The PUT Face Database

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Abstract. In this paper we present a new database of color, high resolution face images. The database contains almost 10000 images of 100 people acquired in partially controlled conditions and stored in 2048×1536 pixels images. The base is publicly available for research purposes and can be used as a training and testing material in developing various algorithms related to the face detection, recognition and analysis.

Key words: Face Database, Face Recognition

1 Introduction

The everlasting interest in face recognition has two main reasons. Firstly, its an excellent field for testing combinations of various computer vision and machine learning algorithms. The complexity of the problem requires constant development and improvement of techniques for extraction of significant features under varying conditions and accurate classification of multi-dimensional data. Secondly, there is a growing demand on techniques which allow accurate, and possibly non-invasive identification of individuals.

The automatic face recognition systems perfectly meet that need. The development of fast and reliable recognition systems would allow access control and identification without the need of carrying keys, cards or identifiers. Moreover, capturing the picture does not require any contact with the subject and can be done without his consent. This makes the visual recognition systems applicable to wide array of security problems such as perpetrators identification or traffic control.

As the face images are very often part of many documents such as ID cards, driving licences, passports etc. collecting the required data is significantly easier than in the case of other modalities (e.g. fingerprints or retina images). However, development of a reliable face recognition system is not a trivial task. The human face is a highly non-rigid, complex 3D body. Its appearance is susceptible to many factors such as pose variations, illumination changes, occlusions or structural disturbances (e.g. make-up, glasses, facial hear etc.). To devise an algorithm robust to these factors one has to have a database of significant size and diversity of contained examples. Common, publicly available databases are required to provide a testing material to perform a rigorous benchmarking of proposed algorithms.

At present there are many databases available for the research purposes. The detailed review of them was presented by Gross[16]. Most of them consist of images with rather low resolution (Table 1). This is a result of the rather prohibitive computational cost of many recognition algorithms applied to high resolution images at the time of creating the databases. However, the current availability of

cheap and powerful computers lifts those limitations and using more detailed images may give a significant boost to the efficiency of face recognition algorithms. With this notion we have decided to create a database containing numerous high resolution images of 100 people.

Database	Resolution
AR[3]	768×576
Banca[10]	720×576
CAS-PEAL[15]	360×480
CMU Hyperspectral[8]	640×480
CMU PIE[12]	640×486
Equinox IR[7]	240×320
FERET[5][2]	256×384
KFDB[11]	640×480
MPI[4]	256×256
ND HID[9]	1600×1200
Yale B[6]	640×480

Table 1. Image resolution in different databases.

2 Capture procedure and database organization

The main reason for creating the database presented in this paper was to provide credible data for the systematic performance evaluation of face detection, facial features extraction and face recognition algorithms. The images were stored in color 2048×1536 JPEG files which are significantly larger than most of the available pictures.

Images of 100 people were gathered to provide enough classes for synthesis and evaluation of classification methods. In order to facilitate creating training and test sets approx. 100 images of each person were taken. This gives a total of 9971 images in the presented database.

Our research focuses mainly on the development of validation systems (i.e. we assume that a person wants to be recognized, so he or she does not purposely hinder the task). Therefore, we took pictures in partially controlled illumination conditions over the uniform background which can be easily provided in an access control system). In such environment the main factor altering the face appearance is the pose variation.

To provide enough data to model this influence each person's pictures were taken in 5 series (Figure 1). The first 4 of them were taken in sequences, with the neutral face expression, while the persons were:

– turning their head from the right to the left (approx. 30 images),

– nodding their head from the raised to the lowered position (approx. 20 images),
– turning their raised head from the right to the left (approx. 20 images),
– turning their lowered head from the right to the left (approx. 20 images),

.

Additionally, for each person the fifth series of approx. 10 pictures was recorded. Those images were taken while people were moving their heads without any constraint to the pose or expression. Additionally, some of the images in the fifth series were taken while the person was wearing glasses.

Images of each person are stored in separate folders, which names are 4-digit, zero based numbers assigned to particular persons. Each filename is an 8-digit number. First four digits make the identification number (same as folder name), 5-th digit is a series number and last three digits make the zero based number of the image in particular series (e.g. "00014005.jpg" contains the fifth image in the fourth series of the person number 1).

3 Additional data

Rectangles containing face and eyes were manually marked on each image in order to supply data for evaluation of face and eyes detection algorithms and to provide precise face alignment required by many face recognition methods. Coordinates and dimensions of those regions were stored in OpenCV Storage[1] files in the YAML format. To facilitate the use of algorithms that require constant aspect ratio of detected regions another set of regions of interest (ROIs) have been created. New ROIs were created by increasing the size of rectangles to preserve the constant aspect ratio and to keep the object of interest in the center of the apropriate region.

A set of 30 landmark points was defined to provide information on accurate position of facial features (e.g. the eyes corners, the mouth corners). Each image in the database was supplied with a OpenCV Storage file containing manually marked locations of all visible landmarks. Additionally, 194 control points were manually marked on the subset of 2193 images representing the near-frontal view. Those points form polylines representing following contours:

– face outline (41 points),
– nose outline (17 points),
– eyes outlines (20 points each),
– eyebrows outlines (20 points each),
– mouth outlines (inner and outer - 28 points each).

These can be used to build statistical shape models (e.g. ASM[14], BTSM[13]) or used as a base for precise facial features extraction, pose estimation and face morphing. The contours were also stored and OpenCV Storage Files.

The database is supplied with two lists of selected face images subsets. The first one called the Learning Set (LS) consists of 2200 consistently selected images. The following images were selected for each person:

Fig. 1. Examples of images in the base. Each row represent different series.

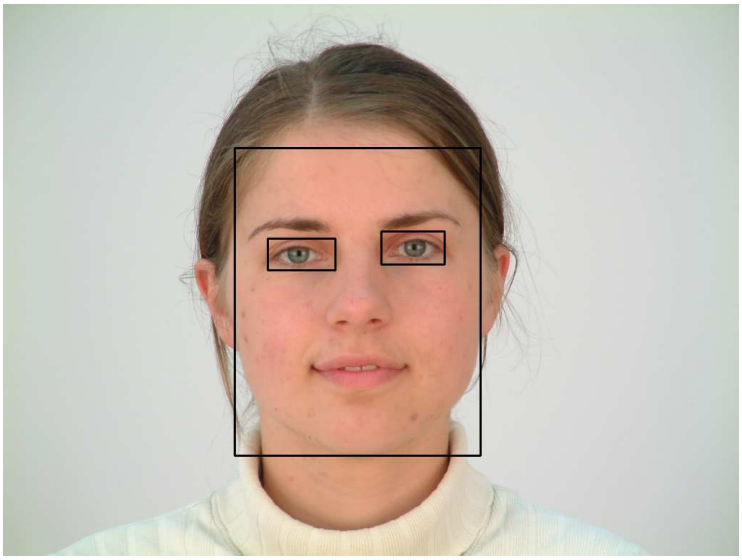

Fig. 2. Example of manually marked face and eyes ROI.

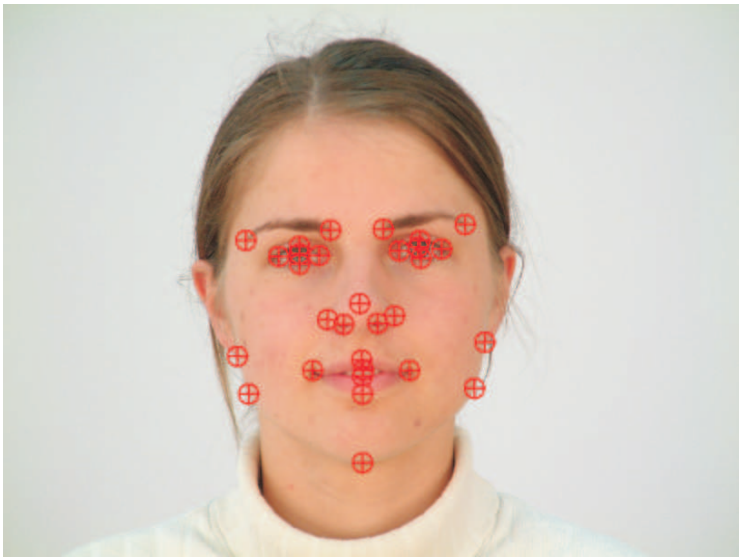

Fig. 3. Example of manually marked landmark points.

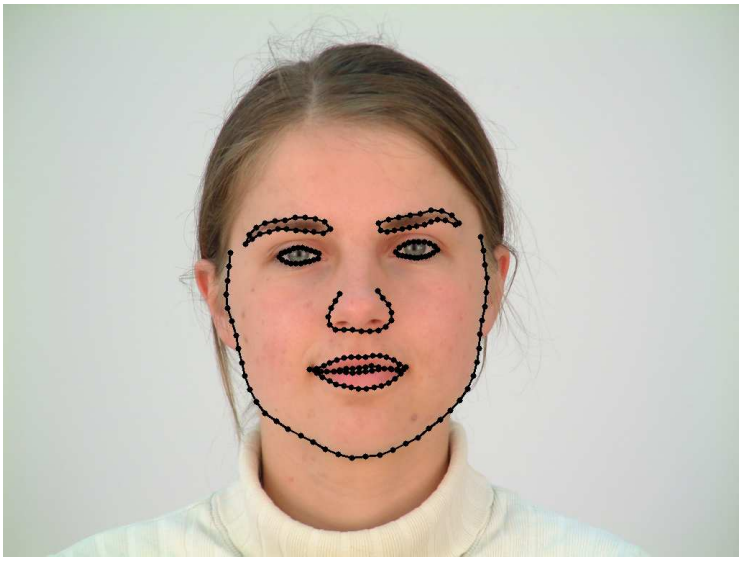

Fig. 4. Example of manually annotated contours.

- frontal view from the first sequence,
- 5 images with gradually increasing turn to the left from the central position,
- 5 images with gradually increasing turn to the right from the central position,
- frontal view from the second sequence,
- 5 images with gradually increasing tilt over the central position,
- 5 images with gradually increasing tilt below the central position,

which gives exactly 22 images per person. This subset can be easily used for the initial classifiers training and testing, especially with the cross-validation methods. The second base subset called Testing Boundary Set (TBS) consists of 11 images of each person selected in the following manner:

- 2 images with head turned more to the left than in any image in the LS,
- 2 images with head turned more to the right than in any image in the LS,
- 2 images with head raised more than in any image in the LS,
- 2 images with head lowered more than in any image in the LS,
- 3 frontal face images with unconstrained pose and facial expression.

4 Potential uses of the database

Some potential applications of the presented database have been presented throughout this paper. To summarize, the following activities could benefit from using the PUT Face Database:

- evaluation of the robustness of face recognition algorithms to the pose variations,

- evaluation of the performance of face pose estimation algorithms,
- evaluation of face recognition algorithms using image sequences as input,
- evaluation of face and facial features localization algorithms,
- development of either 2D or 3D statistical face shape models,
- development of algorithms estimating face 3D structure from the sequence of images.

These of course are not the only possible applications of the presented database. The availability of such an extensive database of colour, high resolution face images can contribute to the development of new algorithms related to the face images processing. Already existing techniques can also profit from applying to this database.

5 Obtaining the database

The database is publicly available for the research purposes only. To receive the database please contact one of the authors or visit the website at `www1.cie.put.poznan.pl/biometrics`.

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