Quasi 3D Rotation for Hand-Drawn Characters

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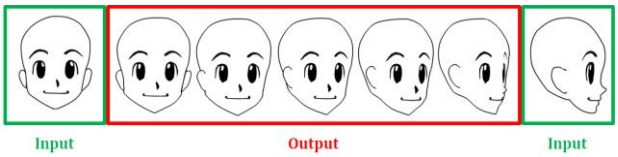

Figure 1. *An example of in-betweening result only from two input hand-drawn images (frontal and profile).*

1. Introduction

This paper presents a novel in-betweening method of a hand-drawn 2D character animation even including 3D motion like face rotation from front view to profile view. In-betweening is one of the most inevitable processes in commercial 2D animation production to generate intermediate frames automatically and naturally between hand generated key-frames. In general, the more number of key-frames are created, the better quality of animated motion is achieved. Especially, 3D-style motion like face rotation is so difficult to maintain high quality that it is necessary to create many key-frames which is time consuming with skilled animators' labor cost. Depending on these back-ground, recently many in-betweening methods are proposed focusing on a character face. Gohara et.al. [2010] proposed a data driven face rotation method for a new character face considering a non-linear rotation angle control from part to part. However, it is necessary to create an exact database of hand-drawn face images with a variety of rotation angles to reflect a style specific to an animator. Moreover, this method is only limited to the rotation angles in which all the parts are always visible. Rivers et.al. [2010] proposed a method to approximate character face parts with 3D primitive objects and texture. In this method, it is not possible to define an intrinsic rule to an each part of face, so sometimes the shape of character face collapsed. So we propose a novel face in-betweening method only from two key-frames of front and profile especially focusing on a trajectory of each landmark and line segment according to the angle of rotation in a horizontal space. By using an interactive editing function of landmark correspondence, a variety of stylized rotated face animation can be generated to reflect a director's taste.

2. In-betweening Method

2.1 Correspondence of each face part

Our method needs only two images with front and profile faces which correspond precisely each other with manually labeled landmarks. After giving key landmarks (red points in left of Fig. 2) by hand, other landmarks along with face contour (blue line in Fig.2) and centerline going through the nose (green line in Fig.2) are defined automatically.

2.2 Interpolation Algorithm

In hand-drawn face images, many inconsistency sometimes happen i.e. the shape of some facial parts does not always change along with rotation and the shape of other parts changes independent to the rotation angle. So we divide the interpolation of each facial part into two elements; a location of part centroid and a relative part shape to its centroid.

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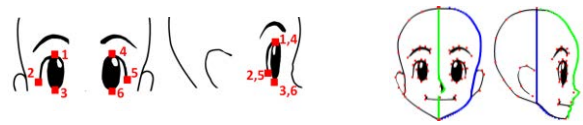

Figure 2. *Manual landmark allocation (red points) and then correspondence (green and blue line) between front and profile face images are automatically completed.*

(a) Centroid interpolation

Each centroid of facial part is interpolated non-linearly by Eq (1).

$$Ir_x = Sr_x \cdot \cos\Theta + Ar_x \cdot (1 - \cos\Theta).$$
$$\Theta = \min\{ \frac{\theta_r}{\theta_{th}}\frac{\pi}{2}, \frac{\pi}{2} \} \quad (0 \le \theta_r \le \frac{\pi}{2}) \tag{1}$$

Ir_x is x coordinate of interpolated centroid, Sr_x is part centroid of front face and Ar_x is it of the target face. θ_r is a face rotation angle and θ_{th} is a threshold angle of part disappearing. The target face is defined as a profile face in case the part is not disappearing while rotation and then θ_{th} is equal to $\pi/2$. In case the part (for example, the left eye in Fig.2) is disappearing behind face while rotation, the target position is defined near the boundary of profile face contour and then θ_{th} is less than $\pi/2$, depending on the part location. Also disappearing part is defined as corresponding symmetrical part (the right eye) of profile part as shown in Fig.2.

(b) Shape interpolation

Each shape of facial part is interpolated by Eq (2) considering the relative shape and location to estimated part centroid.

$$\boldsymbol{I}_{\mathrm{i}} = \boldsymbol{Ir} + (\boldsymbol{S}_i\text{-}\boldsymbol{Sr}) \cdot \cos\Theta + (\boldsymbol{A}_{\mathrm{i}} - \boldsymbol{Ar}) \cdot (1 - \cos\Theta) \tag{2}$$

$\boldsymbol{I}_{\mathrm{i}}$ is a coordinate of each landmark. $\boldsymbol{Ir}$ is estimated centroid by Eq (1), $\boldsymbol{Sr}$ and $\boldsymbol{Ar}$ are centroids of front and target part respectively, and $\boldsymbol{S}_i$ and $\boldsymbol{A}_i$ are position of all landmarks of front and target related to the each centroid $\boldsymbol{Sr}$ and $\boldsymbol{Ar}$ respectively. Depending on landmark $\boldsymbol{A}_i$, all contour lines and edge lines are generated by Catmull-Rom Spline interpolation and each color of part is appended inside a closed curve.

3. Results and Conclusions

Figure 1 shows an in-betweening result of rotating face only with front and profile hand-drawn images. Experimental result shows an appropriate in-betweening performance of hand drawn animation by keeping touch of quasi 3D rotation without any collapse. Moreover, by choice of alternative correspondence, another touch of animation can be generated. Other than facial parts like hair style, body and rigid object also can be treated for animation by interpolating key-frames with 3D rotation action. As future work, automatic landmark correspondence between two images has to be generated with only a few hand labeled points.

References

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