Virtual try-on of eyeglasses using 3D model of the head

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Virtual Try-on of Eyeglasses using 3D Model of the Head

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Abstract

This work presents a system for virtual try-on of eyeglasses using a 3D model of user's face and head. The 3D head model is reconstructed using only one image of the user. The 3D glasses model are then fitted onto this head model, and the user's head movement is tracked in real-time to rotate the 3D head model with glasses accordingly.

CR Categories: H.5.1 [Multimedia Information Systems]: Artificial, Augmented, and Virtual realities; I.4.9 [Image Processing and Computer Vision]: Applications

Keywords: virtual try-on, face tracking, 3D head modeling

1 Introduction

Virtual try-on of eyeglasses has advantages over physical try-on in some cases. Usually there are so many models of glasses that are available, and it is difficult and time-consuning to select a model that looks good on the face. A virtual try-on system can be used to narrow down the selection to a few models efficiently and interactively, and this system can also be combined with a recommender system. Physical try-on of spectacles without lenses could also be demanding for some shortsighted people, since they can not see clearly without the lenses. Another problem with the physical try-on is that the customer is not able to compare two or more models of eyeglasses at the same time. These problems can be solved by a virtual try-on system, where the user does not need to put on the eyeglasses physically. Furthermore, using a virtual system the user can have several snapshots of himself/herself wearing various models of eyeglasses, to help in making the decision for the purchase.

Due to the above-mentioned advantages of virtual try-on of glasses, this system has reasonably good commercial potential in the eyewear market. There are some methods already being deployed. In [Abitbol et al. 2004], a 3D head model of the user is reconstructed from the pictures taken using 3 cameras, and then a 3D virtual spectacles are fitted on the head model. Similar work is reported in [Kim et al. 2005]. The process to fit the 3D spectacles is basically a simple affine transformation, where the parameters are computed directly from the position of the head model and the spectacles model.

Ray-Ban Virtual Mirror [RayBan] allows the user to try-on 3D eyeglasses virtually. This system requires a frontal snapshot of the user, on which several feature points need to be marked manually. These points are then tracked and used to fit the glasses on the face. The glasses will then follow the user's head movement to a certain extent. A similar virtual glasses try-on system has also been developed by SyderGlass [Syderis].

In this work we implemented a virtual glasses try-on system using a 3D head model of the user, which is reconstructed from an image of the user. The virtual glasses are automatically fitted to the head model, and then the head model with the glasses will follow the real head movement as the user moves the head. Compared with the virtual mirror, the user can obtain a better view of how the glasses fit onto the face. Moreover, some views that are impossible from a virtual mirror (e.g. profile view) can be obtained in our system, by transferring the real head rotation around y-axis non-linearly to the rotation of the head model, so that the user does not need to turn the head 90 ° to see the profile view.

2 System architecture

The virtual glasses try-on system architecture is shown in Fig. 1. The main components of the system are the glasses fitting system and the tracking system. After the 3D head model has been reconstructed from an image of the user, the 3D glasses are fitted on this head model. The fitting is performed by computing the affine transformation parameter that "put" the 3D glasses on the head model. The user's head movement is then tracked by the tracking system, which produces the head movement parameters to update the 3D head model.

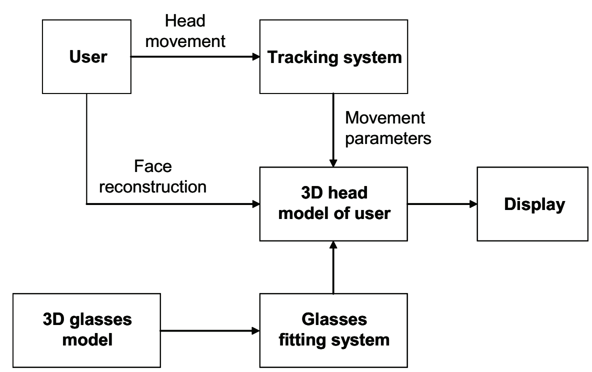

Figure 1: *Virtual glasses try-on system architecture*

2.1 Fitting glasses on the 3D head model

The 3D head model is reconstructed by deforming a generic head model based on some feature points obtained from an image of the user [Nguyen et al. 2009], [Niswar et al. 2010]. For the fitting process, 4 points are pre-determined on this head model: 2 points on the nose near the eyes and 2 points on each of the ear (Fig. 2). Given this head model and a 3D glasses model with fixed orientation along the x-axis (i.e., it can only be rotated around the x-axis) with 4 pre-determined reference points $\mathbf{g}_1$ to $\mathbf{g}_4$ (see Fig. 3), the process to fit the glasses on the 3D head model is as follows:

- Scale the vertex coordinates of the glasses $\mathbf{g} = [g_x \;\; g_y \;\; g_z]^T$ to $\mathbf{g}^s = [k_{xy}g_x \;\; k_{xy}g_y \;\; k_z g_z]^T$ where:

$$k_{xy} = \frac{h_{3,x} - h_{4,x}}{g_{3,x} - g_{4,x}} \quad (1)$$

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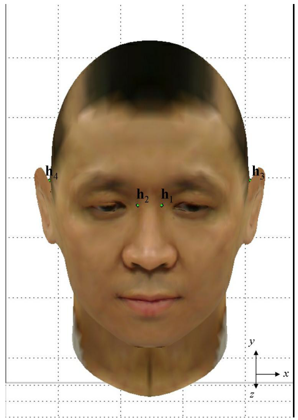

Figure 2: *The reference points on the 3D head model:* $\mathbf{h}_1$ *and* $\mathbf{h}_2$ *on the nose,* $\mathbf{h}_3$ *and* $\mathbf{h}_4$ *on the ears*

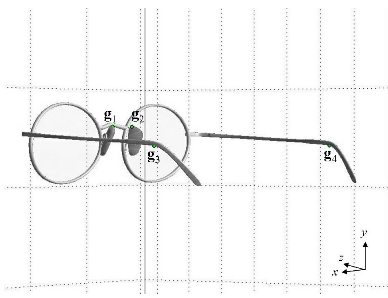

Figure 3: *The reference points* $\mathbf{g}_1$ *to* $\mathbf{g}_4$ *on the 3D glasses model*

$$k_z = \frac{1}{2}\left[\frac{h_{1,z} - h_{3,z}}{g_{1,z} - g_{3,z}} + \frac{h_{2,z} - h_{4,z}}{g_{2,z} - g_{4,z}}\right] \quad (2)$$

- Search the optimal affine transformation parameter $\mathbf{R}_x$ (rotation around the x-axis and $\mathbf{t}$ (translation) to transform the glasses to minimize the sum of the distances between transformed $\mathbf{g}_i^s$ and $\mathbf{h}_i$ $(i = 1, 2, 3, 4)$:
  - Set the initial value $\mathbf{R}_x = \mathbf{I}$ and $\mathbf{t} = [0\ \ 0\ \ 0]^T$
  - Transform $\mathbf{g}^s$ using these values:

$$\mathbf{g}^t = \mathbf{R}_x \mathbf{g}^s + \mathbf{t} \quad (3)$$

  - Adjust $\mathbf{R}_x$ and $\mathbf{t}$ to minimize the sum of distances:

$$E = \sum_{i=1}^{4} |\,\mathbf{h}_i - \mathbf{g}_i^t\,| \quad (4)$$

  This process is a non-linear optimization with 4 parameters: 1 for $\mathbf{R}_x$ and 3 for $\mathbf{t}$. The optimization is performed using the Levenberg-Marquardt method. Afterwards, $\mathbf{g}^s$ is transformed using the optimal parameters, as in Eq. 3.

The fitting result is shown in Fig. 4

2.2 Transferring the head movement to the head model

To view how the glasses fit on the 3D head model, the user's head movement is tracked using an available head tracking system [SeeingMachines] and the resulting movement parameters are used to move (rotate) the head model. A non-linearity is introduced in transferring the real head movement to the movement of the head model, in order to be able to view how the glasses fit to the head model from the side without having to turn the head 90 °. The head movement is transferred to the 3D head model as follows:

- Rotation around the x and z-axis follows the real rotation
- Rotation around the y-axis is transferred non-linearly, limited to 90 °, according to Fig. 5

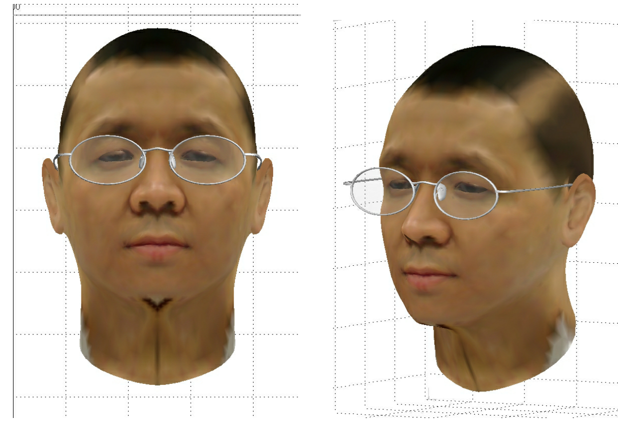

Figure 4: *The 3D head model with the fitted glasses*

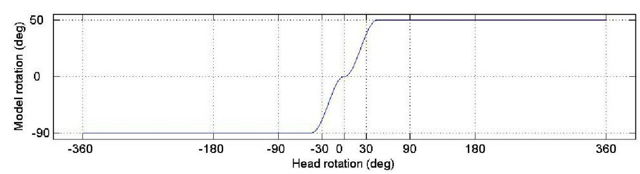

Figure 5: *Transfer function of the real head rotation around the* y*-axis*

3 Conclusion

In this work we presented a system for virtual try-on of glasses using 3D head model of the user reconstructed from an image of the user. By transferring the real head movement non-linearly to the movement of the head model, the user can see some views of how the glasses fit on the head that is impossible to see directly by using a mirror. This system can be implemented using a computer with a web-cam, hence it is relatively inexpensive.

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