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Vilasinee Srisarkun
University of Wollongong, vs12@uow.edu.au

Joan Cooper
University of Wollongong

Chanintorn Jittawiriyanukoon
Assumption University of Thailand

A MODEL FOR SELF-SIMILAR SEARCH IN IMAGE DATABASE WITH SCARS

Vilasinee Srisarkun ∗, Joan Cooper ∗and Chanintorn Jittawiriyanukoon ∗∗
∗ Faculty of Informatics,
University of Wollongong, NSW 2522, Australia.
[vs12@uow.edu.au]
∗∗ Faculty of Science and Technology,
Assumption University, Bangkok 10240, Thailand.
[nin@s-t.au.ac.th]

ABSTRACT

In Thailand, the entire Thai citizens are required to carry a national identity card. Therefore, a personal data of each person such as date of birth, weight, height, blood type, religion, occupation, registered address and individual photograph image are kept in the Central Registration Database Systems (CRDS) operated by the Department of Local Administration under the supervision of the Ministry of Interior. And in order to increase the efficiency of the internal administration, this Central Registration Database can be utilized and shared by other authorized government agencies at their best interest. The Thai Royal Police Department and the Crime Combat Section are one of the government agencies that share the information from the CRDS. Frequently, individual registration database and photographs are needed for the crime investigation.

In previous research, the author proposed a method called "self-similarity search" to handle searching for photographs image database (PID) to support police officers when searching criminal records [18]. By using the proposed method in comparison with the sequential search employed a database search. As a result the proposed method is faster than sequential searching and requires less space. In this research, it is aimed at the refinement of attribute, which will guarantee much faster result when using our proposed searching method provided that scars of suspected person has been earlier found.

Index terms: photograph image database, self-similar searching, simulation, correlation and object relation.

1. INTRODUCTION

Electronic Civil registration and ID card service were implemented at the Department of Local Administration (DOLA), Ministry of Interior in Thailand. The objectives of the systems were to provide electronic civil registration service and issuing National Identity Card at local registrar offices as opposed to centrally processing in Bangkok. And in order to reduce the data redundancy, these individual registration informations are then shared among other authorized government agencies all over the country as to increase efficiency in internal administration.

The Central Registration Database System (CRDS) is completed and services, including civil registration (from birth to death), house registration (including moving in-out of the house), marriage, and change of name, have been put in use at all registrar offices since 1997.

The CRDS project offers timesaving, cost savings, and convenience, by offering one-stop service to all citizens. A person may apply and get his citizen ID card in 15 minutes at any registrar offices, regardless of his/her residence. Before implementation of this system, it took 2-3 months. Also, any persons can report moving out at the destination registrar office. Trip to the origin office is no longer needed. A person may also request to verify, duplicate, and certify his record of registration and ID card at province hall and registrar office throughout Thailand, where previously, this could only be done at the office that he/she had house registration.

The CRDS also provides an efficient, fast and accurate Management Information System (MIS) to the executives of Ministry of Interior (MOI) and 43 other government agencies.
This CRDS offers convenience to people by,
1) Thai people can apply for a passport by presenting only the citizen ID card. Other personal data can be verified on - line.
2) The citizen ID card can be used as an ATM card at participating banks.
3) The project offers an e - mail address to every Thai citizen, both those residing in Thailand and overseas.
4) Thai people from anywhere worldwide, can contact the Ministry of Interior for application on civil registration, and can request his own record to be printed on his own printer.

Figure1: An example of the Thai National ID Card

In addition, the CRDS provides the following information to be shared/used by other government agencies, 1) on-line data on population and house registration, 2) citizen photograph, 3) some vital statistics, and 4) voter list for all levels of election.

This CRDS project is a pilot to modernize the manual system to an electronic system. The implementation covers all districts throughout Thailand. It involved very large-scale database and wide area satellite network, and allowed for civil registration service to Thai citizen worldwide for the first time, via web-based application. The project had significantly increased efficiency in both services and administration. It linked about 2,000 registrar offices throughout the country and therefore allowing for up-to-date information to be available on-line. This project is found to be very cost effective. With the budget of US$ 46,060,178, covering installation and implementation of the Central Registration Bureau, 9 Regional Data Processing Centers, 505 District Registration Offices, and 76 Provincial Halls.

The benefits of the project are 68,338,841 people in Thailand who can get fast and reliable registration or ID Card services (as shown in fig.1). Moreover, other government executives such as 76 provincial Governors, 505 District Governors, 83 Directors of every division and department got 1 PC workstation for information processing, inquiry for data both text and photo image.

It is the author intention to concentrate on the photograph image retrieving instead of the text in this particular research. As frequently, individual photographs are needed for the crime investigation when images need to be identified. Therefore, this paper is suggesting an effective method to retrieve self-similar photograph images from a central registration database.

In the area of photograph recognition, various objects (e.g., face, eyebrows, eyes, nose, etc.) are produced as representations for each photograph image and then used to support decision making in criminal records search. An example of more complex image based upon an OCR system will read documents and will transform them into ASCII files [1]. The developing technique supporting the automated archiving and the retrieval of images by content was introduced in [2].

To support queries by image content in a Photograph Image Database (PID), all images must be analyzed prior to storage, so those attributes can be extracted and stored in the database separately. These descriptions are then used to search the PID and to determine which images satisfy the query selection criteria. Matching between these attributes is a well-known method so called self-similar has been studied extensively in [4], [5]. The effectiveness of a PID system ultimately depends on the image representations, the types of image queries, and the efficiency of searching technique [2] and the traffic congestion of network when accessing to the CRDS [16].

The user may specify several objects with complex shapes and interrelationships and may ask for all images containing self-similar [6], [7]. The term self-similar means that at every time the retrieved images from PID are resemblance to what the users query. Then database searching must distribute the self-similar ones so that all images ranging up to a specified correlation will be retrieved. This paper concentrates on analysis of query for various correlation parameters in PID searching. Self-similar PID can be recognized in multiformity:

- A density of original photograph image content.
- Comparison cost.
- A variance of sample means that sample size is essential with the time-scale comparison.

In sequential searching, the algorithm compares the stored photograph image in central registration database (CRDS) to the query image pixel by pixel, starting from the first pixel until all pixels are covered. The perfect-matched image will only be retrieved, when all pixel values of stored image are matched. As the sequential searching compares the pixel value of the two images pixel by pixel at a time, and it is evident that an image comprises of great number of pixels; the sequential searching time depends on the image size. The larger size is the longer comparing time will be. For example, if an image of 90*120 pixels with 256 monochrome scales will be used then one image produces totally 10,800 pixels to compare.

The method proposed in this paper requires few attributes to represent the content of photograph image. The attribute number is adequate to retrieve the similar photograph images from the database. The space required for attributes storage is insignificant and search time will be considerably reduced. The performance with small database size of previous paper was apparently improved [17]. However, in this paper the performance will be measured by comparing a different size of database. Besides we consider the practical case with attribute “scar”. Images with scar are somehow reduced and found to be less in reality. The database size used in this research is up to 100.

The paper is organized as follows. The object, object number, and face image conversion are presented in Section II. Followed by cost estimation of object correlation, a query by example experiments in section III. Section IV displays the experimental results and finally the conclusion together with future work is summarized in Section V.

2. PROPOSED METHOD

2.1 OBJECT NUMBER

Photograph image consists of objects, which are identified prior to their storage. Each object has the fixed object number starting from zero (e.g., 0 is the relation between face and right eyebrow) as shown in Table 1. Attributes [8]-[10] (e.g., size at 0 degree, reference angle and distance between those two reference objects) are also included.

Each object stored in the database will be compared to each object of the key image (attribute by attribute). In fact the comparison may or may not emanate a perfect match. But the image with a satisfied degree of self-similar is retrieved.

2.2 IMAGE CONVERSION

The face image is segmented into closed contours corresponding to dominate image objects. Each object contains object number and attributes. The object numbers of a face image are shown in Table1.

Moreover, since each object in the photograph image is non-roundness object, each object includes a number of attributes as follows

1. Size at 0 degree
2. Size at 90 degree
3. Size at 180 degree
4. Size at 270 degree

The unit of these attributes is measured in millimeter. In order to reduce the number of object and calculation complexity, we will refer to a center point for all objects as shown in Table 1. For example, let n be the number of objects of an image. If the center point is reference then object number is (n-1). If no reference point is needed then the number of object will be $\sum_{i=1}^{n-1} n-i$.

Objects (reference from center of the photograph image)	**Object Number**
Center of the Face	0
Right Eyebrow	1
Left Eyebrow	2
Right Eye	3
Left Eye	4
Right Ear	5
Left Ear	6
Nose	7
Mouth	8
Scar	9

Table 1. Object Number

Each object contains 3 attributes; object number, distance, and angular direction to the reference point. The distance is measured in millimeter while the direction is measured in degree.

In this research, the objects and object correlation are estimated prior to the storing. The amount includes size, distance, and angle. Searching for stored images in the database requires that all images with positive correlation will be retrieved. The alikeness of the output images depends on the degree of self-similarity. In this particular research an original photograph image with a scar is established and defined see figure 3. Comparing to sequential searching, our searching will retrieve the self-similar images from the database faster and distinctively when the refinement of attribute is set.

3. EXPERIMENTS

3.1 OBJECT CORRELATION ESTIMATION

In order to perform self-similarity searching, which is faster in searching the image from the database and obtains the likeness image, the self-similarity searching method for photograph image database (PID) is applicable. The photograph image, which is taken from the ID Card database (as shown in fig.1), is shot by digital camera, then enlarged 6 times. Next the photograph image is converted into objects and object number. The attribute values of each object and object numbers are then identified. Next, all data is stored in the database. The steps used to identify the objects, object number, and attribute values are as follows.

1. For each photograph image, there are 10 objects – Face center, Right Eyebrow, Left Eyebrow, Right Eye, Left Eye, Right Ear, Left Ear, Nose, Mouth, and Scar.
2. For each object, the center of the object is identified as shown in Figure 2(b).
3. Then, for each object, the size at 0 degree, size at 90 degree, size at 180 degree, and size at 270 are measured from the center of the object. The unit in millimeter is shown in Figure 2(a). According to Figure 2(a), size at 0 degree is 14.5 mm., size at 90 degree is 6 mm., size at 180 degree is 14.5 mm., and size at 270 degree is 6 mm. If any objects do not exist in the photograph image, these attribute values are set to a default value of zero.
4. For all face images, there are 9 objects number in which Face object is the reference object – Face Center (FC) towards Right Eyebrow, FC towards Left Eyebrow, FC towards Right Eye, FC towards Left Eye, FC towards Right Ear, FC towards Left Ear, FC towards Nose, FC towards Mouth, and FC towards Scar – as shown in Figure 3(a).
5. Then, each attribute of the object is identified. The distance between 2 objects is measured in millimeter from the center of these 2 objects.

The angle between 2 objects is measured in the horizontal direction of the line connecting between these 2 object centers as shown in Figure 3(b). If any object does not exist in the photograph image, these attribute values are set to zero. Finally, all contents of the photograph image, as shown in Figure 4(a), are stored into the database.

In comparison between each image in the database and key image, measurement of well-matching is necessary. The cost of matching between the two objects will be defined as degree of similarity *d* which is the cost percentage of well-matching of the objects or object correlation between associated objects [17]-[18].

However, in this paper, we focus particularly the case with scars then we firstly check the well matching of the attribute "scar". If no scar is matched then the rest of object matching will be skipped. Results shows that compared to previous research [17], [18] the attribute "scar" will dramatically help improve the searching performance see figures 5 and 6.

Let k be the number of attributes (in case of scar $k = 9$) of an object or object correlation. Let q be an attribute value of the object of the key image and r is an attribute value of the object of stored image as shown in Figure 4(b). The absolute values of q and r are computed as follows:

$$q_i = |q_i| \text{ and} \quad (1)$$

$$r_i = |r_i| \quad (2)$$

where $i = 0, 1, 2, \ldots, k\text{-}1$

The cost of each attribute between 2 objects is defined as:

$$cost = |q_i - r_i| \quad (3)$$

where $i = 0, 1, 2, \ldots, k\text{-}1$

Then, cost percentage is defined as:

$$cost\_percentage = \frac{|q_i - r_i|}{\max(q, r)} * 100 \quad (4)$$

Similarity searching in the database of stored images requires that all images within the pre-specified degree of similarity *d* must be retrieved. That is, all images with the following condition are retrieved.

$$cost\_percentage \leq d \quad (5)$$

In this paper, the *cost_percentage* of the scar attribute ($k = 9$) will be firstly computed. If the condition in eqn.5 is **TRUE** then the system will proceed for other remaining attributes check. But if **NEGATIVE** then the system will skip checking remaining attributes, marking "**NO MATCH**" and immediately check another stored images.

The authors compare results as such with sequential searching and with similarity searching proposed in previous research [18]. In sequential searching, it is taking longer time to find the similar images in the database. Similarity searching with "**NO SCAR**" takes average but it is proven to be faster than sequential one. The search with scar proposed in this paper takes least time and is fastest among the three.

3.2 QUERY BY EXAMPLE

Query program written in C language is implemented. To check the efficiency of the proposed method, a sample up to 100 face images is employed in order to find a closer likeness image with a scar to an original photograph (key image) that particularly confine the scar. However, large data sets of face images are complicate to identify attributes, object correlation and so on. PC with PentiumIII 450MHz is used for the experiment. All databases had been stored in the hard disk. The experiments have been divided into several categories with a different number of images stored in the database as of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100.

For each category, as specified in section 4, five images in the database with cost ranging from 0% to 10% are randomly used for computing the average search time of sequential searching, similarity searching with no scar and similarity searching with a scar specification.

4. RESULTS AND ANALYSIS

The experiment of sequential searching and self-similarity searching with and without a scar by using the query samples, the following figures show the search time as the experimental result from each group.

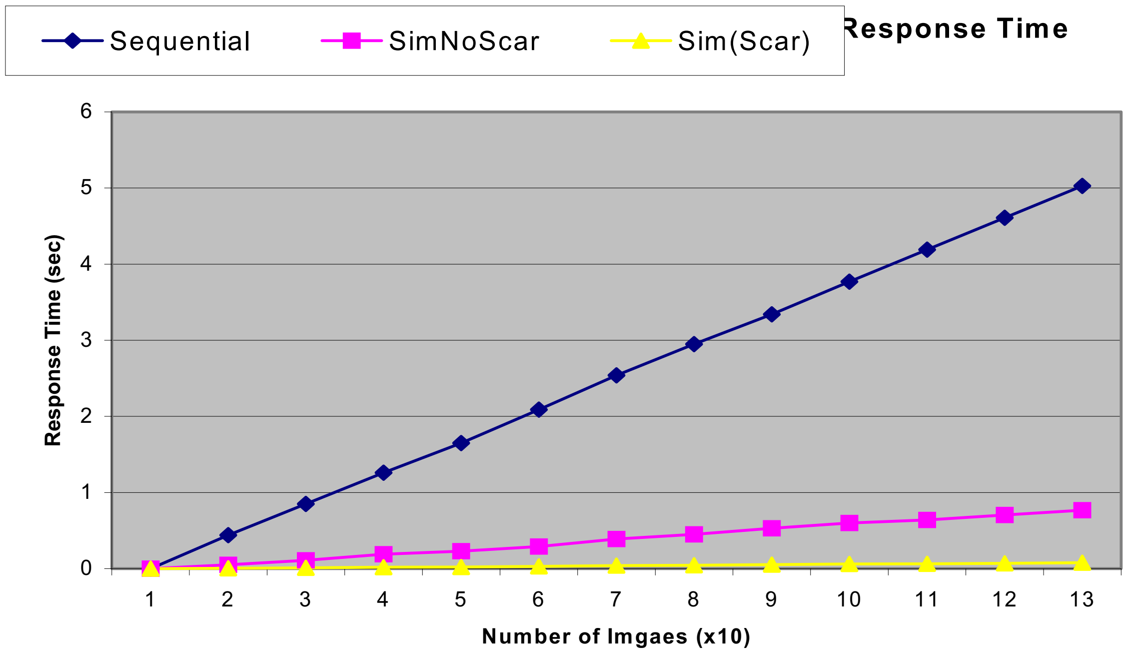

Figure 5 : Response Time of Sequential Search, Similarity Search with and without scar specification

Figure 5 indicates the average response time for sequential search and self-similarity search with and without scar by varying a number of face images in the database.

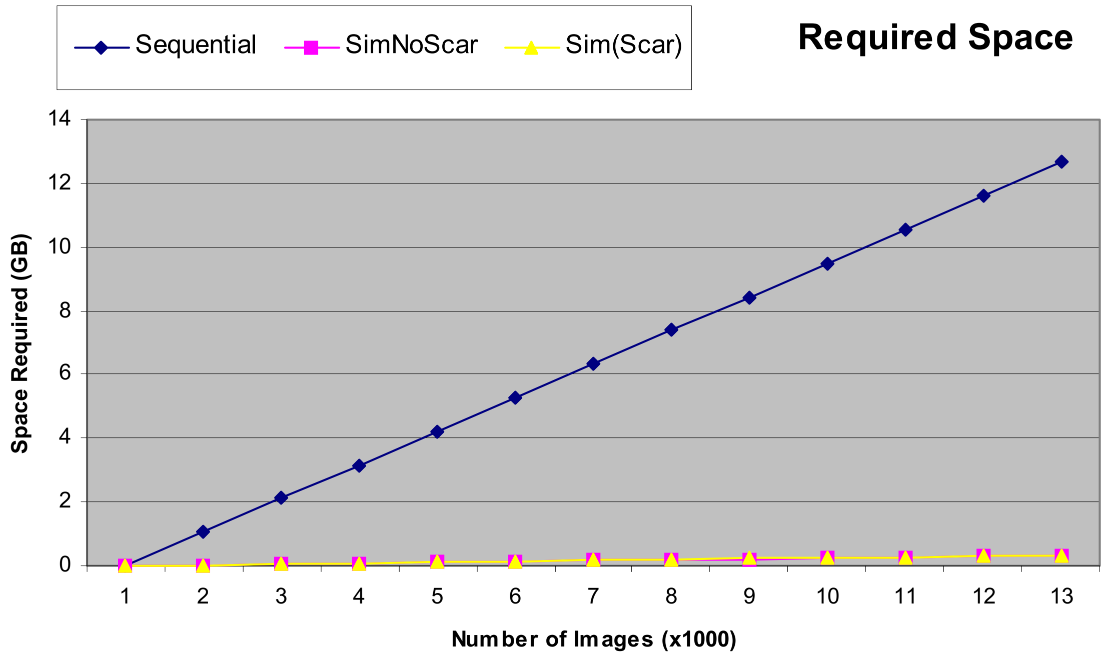

Figure 6: Space Required for Sequential Search versus Similarity Search with and without scar specification.

Figure 6 indicates the space required for sequential search and self-similarity search with and without a scar using ten thousand images in the database. Sequential search requires much larger space to store those images while self-similarity search (both with and without a scar) requires little space.

5. CONCLUSIONS

In this paper, a self-similarity searching with a scar specification in the refinement of attribute to handle the stored image search is developed. The self-similarity search proposed in this paper can be applied to significantly reduce the crime records searching time especially when the scar is defined before retrieving the image. Results indicate that similarity search with a scar definition will improve dramatically the performance compared with previous researches [17], [18]. This will help a police officer spend less time in investigation process. Moreover storage space required after adding one more attribute (a scar attribute) to store face images compared to previous researches [17],[18] can be overlooked.

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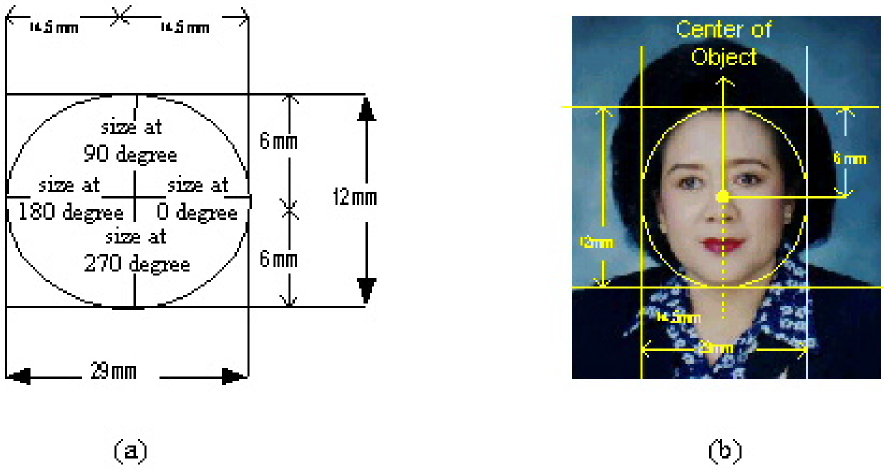

Figure 2: (a) Size Measurement at Different Angle; (b) Object Center and Measurement

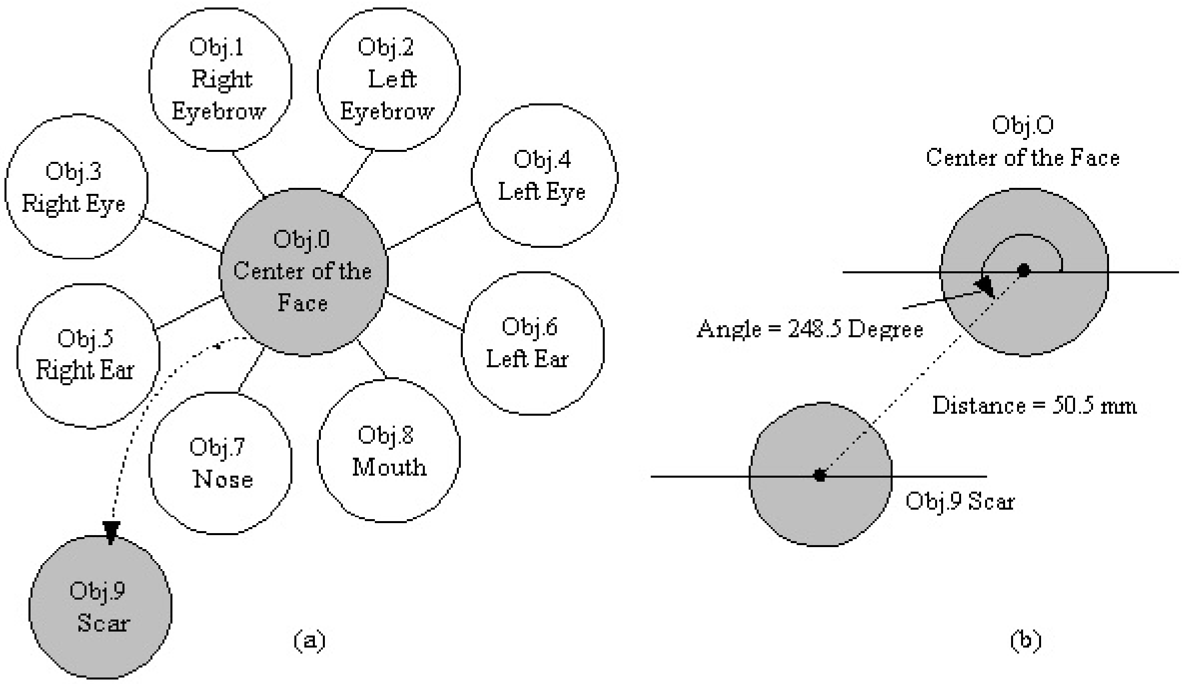

Figure 3: (a) Object Angle ; (b) Object Angles Measurement

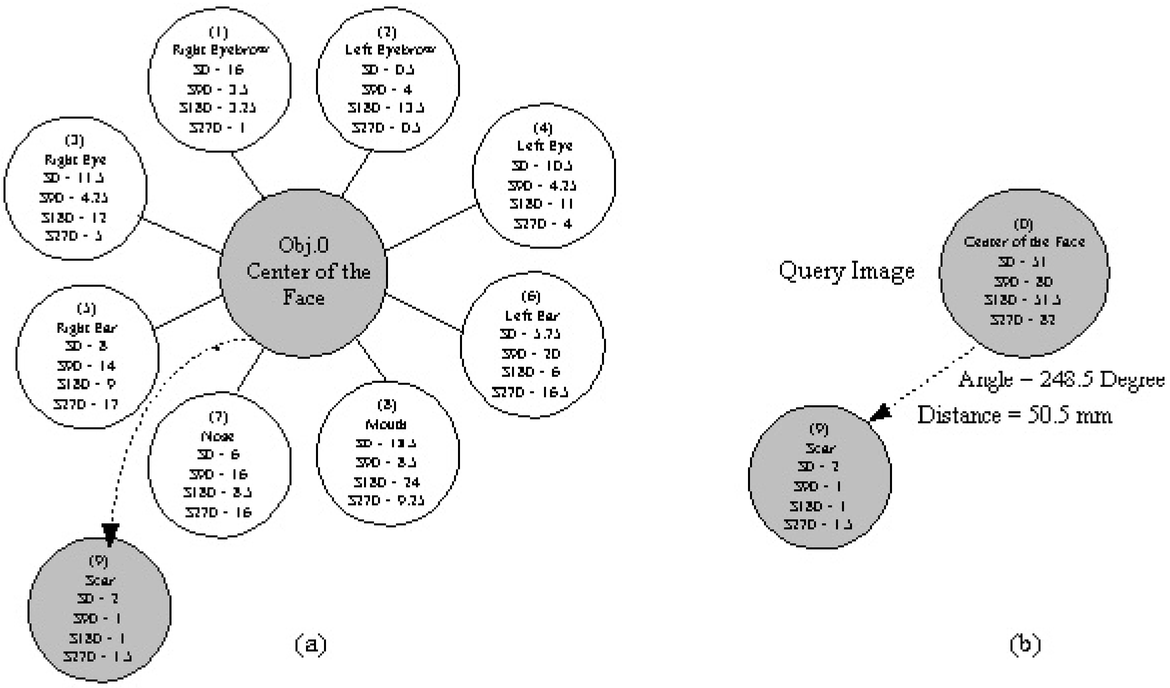

Figure 4: (a) Data Contents of a Storage Image ; (b) Example of Data Contents of a Query Image