Semi-Automatic Method of Face Recognition Based on Extended Training Set

O. Krutikova\textsuperscript{1}, A. Glazs\textsuperscript{2}

\textit{Image Processing and Computer Graphics Department, Riga Technical University, Latvia}

\textsuperscript{1}E-mail: Olga.Krutikova@rtu.lv, \textsuperscript{2}E-mail: Aleksandrs.Glazs@rtu.lv

\textbf{Introduction.} Face recognition is one of the actual tasks of image recognition theory.

There are many face recognition methods based on 2D images, but they have a significant drawback - it is not always possible to obtain intermediate information about the proportions of the human face, if the source data are only the images from the front. For example, when using Principal Component Analysis, PCA - [1], certain conditions are required, like proper lighting, neutral face expression, absence of beard and glasses. Another example of 2D face recognition – method of Viola-Jones [2] works well with images of faces turned by less than 30° away from the camera, but unfortunately is useless for images of faces rotated by arbitrary angle.

The task of face recognition may be solved by using a training sample that contains a large quantity of images, but unfortunately, usually only a small set of images is available for the training sample. In order to extend the training sample and obtain additional images a 3D model of the head could be used. Such an approach provides information about the form of the face, when the face (model) is turned by an arbitrary angle.

Therefore, in our previous work we described an approach [3] for creating a polygonal 3D model of the head, constructed by using three base images (profile, front, half-turn.)

In this paper, we propose a method for using the mentioned polygonal 3D model in the face recognition algorithm.

\textbf{Proposed method.} The proposed method consists of several steps: 1) creating the 3D model of the head; 2) extending the size of the training set by generating new 2D images of a face, that are based on the created 3D model; 3) searching for two images from the extended training set of two different classes, that have the most similar turn angle with the examinational image; 4) determining the examinational object’s “closest neighbor” among the two images (classification of the examinational object).

To solve the first step and create the 3D model of a head, a base training set was used, that consisted of two images of a face.

The difference from the approach described in [3] is that we propose to use a different method for acquiring and processing the face texture, consequently removing the unnecessary details (hair and beard). Figure Fig. 1 shows the
comparison between the newly proposed method of texture processing and the previous approach [3].

\textbf{Fig. 1.} a), d), g) – original images of a face; b), e), h) – images acquired by using the 3D model of the head [3]; c), f), i) – images acquired by using the proposed method for 3D model texture processing

In order to acquire the new face texture, we first process the base frontal photographic image. We only need information about the part of the face containing eyebrows, eyes, nose and lips – the T-zone, the rest of the image is colored using the average color value, which is obtained in the nostrils area. Figure 2 (see Fig. 2, a) shows the result of such preprocessing. Furthermore, the image acquired by such preprocessing was smoothed by using the Gaussian filter [4] in the dark areas shown on figure 2 (see Fig 2, b). The obtained result is shown on figure 2 (see Fig. 2, c). Analogical processing was used for the base profile photographic image (leaving only the ear zone and using the previous average color value as base color for the rest of the image). After such processing, we obtain the final face texture, shown on figure 2 (see Fig. 2, d).

\textbf{Fig. 2.} a) frontal image of a face containing the T-zone, after coloring with average color value; b) the dark color shows the area processed by the Gaussian filter; c) resulting image after using Gaussian filter; d) final face texture
Furthermore, we use such modified polygonal model for face recognition tasks.

To solve the second step, the created 3D model of a head was turned at different angles to create an extended training set, which will contain 2D images of faces. Control points were then manually placed on these images.

To solve the third step, the control points were manually placed on the examinational image, and two “closest neighbors” were found in the training set, that had a minimal difference in face turn angle with the examinational image.

To solve the fourth step, one of the two “closest neighbors” was chosen that had a minimal difference in distance ratios between the control points. Thus classifying (recognizing) the examinational object.

**Experiment.** We used 6 base photographic images of two similarly looking people (3 photos for each person: front, half-turn and profile) as the input data (training sample). For the classification we used 8 additional photographic images of their faces turned by an arbitrary angle (examinational sample). Figure 3 (see Fig 3, a, d) shows the examples of base images from the input data. These base images of two persons were used to construct two 3D models of their heads (see Fig 3, b, e).

![Fig. 3. a, d) – base images; b,e) – acquired 3D models; c), f) – images obtained by rotating the 3D model by 20 and 50 degrees](image)

We obtained new images of the person’s face (extended the training sample) via rotating the two 3D models by 20 and 50 degrees. We processed every image in the training sample, placing special control points (see Fig. 4) that we used as the main features during face recognition process. The information about the position and distances between these control points was saved in the database. The control points were also placed on the examinational sample.
images. Using the control points, we were able to determine the position of the head, as well as the angle of the head’s rotation (for half-turn images). The proposed recognition algorithm searches the database and compares the control points of every training sample image with the examinational image; looking for closest matching image: the difference between the distances of control points in those images must be minimal.

![Fig. 4. Control points for face recognition algorithm](image)

The algorithm was tested on 8 examinational images. The use of extended training sample (5 images) allowed obtaining 6 correct recognitions out of 8 images (see Fig. 5). The use of basic training sample (3 images) only provides 5 out of 8 correct answers.

![Fig. 5. The results of the proposed face recognition method](image)

**Conclusions.** The proposed semi-automatic method of face recognition using an extended training sample provides higher reliability of face recognition when compared to using the base training sample. It should be noted, that the efficiency of the proposed method can be increased by additionally extending the training sample (including the new images obtained by rotating the 3D model). In future work it is planned to automate the placement of control points on images of the faces, which were created by turning the 3D model of the head at different angles. It is also planned to increase the amount of classes (new faces) in the data base to test the algorithm.
References


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The existing algorithms of face recognition are designed to be used with adequate training samples (different positions of the face, special conditions, etc.). Therefore, in this paper we propose a semi-automatic method of face recognition that is based on extending the training sample by using a 3D model of a head. The recognition algorithm uses control points and relations between them. The experimental results show the efficiency of the proposed approach.