3D model creation based on 2D images

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Introduction. Restoration and identification of images of faces are widely used in scientific and applied fields (forensics, medicine, security systems, etc.) 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, these algorithms are also very sensitive to lighting, which can significantly reduce the accuracy of face recognition. Based on that, there is a need of new methods for reconstructing a 3D model of a face to generate new images of a face (turn, tilt of the head).

There are various algorithms for constructing a 3D model of a face. Such methods as [1], [2], [3], use an approach based on parametric models of a face. The disadvantage of these methods is the high computational complexity.

In this paper, a method is proposed for adapting an average polygonal 3D face model from several 2D images.

Proposed method. To create a 3D model of a face a polygonal structure was selected, and a program FaceGen Modeller 3.1 was used to create the model of the face. The initial model was simplified (1439 vertices of the initial model were reduced to 887) using a program Autodesk 3Ds Max 2012. The resulting face model (see Fig. 1), was later used for adapting to a specific human face.

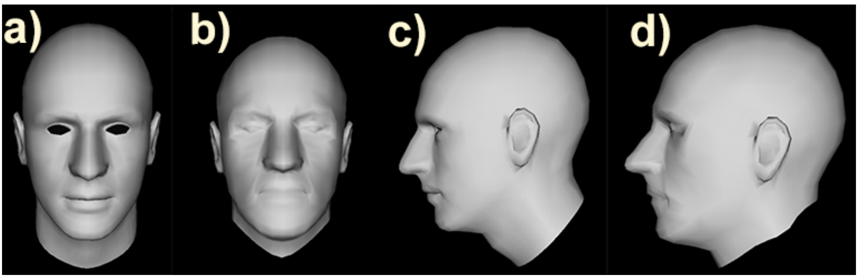

Fig. 1. Average 3D model of a head a), c) 3D model of a head created in a program FaceGen Modeller; b), d) 3D model of a head with a simplified polygonal structure.

Step 1. The input data for the proposed algorithm is a set of 3 images of a face - full face, half turn, the profile (see Fig. 2).

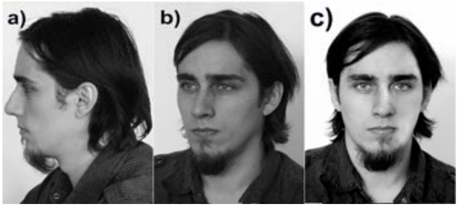

Fig. 2. The initial images of the face: a) profile; b) half-turn; c) full face.

Step 2. To isolate fragments of the face such as the contour of the nose, the location of the pupils, the distance between the eyes, etc. the proposed method uses manually placed control points in different projections (see Fig. 3).

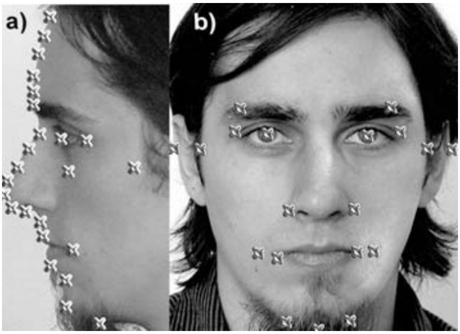

Fig. 3. Placing the control points on the face a) profile; b) full-face

Step 3. Since the input images are given in a 2D space and the coordinates of vertices of a model are in 3D space, the coordinates x (see formula (1)), y (see formula (2)) were calculated from the images of a full face, and the z coordinate was calculated from the profile images (see formula (1)):

$$x = \frac{x_{pic}}{2w} \cdot \frac{w}{h} - \frac{w}{h}, \quad z = \frac{z_{pic}}{2w} \cdot \frac{w}{h} - \frac{w}{h}, \tag{1}$$

where x, z – calculated coordinates of a control point in 3D space. x_{pic}, z_{pic} – x, z coordinates on an image; w, h – width and height of an image.

$$y = -\frac{2y_{pic}}{h} - 1, \tag{2}$$

where y – calculated coordinate of a control point in 3D space. y_{pic} – y coordinate on an image; h –height of an image.

Step 4. The width and height of an image of a face was calculated as a difference between certain 2D coordinates (x, y).

Step 5. The width, height and depth of the initial 3D model of a face also were calculated by finding minimal and maximal x, y, z values from all the vertices of a model. Then the model was scaled on the x axis by using formula (3), on the y axis by using formula (4), and on the z axis by using formula (5).

$$x' = x' \cdot \left(\frac{maxX_{pic} - minX_{pic}}{maxX - minX} \right), \quad (3)$$

$$y' = y' \cdot \left(\frac{maxY_{pic} - minY_{pic}}{maxY - minY} \right), \quad (4)$$

$$z' = z' \cdot \left(\frac{maxZ_{pic} - minZ_{pic}}{maxZ - minZ} \right), \quad (5)$$

where x', y', z' – current coordinates of the 3D model; $minX_{pic}$, $minY_{pic}$, $minZ_{pic}$, $maxX_{pic}$, $maxY_{pic}$, $maxZ_{pic}$,– x, y, z coordinates on an image; $minX$, $minY$, $minZ$, $maxX$, $maxY$, $maxZ$ – minimal and maximal values before scaling the 3D model.

Step 6. 3D model of a face was divided into regions (forehead, eyes, nose, lips etc.). Control points were matched with vertices of the 3D model and the coordinates of the vertices were multiplied with a weight coefficient ranging from 0.5 to 1. This was done to deform the polygon mesh of the model.

Step 7. The face texture was extracted from the images of the full-face and profile based on the control points, this texture was later placed on the 3D model.

Step 8. The Created 3D model was visually compared with the photographs and if the model was similar then the algorithm stops, otherwise the algorithm returns to step 2.

The results of the proposed algorithm, and the results of the program FaceGen 3.1, which used the same input data are shown on Figure 4.

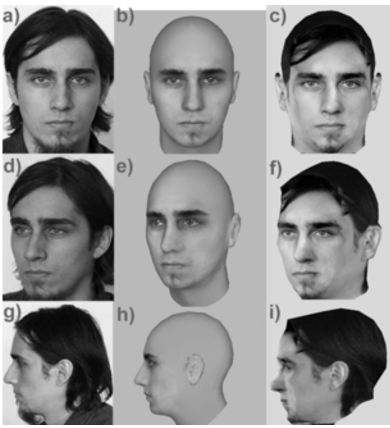

Fig. 4. Comparison of the input images with the generated 3D models: a), d), g) input images full-face, half-turn, profile; b),e),h) 3D model of a face generated by program FaceGen; c), f), i) proposed method

Conclusions. A semi-automatic method was developed for adapting an average 3D model from three 2D images of a face, and an algorithm of placing a face texture on a polygonal model. As the results show, the proposed method manages to adapt the model of a face to real images of a face, where the initial model was created using a program FaceGen Modeller. The drawback of the proposed algorithm is that it is sensitive to light, and it produces a few artifacts.

References

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The existing methods that are used for face recognition from 2D images do not always provide an opportunity to gain intermediate information about the proportions of a human face, these algorithms are also very sensitive to lighting, which decreases the accuracy of face recognition. Based on that, there is a need of new methods for reconstructing a 3D model of a face to generate new images of a face (turn, tilt of the head). In this paper, a method is proposed for adapting an average polygonal 3D face model from several 2D images.