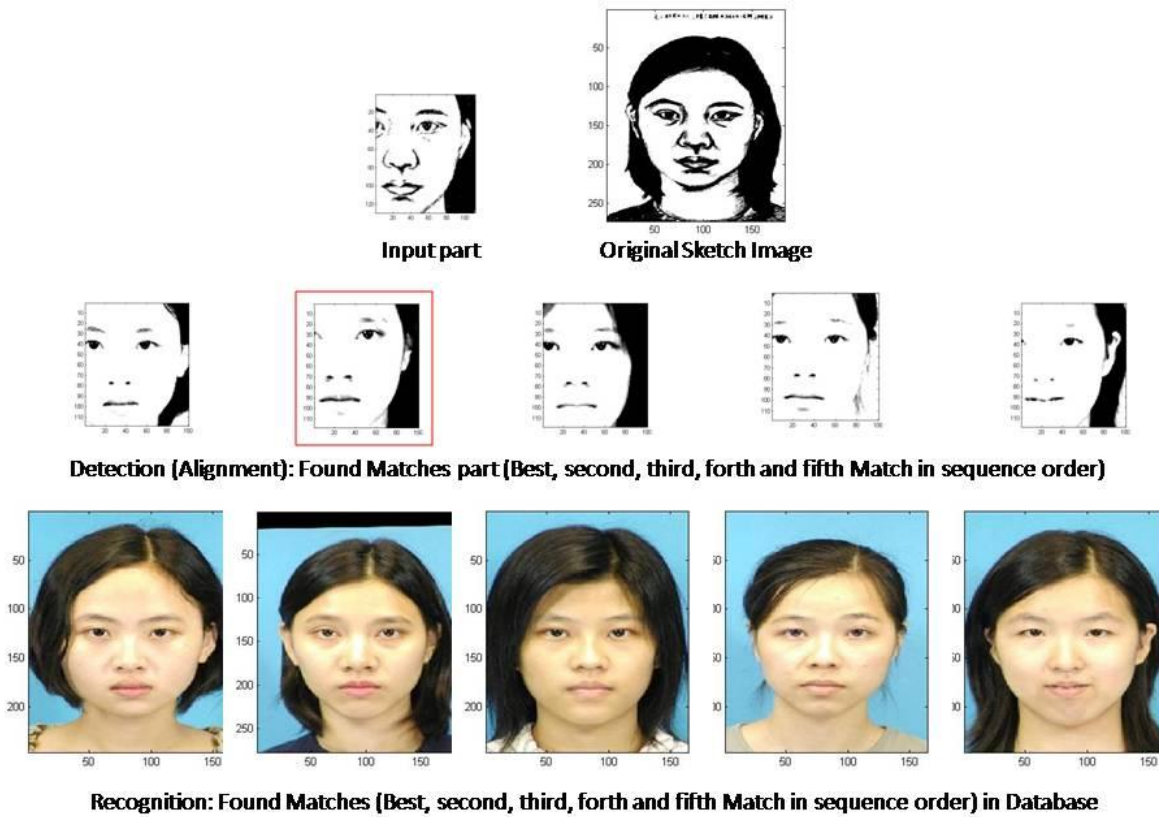


Figure 5: The second best and correct match

In Figure 5, input part is extracted from original sketch image in the first row. ADC software provided the best five match parts in second row and red frame indicates the second best and correct match and the third row are corresponding faces of the matches.

In this validation, the first and second match of the second row are hard to determine who is the correct one. In incorporation of third row it helped us determine the best match belongs to the second face.

In Figure 6, input part is extracted from original sketch image in the first row. ADC software provided the best five match parts (second row) and red frame indicates the third best and correct match and the third row are corresponding faces of the matches.

In the second row the first, third and fifth match are hard to determine who is the correct one as compared to the input part. However, in third row we can see the best match belongs to the third face.

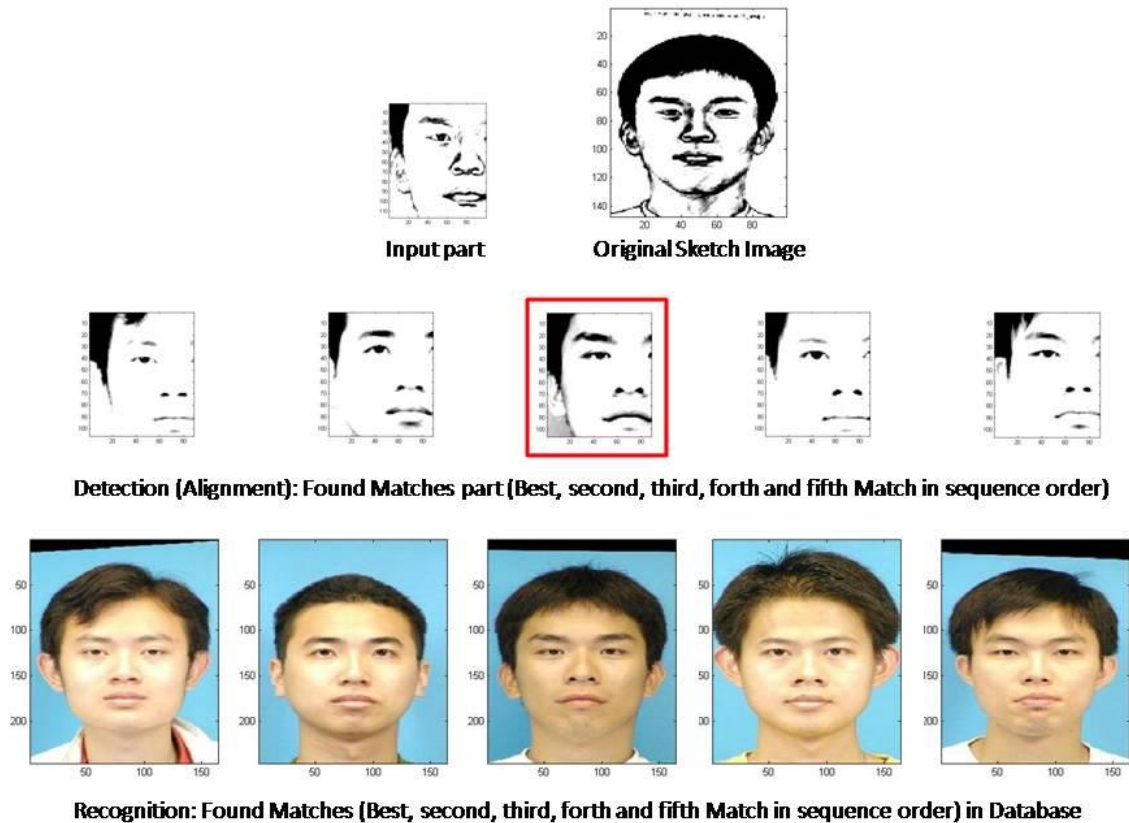


Figure 6: The third best and correct match

Conclusions

In this study, from 100% correct recognition with the best 5 matches in idealistic scenario (no scaling), it is 10% degraded performance in emulated reality (scaling) to 90% correct. Based on this result on limited feature information from partial sketch and gray scale input part, ADC algorithms suggests that it can perform better than the result above (90%) when feature information is enhanced and it is convinced that the results will be more significant with the unique feature inputs of each particular object.

ADC algorithms that were provided an excellent performance in simulated practical environment are ready to serve as a tool to assist operator for eluded suspects recognition. Since our algorithms are so effective for partial object that it logically enables to integrate parts such as nose, eyes, forehead etc to improve the performance further.

Based on this study, our bio-inspired algorithms are ready to validate the real world applications for security purpose.

In commercial arena, ADC algorithm is ready to pave the way for sketch-object search and recognition of desired products from users' memory or imagination.