1. Introduction

There are two major approaches to creating 3DCG facial expressions: The first is based on facial muscle simulation and the second is the blend-shape approach. The blend shape approach is more familiar to creators than the facial muscle approach when they synthesize the facial expressions of 3DCG characters. However, the facial muscle model has the advantage of being physics-based. It can, therefore, produce realistic facial expressions and create facial expressions using fewer parameters than the blend shape approach, thereby reducing processing time and computational requirements. We introduce a method which can be used to synthesize individual facial expressions based on the facial muscle model [Waters 1987].

To represent individual facial expressions, we first allocate 17 major facial muscles to the face model (conventionally 44 are used), plus the actuator that controls jaw rotation. We then automatically estimate the optimal facial muscle contraction parameters and the jaw rotation angle parameter to synthesize a hand-generated “key shape with the target expression” (hereafter, we will refer to this as the “target shape”). To improve the approximation for a target shape that is difficult to synthesize by 17 facial muscles, we successively insert a few new facial muscles into the face model.

Using our approach, it is also possible to transfer a character’s expression to another character by cloning the original’s facial muscle placement and contraction parameters.

We are also able to utilize the advantages of the two major approaches with our system, because it allows the geometry of the key shape to be automatically replaced by facial muscle contractions.

2. Estimating Facial Muscle Parameters

The 17 facial muscles are located in the face model in an anatomically consistent manner. In general, synthesized facial expressions appear more natural given a sufficient number of facial muscles (conventionally 44). However, it is difficult to find the optimal contraction parameters of the 44 facial muscles to represent a target shape. We therefore utilize only 17 facial muscles in our approach to solving this optimization problem. We define “Facial Expression Parameters” (FEPs) consisting of the contraction parameters of the facial muscles and an angle parameter for the jaw rotation. In our system, facial expression synthesis is performed by using the approach of Lee et al. [1995]. To synthesize a facial expression that is similar to a target shape, we solve for

$$
\tilde{p}_{opt} = \arg \min_p \sum_i \alpha_i \left( \tilde{x}_i - \tilde{x}_s(p) \right)^2,
$$

where $\tilde{x}_i$ is the position of vertex $i$ of the target shape, $\tilde{x}_s(p)$ is that of the facial muscle model $m$, and $\tilde{p}_{opt}$ is the optimal FEP $p$ that enables us to synthesize the facial expression most similar to the target shape using the 17 facial muscles. Because we recognize facial expressions depending mostly on the eyes and lips, we set $\alpha_{eye} = 10$ for vertices around the eyes and lips, otherwise we set $\alpha_i = 1$.

Figure 1 shows examples of a synthesized facial expression using the described method.

3. Attaching New Facial Muscles

To synthesize more natural and expressive facial expressions, we add a small number of new muscles to the 17 muscles of the facial muscle model described in Section 2. A new muscle is attached to vertex $s$ of the facial muscle model toward $D_i$:

$$
s = \arg \max_s \left| \tilde{x}_{ij} - \tilde{x}_{im} \left( \tilde{p}_{opt} \right) \right|$$

$$
\tilde{D} = \tilde{x}_{ij} - \tilde{x}_{im} \left( \tilde{p}_{opt} \right)
$$

Note that $\tilde{D}$ denotes the displacement vector of vertex $s$ between the target shape and the facial muscle model (they have the same topology).

4. Results And Discussions

Figure 2 shows the results of facial expression synthesis using our method: (a) shows the target shape (original) and (b) shows the synthesized face with 17 facial muscles. In this case, (b) does not express the target shape adequately. (c) shows the synthesized face to which a few additional facial muscles have been added to the basic facial muscle model’s 17. (c) is more similar than (b) to the original (a), which indicates that our method is effective. (d) shows an example of an expression retargeted from (a) to another character. (d) expresses the target shape’s facial expression effectively. The target shape can be synthesized with fewer facial muscle parameters than using the previous facial muscle-based method, which utilized 44 facial muscles.

We conclude that a target shape can be synthesized effectively using fewer than 20 facial muscles and that our method enables the specific expression of a key shape to be transferred to another character.

5. Acknowledgement

This study was supported by the Special Coordination Funds for Promoting Science and Technology of the Min-

Reference


istry of Education, Culture, Sports, Science and Technol-
ogy of Japan.