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A Study of Facial Expression of Digital Character with Muscle Simulation System

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Abstract

Facial rigging technology has been developing more and more since the 21st century. Facial rigging of various methods is still attempted and a technique of capturing the geometry in real time recently also appears. Currently Modern CG is produced image which is hard to distinguish from actual photograph. However, this kind of technology still requires a lot of equipment and cost. The purpose of this study is to perform facial rigging using muscle simulation instead of using such equipment. Original muscle simulations were made primarily for use in the body of a creature. In this study, however, we use muscle simulations for facial rigging to create a more realistic creature-like effect. To do this, we used Ziva Dynamics' Ziva VFX muscle simulation software. We also develop a method to overcome the disadvantages of muscle simulation. Muscle simulation can not be applied in real time and it takes time to simulate. It also takes a long time to work because the complex muscles must be connected. Our study have solved this problem using blendshape and we want to show you how to apply our method to face rig.

Keywords: *Facial Rigging, Muscle Simulation, VFX, Motion Capture, Ziva VFX, Digital Character*

1. INTRODUCTION

Facial rigging technology has been developed ever since the 20th century. In recent years, technologies that combine FACS with real-time geometry scans have been featured and continue to be screened in films that have extremely realistic digital characters which were difficult to challenge in the past. The human face is a very complex structure composed of a skull and dozens of small muscles combined with muscular membranes and fat layers on it, so that human beings express their emotions through contraction and relaxation of their muscles. However, the latest FACS system does not care about the movement of muscles in the face, but eventually it analyzes the changes on the facial skin and judges emotion expression. Of course, face rigging using FACS is the most advanced and real-time production method, but the FACS method does not represent the movement of muscles in the face realistically. The combination of FACS and geometry scans is still in flux, and facial rigging using FACS is a kind of advanced blendshape method.

Unlike the conventional method, we actually tried to simulate the change in the face made by the muscles

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and move the skin tissue to make a facial expression. We apply a muscle simulation system which is designed to be used on the body, to the face and try to reproduce the actual muscle movements and skin movements, not just changes in facial expressions. The muscular and skin tissues are reproduced as much as possible. For example, the simple animation that raises the mouth corners causes the muscles of the face to move and interact at the same time. So a more realistic motion can become possible. The purpose of this study is to propose a method to create realistic facial expressions by using a different research method than the FACS method which requires a lot of preparation time, cost and manpower.

2. RELATED WORK

Although there is not much research on facial rigging using muscle simulations, interest has been gradually increasing recently. Sifakis, Neverov, and Fedkiw found that a motion capture marker was used to simulate the muscles in their study [1]. This study used a motion capture marker as a means of controlling muscle movement, suggesting a way to control muscle simulation according to the movement of the marker. This method is based on the fact that the muscle can not move by itself and the movement of the motion capture marker is linked to the process of the contraction of the muscles and the making of the facial expression.

Another study, *Art-Directed Muscle Simulation for High-end Facial Animation*, showed how to use blend-shape in muscles [2]. Muscle simulation has the disadvantage that it is difficult for the user to control the shape of the muscle in exactly the shape desired. To solve this problem, it is necessary to add blendshape to the movement of the muscle itself. In the simulation of muscles, a difficult shape, for example, a detailed shape of the lips, is adjusted through the blend shape so that the muscle shape of the target shape is exactly the desired shape. Research has been carried out to accurately capture facial expressions in real time using 3D scanning and motion capture. Disney Research is a leading research achievement in this area. In the High-Quality Single-Shot Capture of Facial Geometry, they presented a method of capturing very accurate, high-quality three-dimensional geometry with a single shot with a simple camera and lighting device. It is called *Medusa*[3, 4].This method enables high-quality geometry capture with only a small amount of equipment, without the need for a gigantic device of a conventional light stage. In real-time high-fidelity facial performance capture, they synthesized the research between them to capture real-time geometry using miniaturized equipment and link it with the FACS solver [4, 5]. In addition, real-time capturing of wrinkles appearing on facial skin is possible by real-time extraction of skin's fine lines with normal map.This approach, of course, requires many preparatory steps before the real-time capture step. Particularly when using FACS, the necessary training steps are also needed, but they simplify this step by extracting Training Data from the reduced mesh[5-10]..
In addition, Digital Domain has developed technologies called "Masquerade" and "Direct Drive"[3,4].

Figure 1. Facial motion capture using Medusa[3]

Disney's Medusa is compact and portable. The Digital Domain team introduced a software system called <Masquerade> into the facial rig, allowing the DATA from the head cam to see the captured data from *Medusa*. To do this, they had to take the head cam and body motion capture data from the actor and then the actor again to the <Medusa> system and receive the detail data again. In this way, we can obtain the data that the body and the face naturally synchronize [3, 5]. Facial capture rigging using FACS has been in use since early 2000, but Disney Research's recent research approach has the advantage of capturing and real-time at the same time as geometry. However, the limitations of Facial Capture Rigging using FACS are obvious. Advanced FACS solver technology requires special equipment like *Medusa* system. The training period has been reduced compared to the past but it still needs long period of training time.

3. FACIAL RIGGING PRODCUTION PROCESS

3.1 Making Geometry

In this study, we selected ZIVA Dynamics' ZIVA VFX, which shows the closest performance to actual muscle expression among the muscle simulation software currently used for making the muscle simulation rigging [6]. For realistic simulations, we need geometry to replace the actual human face tissue. To do this, we need to prepare skull geometry, muscle geometry, fascia geometry, and face skin geometry in advance. When creating facia geometry, make sure that the fascia is located closely between the facial skin and the muscles as much as possible. It should be located as close as possible to the muscle, but it should never be in contact with the muscle. If the fascia and muscles come into contact, errors will occur in subsequent simulations. And the fascia should be shaped to maximally enclose the shape of the muscle, but it should also be close to the model of the face skin. This may require repeated modeling while correcting errors depending on the situation. This process takes time, but it must be done carefully to avoid errors. There are approximately 80 human facial muscles in total. It is hard to make all 80 muscles in geometry and it is also time-consuming work. We need to choose the muscles that has large size and can make the most characteristic shape of the muscle.

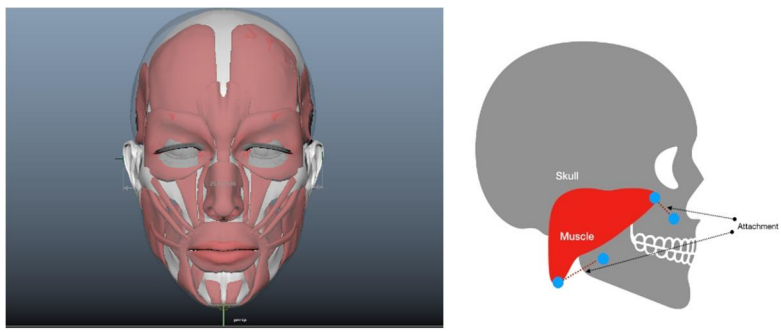

Figure 2. Geometry for muscle simulation, Bone, Muscle, Facia & Skin and attachment

3.2 Attachment between Muscle and Bone

Bone and muscle tissue can be joined and simulated later. The method of attaching the muscles to the bones is as specified in the muscle simulation software. We bonded a portion of the muscle to the bone as if the actual muscle were attached to the bone, and also allowed the muscles and muscles to be joined and influenced by each other. This method is important and is indispensable for obtaining the actual muscle-like movement. When the jawbone to which the muscle is connected moves, it is affected by this movement, and the muscle geometry contracts and expands like a real muscle[11].

3.3 Movement of Muscle

Human facial expressions are expressed through relaxation of muscle tissues inside. So it is not enough for muscles to stick on the bone. For simulation of the contraction and relaxation of the entire muscle, we need to apply realistic muscle attribute to the muscular geometries. This is an attribute that allows muscles to relax and relax when simulating a muscle model. It is because humans interact with the movements of whole muscle tissues when they are facial expressions. However, when muscle is made for CG, it is necessary to make the contraction and the relaxation function only in the necessary part, not the whole muscles.

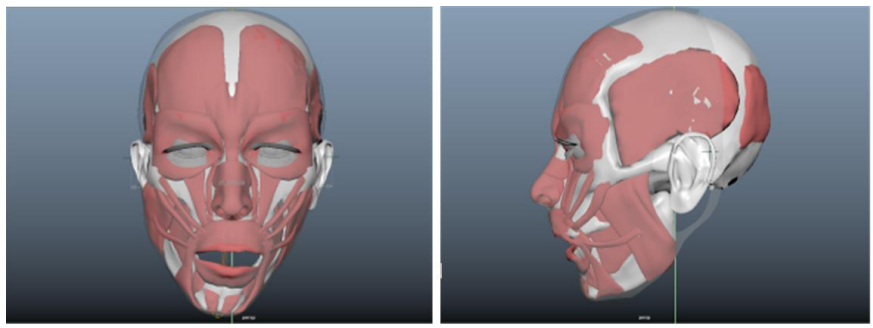

Figure 3. Muscle movement test

3.4 Fascia Simulation and skin

Making Muscles with linked bones do not produce good muscle simulation by themselves and this is the beginning of the whole process. The next step is to connect the muscle tissue to the fascia. The fascia can be created using geometry for face skins. The fascia is a thin membrane that surrounds muscles on muscle tissue. When the muscles contract and expand, the fascia works together. For this experiment, we used ZIVA VFX as muscle simulation software because the software has the ability to implement a fascia that other muscle simulation software does not. The simulation software use a cloth simulation for realistic fascia movement. In this way, the fascia of the simulation software works like an actual membrane with elasticity. The skin geometry is attached on the fascia produced by the above method and the final work is completed.

3.5 Making Facial Expression

After the basic muscle simulation is completed, the cubes are created, the bone properties are given, and the basic facial expression is created by animating the cube. Human facial expressions are made up of contractions and expansions caused by the movement of muscles. In CG production, however, we connect virtual bones to our muscles and make facial expressions through the movement of the bones. For example, if we want to express eyebrow movements properly through muscle simulation, we can animate several cubes in the eyebrows at important positions.

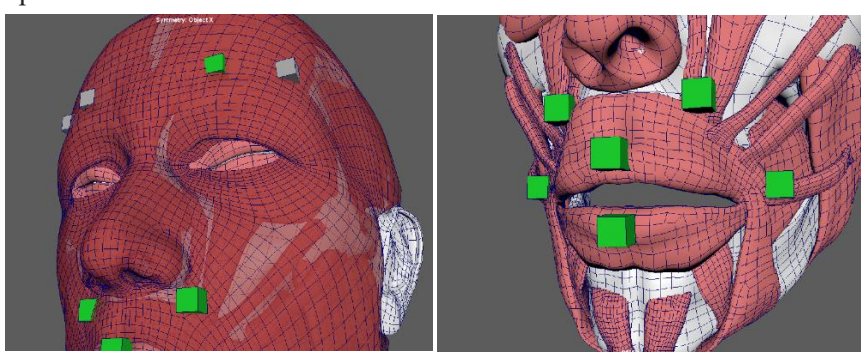

Figure 4. Positioning and attachment of Cubes to Muscle

3.6 Adding Blendshape layer

Facial expressions, which are made only with muscles, can be accurate to express muscular and skin movements but are not strong enough to express small details. Artist can really take a lot of time to reproduce human face movements, but the waste of time and manpower is huge loss for production use. Therefore, it is not necessary to simulate the movement of small details, such as the expression of the cheek and forehead wrinkles, by muscle simulation. Creating these small detailed expressions using blend shapes is a way to save work time.

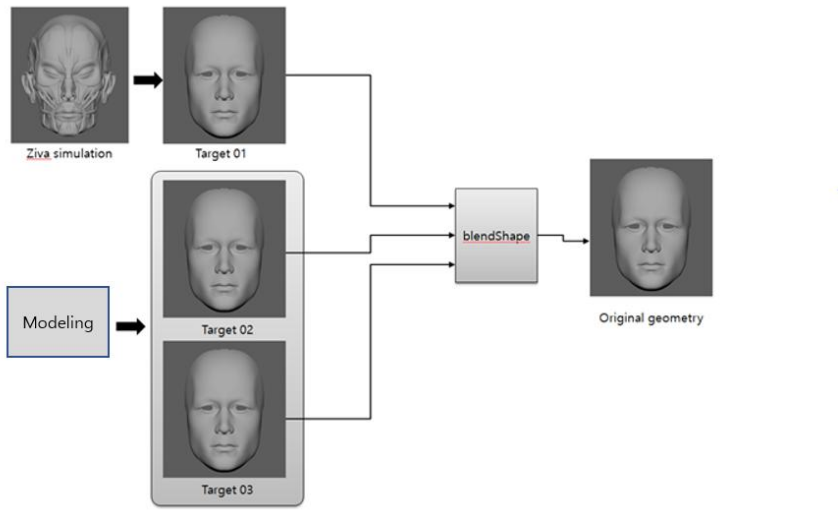

Figure 5. How blend shape works

4. RESULT

As you can see in Figure 6, not only the big changes are caused by the movement of the muscles and bones in the final result, but also the shape of the small details made by the face muscles and blend shapes. The movement of the chin on the A section confirms that as the chin moves to the left, the muscles around the left cheek swell up to form a natural shape. Also, around the cheek on the opposite side, the entire area is stretched naturally, but still the shape of the cheekbones beneath the skin is naturally maintained. As you look at the movement of the B section, you can see that the jaw opens and the skin around the nose and around the nose moves naturally downward as well. However, as with the results in section A, the skin remains the same. In the C section, it can be seen that the up-directional movements of the eyebrows make the wrinkles and as the mouth tails rise, the muscles are caught and gathered around. The D section is a test of various other facial expressions. Even when the lip tails are lowered or the lips are shaped like Ooh sound shape, the shapes are formed by the movement of the muscles.

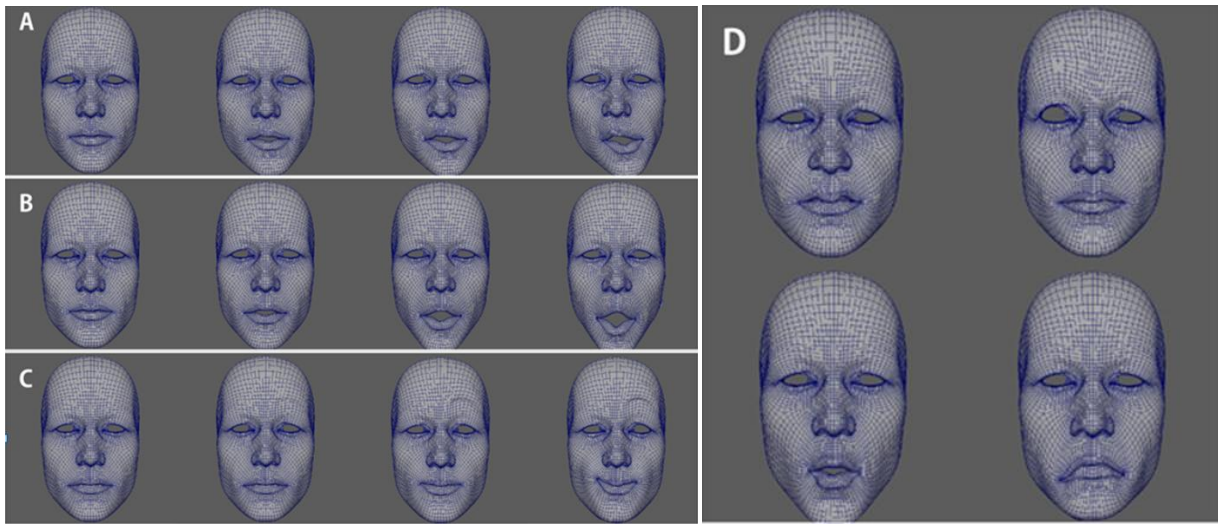

Figure 6. Result of Facial Muscle simulation and Blend-shape Layer

5. COMPARISON WITH OTHER METHODS

Typical Blend Shape Rigging is a method of modeling the facial expressions as target shapes after the face rigging is over. This method is used in conjunction with cluster deformer rigging and creates facial expressions by creating many joints and controllers on the face. This method has its advantages and disadvantages when comparing rigs based on muscle simulation method. Facial rigging, which mainly uses cluster deformers and blend shapes, has been used for a long time as an intuitive way to predict results. This method is usually applied after binding the joint and face geometry to the skin cluster [7]. The advantage of this method is that the work process is quick and simple, and smooth running rigging is possible if the weight of the skin is well controlled. Rigging is also lightweight so you can see your movements in real time. Because of these advantages, motion capture rigging uses this skin cluster and blend shape method mainly. This method makes real-time facial animation possible. It can also work together with FACS technology [8]. However, for a realistic facial expression, a large number of clusters may be required and a large number of blended shape targets may be required. And it is very hard to reproduce the movement of the skin in real life. On the other hand, the rigging based on muscle simulation shows realistic movements. Since the actual face muscle and skeleton are imitated from real human, the movement of the face is natural and realistic. In particular, the ZIVA VFX's ability to make realistic movements of fascia, fats and skin allows for a more realistic shape. However, rigging based on muscle simulation still has the limitation of simulation. It is not possible to implement simulation based on real time and it is necessary to always create a cache to check it properly. Also, production time may be longer than normal facial rigging

Table 1. Comparision list [12-15]

	Blend-shape rigging	Cluster Deformer Rigging	ZIVA muscle Simulation
How to make	Use Blendshape target	Face rigging using skincluster or cluster.Mostly used in game animation in basic way.	Use simulation.Work with CG bone, muscle, fascia, and skin.

ad-vantages	Easy, reliable and widely used. Simple working method. The quality of the target geometry production is important.	fast and flexible expression using cluster. Lightweight and intuitive rigging control. Strong in exaggerated expression.	The way the final skin is transformed by the movement of virtual muscles and bones. Extreme realistic representation possible.
disad-vantages	For complex types of rigging, it depends on the skill of the artist. The number of targets increases as the expression becomes more diverse. Possible unexpected results	Use of realistic characters is limited. Do not expect a detailed and realistic movement	The production process is complicated and requires a long preparation time. Additional acquisition of ziva software required. Facial rigging for real time is not possible.

6. CHARACTERISTIC OF MUSCLE SIMULATION METHOD

The most important feature of muscle-based simulation rigging is the realistic deformation [16-18]. In rigging using cluster / blend shape deformation mainly acts in a straight direction. However, the muscular method is not only straight, it also recognizes the muscular membranes and bones under the skin geometry and moves over the shape line.

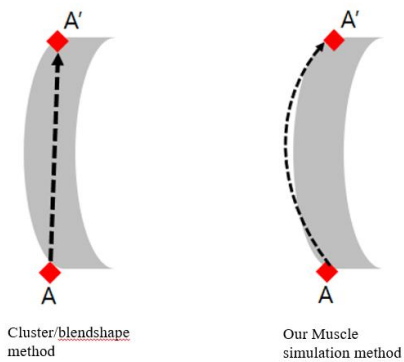

Figure 7. Comparison of movement of geometry vertex between cluster/blend-shape method and our muscle simulation method

7. CONCLUSION

The purpose of this study is to find ways to make realistic facial expressions when applying muscle simulations to face of digital characters. The main challenge of this study was how to effectively apply muscle simulations to face with muscle simulation software that originally made for the muscles of the body. For this purpose, only the muscles that can show the greatest movements among dozens of muscles in the face were selected and fabricated. Our study focused on the movements of the jaw bone and the vicinity of the cheekbones and the realistic representation of the forehead, which can highlight the merits of muscle simulation. Using our method, there was no problem with the above-mentioned motion reproduction. The jaw bone is slid as if the human jaw bones are moving under the skin, and when the mouth is opened, the skins near the jaw bone can move smoothly along the bones and muscles. Near the forehead, the skin moved naturally along the surface as the eyebrow moved. The next challenge was to reproduce a detailed facial surface. It is possible to express the wrinkles around the mouth and eyebrows by making fine muscles and muscular membranes, but

this requires a lot of time and effort. Instead, the study used the blend shape feature. By attaching a blend shape to motion that requires details, we produced fine shapes that are difficult to express simply and quickly with our method.

The results of this study are general-purpose and can be used in real production. In addition to the example presented, other expressions can also be easily expressed by the muscles. If we apply the result of this study to make a character of realistic movement, it is possible to make characters of high quality in a relatively easy and simple manner. With this technology, not only large productions but also small productions or individual artists can easily challenge the advanced creature technology produced by existing Hollywood productions.

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