Example-Based Blendshape Sculpting with Expression Individuality

Takuya Kato†1 Shunsuke Saito†1 Masahide Kawai†1 Tomoyori Iwao†1 Akinobu Maejima†1 Shigeo Morishima†2
Waseda University†1 Waseda Research Institute for Science and Engineering†2

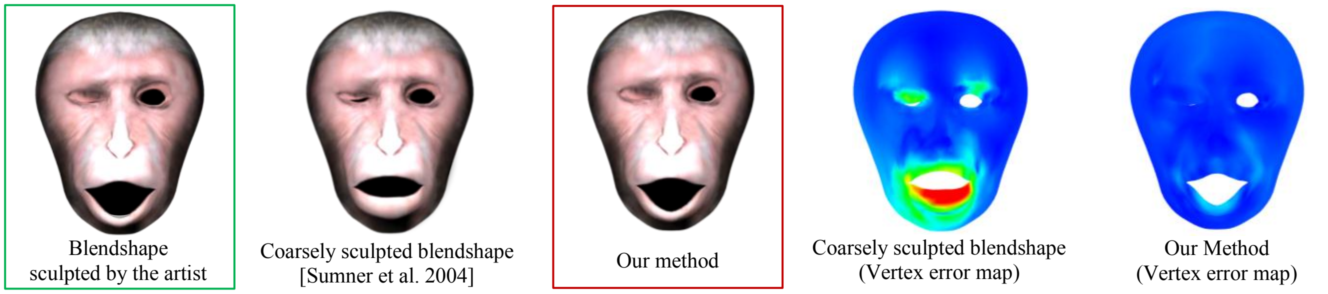

Figure 1. *Monkey blendshapes created from human source model. Blendshape sculpted by our method has less vertex errors compared with coarsely sculpted blendshape, blendshape generated by Deformation Transfer [Sumner et al. 2004] for instance.*

1. Introduction

One of the biggest drawbacks of *Blendshape Animation* is the enormous labor of sculpting its *blendshapes* with "expression individuality". Expression individuality is diverse facial expression in which each of the characters' facial expressions has on their own, other than its semantics. It was problematic for artists to sculpt blendshapes with unified expression individuality for every expression of the characters. Methods that generate coarsely sculpted blendshape, Deformation Transfer [Sumner et al. 2004] for instance, often yield artifacts which are caused by the individuality of each character's facial expressions. Example-based Facial Rigging [Li et al 2010] was one of the solutions to supplement these artifacts, yet it was not effective when the numbers of training examples are limited.

In this paper, we propose a method to generate blendshapes with expression individuality with small number of training examples. Our system transfers expression individuality defined on training examples by defining it as mapping. By introducing region division and mapping blending, our method is applicable even the numbers of the training examples are limited with less artifacts.

2. "Expression Individuality" Mapping

Expression individuality is defined as the difference between the poorly expressive blendshape to the finely expressive blendshape. Therefore, let m be the facial expressions, $\boldsymbol{s}_m$ and $\boldsymbol{t}_m$ be the coarsely sculpted blendshape and the finely sculpted training example of expression m, we create mapping between $\boldsymbol{s}_m$ and $\boldsymbol{t}_m$. For each $\boldsymbol{s}_m$ and $\boldsymbol{t}_m$, we incorporate deformation gradient of each triangles, which represents deformations. For triangle i we define mapping $\boldsymbol{f}^i_m \in \mathrm{R}^{3\times 3}$ between each deformation gradients as

$$\boldsymbol{f}^i_m = \boldsymbol{t}^i_m {\boldsymbol{s}^i_m}^{-1} \quad (1)$$

where $\boldsymbol{t}^i_m \in \mathrm{R}^{3\times 3}$ is the deformation gradient between rest pose model and the training example, and $\boldsymbol{s}^i_m \in \mathrm{R}^{3\times 3}$ is the deformation gradient between rest pose model and the coarsely sculpted blendshape. We define this mapping for every triangles of every training examples sculpted by the artist. In this paper, we applied naïve Deformation Transfer [Sumner et al. 2004] to generate coarsely sculpted blendshape.

3. Blending the Mappings

We incorporate mapping onto divided regions of the blendshapes by blending the elements of the mappings. By blending the mappings in which the training examples are geometrically similar to the input model, our system generates the mapping which is optimized for the input model. In order to measure the similarity, we estimate the blending coefficients by solving naïve blendshape coefficients estimation for each region.

While blending the mapping with estimated coefficients, the artifacts are yielded by the linear blending of the mappings. Accordingly, we introduce a novel method to "naturally" blend the mappings using the idea of spherical linear interpolation of quaternion and exponential map of matrix. The blended mapping of i th triangle $\boldsymbol{Blendf}^i \in \mathrm{R}^{3\times 3}$ is defined by

$$\boldsymbol{Blendf}^i = \prod_{m=0}^{M} slerp\left(I, \boldsymbol{Rotf}^i_m, w_{rm}\right) \cdot \exp\left(\sum_{m=0}^{M} w_{rm} \log\left(\boldsymbol{Symf}^i_m\right)\right) \quad (2)$$

where $slerp$ defines the spherical linear interpolation of the quaternion of two rotation matrix, I is the identity matrix, $\boldsymbol{Rotf}^i_m$ is the rotation matrix for m th blendshape, $\boldsymbol{Symf}^i_m$ is the symmetric part of the f^i_m for m th blendshape, w_{rm} is blendshape coefficients for region r which i th triangle is affiliated with. We apply this blended mapping to i th deformation gradient defined between rest pose model and input model $\boldsymbol{J}_i \in \mathrm{R}^{3\times 3}$ as

$$\mathbf{B} = [\boldsymbol{Blendf}^1 \times \boldsymbol{J}_1, \dots, \boldsymbol{Blendf}^i \times \boldsymbol{J}_i, \dots, \boldsymbol{Blendf}^N \times \boldsymbol{J}_N]^T \quad (3)$$

Finally, we solve equation (4) for x-, y- and z-coordinates for the vertices of output blendshape sculpted by our method, $\mathbf{X}' = [\mathbf{x}'_1, \cdots, \mathbf{x}'_N]^T \in \mathrm{R}^{N\times 3}$

$$\min \|\mathbf{B} - \mathbf{A}\mathbf{X}'\| \quad (4)$$

where $\mathbf{A} \in R^{3M\times N}$ is the large sparse matrix in which $\mathbf{A}\mathbf{X}' \in R^{3M\times 3}$ is the deformation gradient defined between the rest pose model and output blendshape sculpted by our method**.**

4. Result and Future Work

The comparison with coarsely sculpted blendshape and the blendshape sculpted by the artist is shown in Figure 1. The result shows that our method efficiently sculpts blendshape with expression individuality comparing with result sculpted by naïve Deformation Transfer. The vertex error compared with the blendshapes sculpted by the artist is shown in Figure 1, which also shows that our method improves coarsely sculpted blendshape. We aim to investigate a method to automatically select effective training examples for our system as a future work.

References

SUMNER, R., AND POPOVIC, J., 2004. Deformation Transfer for Triangle Meshes. *ACM Trans. Graph*. 23, 3(Aug.), 399-405

LI, H., WEISE, T., AND PAULY, M. 2010.Example-based facial rigging. *ACM Transactions on Graphics* (Proceeding SIGGRAPH 2010) 29, 3(July)

SIGGRAPH 2014, August 10 – 14, 2014, Vancouver, British Columbia, Canada.

ACM 978-1-4503-2958-3/14/08