Portability: A New Challenge on Designing Family Image Database

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Abstract - Faces are among the most important classes of objects, computers have to deal with. Automatic processing of facial images has attracted considerable attention in the last decades and many algorithms are proposed for that. Without doubt the facial image databases are the most important means which are used to test these algorithms. Despite of various databases provided, less attention is being paid to develop a benchmark for creating a face image database. A comparison among more than 40 available face image databases is carried out to extract their intrinsic and extrinsic features and to propose a benchmark. This paper introduces an efficient and innovative portable design for gathering face image data. It covers many photography conditions such as different poses, backgrounds, and illuminations. A set of 178 images from 20 individual is gathered and a comparative evaluation is carried out to prove the efficiency of developed benchmark and database design.

Keywords: Image Database; Portability; Design Methodology; Facial Feature Extraction; Surveillance system; Facial Family Image Database.

1 Introduction

In communication between people, faces play one of the most important roles. Faces allow recognizing a person's identity but moreover they carry rich information about a person's emotional state. As humans, we are able to gather important information from a person's image. Leakage of this ability in robots makes simulating human intelligent, particularly visual system, for machine an active research field in computer science. New applications such as visual surveillance, robotics, and intelligent human computer interface lead researchers to propose many algorithms for face recognition [1], [3], face detection [2], facial feature extraction [5], facial expression recognition [6], gender [7] and age classification [8] etc.

Despite many researches in the previously mentioned fields, no previous work has been reported on any aspects of detecting family similarity in images of faces. Analysis of family facial similarity will assist intelligent machines in numerous ways, finding facial similarity rules will help face recognition and surveillance systems increase their accuracy. Nevertheless, in the shorter term, an improvement of understanding how humans classify people in a specific family genealogy can be used in the application area like synthesizing baby face pre-born. It also has other application in image forensic and facial image synthesis of an offender from parents’ images when offender’s image is not available.

To gain an understanding for the similarity rules of a family faces, we need a family face database. Although many face databases are available and researchers should appreciate collectors, no one has complete set of a family face images. This shortage leads us to collecting this type of database. Create more diversity in the data was the other reason that leads us to gather this database. We see and interpret many faces everyday and thus are continuously trained to successfully distinguish between a large numbers of different faces from the childhood on.

Any type of data gathering has its difficulty and collecting face image database has two extra ones:

(i) Face image is part of personal privacy and usually least person tends to give their privacy data to others.

(ii) Standard face image database usually collects in a standard photography situation. This studio has expensive instruments and beside that person sorely accept coming to the studio.

This paper introduces design of an innovative portable, standard, and inexpensive photography studio which helps constructing Family Face Images Database (FFIDB) in a fast and efficient manner. These images with different poses, illuminations and expressions can be used for analysis facial similarity, facial feature extraction, face localization, facial expression detection, and other similar researches. To develop such a database, existing face image databases, anthropometric researches, facial expression detection, facial feature extraction, and other relevant researches have been studied.

This paper is organized as follow. Section 2 presents analysis of 40 publicly available databases and classification of their 18 intrinsic and extrinsic properties in a comparative manner. Designing a portable standard photography studio and data gathering benchmark are topics of Section 3. Section 4 introduces Family Face Image Database and shows the result of facial feature extraction algorithm. Finally, conclusions follow in Section 5.
2 Existing facial image databases

Face image databases are means used to evaluate facial image processing algorithms and methods. Due to this usefulness, many researchers have attempted to gather them. Every person has a set of unique biometrics features. Therefore diversity of the databases is very useful in estimation of robustness of the developed algorithms in face recognition, facial feature extraction, facial similarity, age estimation etc.

Every database has some intrinsic and extrinsic features. For a better database designing, we attempt to analysis these features in 40 existing databases and to categorize them under 18 categories of features on basis of observation. Table 1 tabulates these observations and classifications for five databases and others are surveyed below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Illumination</td>
<td>15 Fluorescence, 0°, ±45°, ±90° (Horizontal) and 0°, ±45° (Vertical)</td>
<td>N/A</td>
<td>N/A</td>
<td>Sun light</td>
<td>2 Sources – Side of subject</td>
</tr>
<tr>
<td>Background</td>
<td>Blue, White, Black, Red and Yellow</td>
<td>N/A</td>
<td>Fixed – N/A</td>
<td>White</td>
<td>Fixed - Color not mentioned</td>
</tr>
<tr>
<td>Camera Position</td>
<td>9 Cameras on hemisphere – 0°, ±22.5°, ±45°, ±67.5°, ±90°</td>
<td>A frontal analog camera</td>
<td>A Frontal Camera</td>
<td>A frontal camera</td>
<td>A frontal 35mm analog camera</td>
</tr>
<tr>
<td>Expression</td>
<td>Natural, Smile, Closed Eye and Open mouth</td>
<td>Natural, Angry, Afraid, Happy, Sad, Surprise and Hate</td>
<td>Natural</td>
<td>Natural, Smile and Scowl</td>
<td>Natural and Smile</td>
</tr>
<tr>
<td>Occlusion</td>
<td>Glass Frame, Sun Glass and Hat</td>
<td>N/A</td>
<td>Glass Frame</td>
<td>Glass Frame, Beard and Moustache</td>
<td>Glass frame</td>
</tr>
<tr>
<td>Time</td>
<td>2 Sessions with 6 Month Distance</td>
<td>A Session per Subject</td>
<td>Multiple Session in 2 Months Period</td>
<td>A session per subject</td>
<td>2 Sessions For 365 Subjects With 2 Years Period</td>
</tr>
<tr>
<td>Number &amp; Gender</td>
<td>1040 Subjects – 595 Men and 445 Women</td>
<td>10 Women</td>
<td>37 Subjects - N/A</td>
<td>616 Subjects – 487 Men and 129 Women</td>
<td>1199 Subjects - Men and Women</td>
</tr>
<tr>
<td>Voice</td>
<td>N/A</td>
<td>N/A</td>
<td>Available</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Video</td>
<td>N/A</td>
<td>N/A</td>
<td>Available</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Age Info</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Available –2 to 81</td>
<td>N/A</td>
</tr>
<tr>
<td>Environment</td>
<td>Studio</td>
<td>Specific photography tool</td>
<td>Studio</td>
<td>Outside studio</td>
<td>Studio</td>
</tr>
<tr>
<td>Additional Information</td>
<td>N/A</td>
<td>N/A</td>
<td>Naming File and Expressions</td>
<td>Age, Skin Type, Job and Cosmetic Points</td>
<td>Photography date – Occlusion – Eyes and lip positions</td>
</tr>
<tr>
<td>Image Type</td>
<td>Digital with resolution 480x360</td>
<td>Digitalized with resolution 256x 256</td>
<td>Digital With Resolution 350x286</td>
<td>Digital with resolution 640x480</td>
<td>Scan with resolutions 256x384 and 512x768</td>
</tr>
<tr>
<td>Race Info</td>
<td>Chinese</td>
<td>Japanese</td>
<td>N/A</td>
<td>Persian</td>
<td>N/A</td>
</tr>
<tr>
<td>Distance</td>
<td>1.2 (m) and 1.4 (m)</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Almost Fixed</td>
<td>Fixed</td>
</tr>
<tr>
<td>Dimension</td>
<td>2D</td>
<td>2D</td>
<td>2D</td>
<td>2D</td>
<td>2D</td>
</tr>
<tr>
<td>Calibration</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pose</td>
<td>Head down and up 30° - Camera Poses</td>
<td>Frontal</td>
<td>Head Rotation from -90° to 90°</td>
<td>Frontal, Profile, Head up and down</td>
<td>Body Rotation 0°, ±15°, ±25°, ±40°, ±60° - Head Rotation ±22.5°, ±67.5°, ±90°</td>
</tr>
</tbody>
</table>

The AR Database [31] contains images of 116 individuals. Totally 3288 images were taken in four different expression, four illumination condition and two occlusions in two times. The BANCA multi-modal database [14] was collected from 52 subjects during 12 sessions in three months. Totally 208 images with different qualities are exist in the database. The CMU-PIE (Pose, Illumination, and Expression) Database [15] systematically samples 13 poses, two illumination conditions, and three facial expressions. It is comprised of 41368 images from 68 individuals. In the Korean Face Database (KFDB) [16] totally 52,000 images of 1000 subjects exist in seven poses and five facial expressions which were recorded with two different color lights. The face database from the Max Planck Institute for Biological Cybernetics [38] is based on 3D data collected with a Cyberware laser scanner. The database contains 200 subjects. The face representation after all processing consists of approximately 70,000 vertices and a similar number of color values. For all
subjects, 2D image data at seven face poses are available and for 7 of the 200 subjects, the full 3D data are available.

Notre Dame HumanID Database [18], [19] has more than 15,000 images of more than 300 people in two facial expressions, 2–week time laps, and under three illumination conditions. The image resolution is 1600×1200. Harvard Robotics Lab (HRL) Database has at least 75 images of 10 subjects in 77-84 different illumination conditions [9], [10].

The MIT Database contains 433 images of 16 subjects under three lighting conditions, three scale conditions, and three head tilt condition. Olivetti Research Lab (ORL) Database [17] contains slight variations in illumination, facial expression. It includes 400 images of 10 subjects. The UMIST Face Database [37] contains 564 image sequences of 20 subjects slowly rotating their head from profile to the frontal view. The Yale Face Database [13] contains 165 images of 15 subjects in various conditions including with and without glasses, illumination variation, and six facial expressions. In Yale Face Database B [14], 5850 images of 10 individuals were recorded under 64 lighting conditions in nine different poses. The FG-NET Aging Database (Face and Gesture Recognition Research Network) [22] contains 1002 scanned face images showing 82 subjects at different ages. Images have different resolutions. The database was developed to assist researchers who investigate the effects of aging on facial appearance.

The above databases have different conditions including expressions, poses, illuminations and backgrounds which are mostly used for face detection and recognition. Another databases are also exist which we just express their names. These databases are Cohn-Kanade AU- Coded [20], MIT-CBCL [24], Facial Action & Expression [25], University of Essex [26], NIST MID [27], NLPR [28], M2VTS [29], XM2VTS [30], University of Maryland [6], Bio-ID [35], Caltech Faces[39], UCFI [40], Georgia Tech[41], CVL[42], Indian Face[43], VidTIMIT[44], GAVAB [46], VALID [36], University of Oulu [32], XM2VTS [30], 3D-RMA[45], and IMM[21].

Results of the study on the image databases are surveyed in Figure 1. As it is shown, every column in the chart dedicates a feature. Explanation that is written above each column indicates the frequency of database which considers specified feature in their data collection process. For example, among the 40 databases, 33 have images with different expressions and they contain at least three different expressions.

3 Database design methodology

Generally, there are two paradigms which researchers use for collecting image database. The first paradigm suggests the photography in a studio environment while the other suggests outdoor conditions. Each has its advantages. Using controlled environment of a studio with expensive instruments reduces the algorithms' pre-processing costs. In other hand, photographing in uncontrolled environment has the advantage of gathering various data with different factors of age, race, job condition etc. To employ these advantages together, a portable standard photography studio is desirable.

Figure 1. A chart which shows features of 40 databases. Used abbreviations are “avg.” as average,” info.” as information, and “sub.” as subject.

In designing of a portable studio some objectives are to be considered: (1) Illumination (2) Background (3) Camera Calibration and Pose (4) Voice, Acoustic, Video and Noise reduction (5) Distance. The rest of the already mentioned 18 factors of a database are not issues in hardware design and are associated with the aim of the research. Figure 2 shows how a portable standard photography studio can cover all features of a face image database. For example a database which use for face recognition needs variety of face images with different poses and illuminations. Therefore, the purposed portable
photography studio can help researcher to gather standard database.

3.1 Structure design and distance setting

To achieve a benchmark for various data a standard portable studio will be recommended but mobility of studio can cause its own problems such as weight, size, and costs. Figure 3(a) and 3(b) are shown a portable studio which it has solved all problems.

Structure of the studio is made of light weight aluminum. Pieces are sized 1 meter in length and wooden jointed are used for connection. As it is shown in Figure 3(c), the total structure of the studio can be disassembled and fitted in a basket and also can be easily extended to cover various distances in photography process. Dimension of the designed studio is $2 \times 1 \times 1 \text{ m}^3$ and its weight is $10.3 + 0.85 \text{ Kg}$.

3.2 Light and sound condition

When studio’s structure has been assembled, it should be covered. The cover as illustrated in Figure 3(a) is oilcloth and blocks any external light from passing through. A black cloth has been sewed to the inside layer for controlling internal light reflection. Furthermore, a white cloth has been sewed to the background. White cloth has been picked because the only color that does not exist in human’s skin is white and it can only be found in the corneas. If the gap between inside and outside layer is filled with asbestos the studio becomes soundproof too. This cover is very light and its weight is about 3 Kilograms.

Three 6500 Kelvin florescent lamps are used for lighting. This temperature makes environment color cool blue. Therefore, in order to eliminate this effect the lamps are covered by a yellow tracing-paper. Lights could be elevated up to 2 meters depending on the research’s requirements. Diversity in illumination is achieved by turning one, two or all lamps on. Figure 4(b) and 4(c) illustrated studio’s lighting.

3.3 Camera and poses

A database which has several cameras for photography and video recording in prices poses is very useful. As it is shown in Figure 3(a), a groove is also created for the camera. Camera can be adapted with the subject height and research’s requirements. In addition, more than one camera can be used in a vertical position with different heights. The special design of the studio allows high precision.

In the previous work [5], we observed that fewer subjects tend to rotate on the chair; therefore a chair with discus seat and rotation ability is used. An indicator is mounted in front of the chair. A person can rotate the seat to match this index with existing scaled plate under the chair and in this manner placed in precise position. The inner part of studio contains two installed signs which help subject to fix the head positions upward and downward. Figure 5 illustrated these chair with indicator and angel’s page.
In addition to hardware arrangements which are described in the sub sections 3.1, 3.2 and 3.3, there are other issues must take into consideration for data gathering. These issues include:

- **Identifying environment:** This criterion is related to the research goal. For example, in the area of family similarity recognition, researchers need images from different families.
- **Obtain necessary justification:** When data gathering is carried out in the public places or offices, legal justification must obtained.
- **Negotiate with subjects and data gathering:** It includes finding appropriate person and satisfy him/her to give his private data.

### 4 Family face image database

To gather the FFIDB, 20 people (10 men and 10 women) of a specific family were invited to participate in the experiment. Totally 178 color images were captured. The images are in the 1200×1600 pixels resolution, 24 bit depth, and JPG format, refer to Figure 6. Based on other databases' information which illustrates in an abstract form in Figure 1, several conditions are considered. These conditions are as follow:

1. Four illuminations are formed by turning the right, left, center and all lights on.
2. Two expressions include natural and happy were captured.
3. Every subject placed in six poses; include: 0° with looking forward and downward, ±45°, and ±90°.
4. One person with glass and six women with scarf are subjects which have occluded images.

![Figure 6](image-url)

Every subject has a video file. In this video, he/ she introduced him/herself in Persian and tell his/ her relation with the researcher. With respect to the analysis presented in Section 2, FFIDB covers the usual features of existing databases. To evaluate this database, the facial feature extraction algorithms proposed in [8] employs. This method based on the geometry of the features. The prior knowledge about the location of the features plays an important role in extracting the region of interest.

Dehshibi et al. [8] use the anthropometric properties of the face and extract the eye region from the face area. The eye searching region contains eye and eyebrow. Then, the mean integral and combined projection function are applied to extract the bottom of the eyebrow. The region above this point is removed to increase the algorithm accuracy. Finally, the combined projection function is applied on the new searching region to find the pupil location. Summary of this algorithm is as follow:

**Pupil Detection Algorithm**

1. Apply mean integral projection function (MIPF) on the eye searching region
2. Find the global maxima \(a_{\text{max}}\) and minima \(a_{\text{min}}\) of the MIPF
3. Find the nearest left \(b_{\text{left}}\) and right \(b_{\text{right}}\) maximum point of \(a_{\text{min}}\) on the MIPF
4. Apply combined projection function (CPF) on the eye searching region
5. Find the global maxima \(\lambda_{\text{max}}\) of the CPF
6. if \(\lambda_{\text{max}}\) \(\leq\) \(\alpha_{\min}\) or MIPF\(b_{\text{right}}\) > CPF\(\lambda_{\text{max}}\) then
   - if \(\left|b_{\text{right}} - a_{\min}\right| < T\) then
     - \(\text{eyebrow\_bottom} = a_{\min}\)
   - else
     - \(\text{eyebrow\_bottom} = b_{\text{left}}\)
     /* T is a threshold and here is equal 3 */
7. Remove the region above eyebrow\_bottom to obtain new eye searching region.
8. Apply CPF on the new eye searching region.
9. Find global maxima of the CPF. This point is the location of pupil.

Results of feature extraction algorithm are illustrated in Figure 7. The result in Figure 7 shows studio portability provides standard conditions that lead us improving data and consequently data processing.

![Figure 7](image-url)

### 5 Conclusions

Face recognition, facial feature extraction, facial expression, and gender classification are hot topics in the image processing field. Many algorithms and methods were
developed for these fields but the only way that we can rely on them is to test them in the real world. Face databases are means used for testing these methods.

Gathering appropriate database is an expensive and time taking process. Some researchers use controlled environment for gathering image database that is costly and gathering various data is impossible. Others use uncontrolled environment which has its disadvantage.

This paper introduces an innovative design for a portable photography studio that is not expensive which helps creating a unique Family Face Image Database (FFIDB). This database contains 178 color images were captured from 20 people (10 men and 10 women) of a specific family. The images are in the 1200×1600 pixels resolution, 24 bit depth, and JPG format. This database has images in four different illuminations, six poses, and two expressions. The experiment shows the gathering image database and data processing are improved.

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7 References


