Composition and Simulation of Finger Movements Using an Action Unit
（アクションユニットを用いた手指の運動構成とシミュレーション）

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Abstract Recently, programs that use 3D models have become remarkable due to the digitalization of various media, improvement in the performance of computers, and the development of the Internet. Present production technology contains much advanced software that cannot be easily utilized because it takes a considerable amount of time for a general user to master it. In this research, a system was developed that can easily simulate the movements of a finger by using an “action unit” that models as the muscle. The model of the finger constructed using this system is subjectively evaluated.

Key words: Action unit, Finger, Muscle model, VRML

1. Introduction

Recently, three-dimensional models have been attracting attention because of the digitalization of multimedia, improved performance of computers and the development of the Internet. Many advanced techniques are currently available. However, it takes time for ordinary users to master them. They are not options that can be easily utilised. Therefore, advanced techniques need to be made simpler, and there is a demand for an environment within which multimedia contents are capable of being produced easily. In this research, the natural movement of a finger is simulated, paying attention to the finger itself.

2. Action unit model

In a general CG animation system, there are many requirements for managing information of a three-dimensional character using an original method. Therefore, it is difficult to recycle other systems. In addition, these systems are designed for use in a stand-alone environment. Therefore, it is difficult to manage the shape of a three-dimensional character and the information concerning its movement on a network. Moreover, many aspects are required in order to construct a movement library using an original method\(^{(10)}\). A model is necessary in order to display the human body on a computer. A version with joints had historically been used as such a model for the human body\(^{(9)}\). However, an “action unit model” that uses muscles is employed in this research. The action unit model positions the muscles at the correct anatomical locations\(^{(15)}\). There was no limitation on the human movements in the general three-dimensional software. Therefore, there was always the possibility of making unnatural movements. However, this possibility is obviated by using the action unit. In addition, I use VRML in this study to design a finger model\(^{(6)}\). It is a language that constructs a virtual reality world of three dimensions from the Internet. In a general CG animation system, there are many requirements for managing information of a three-dimensional character using an original method. Therefore, it is difficult to recycle other systems. However, VRML can observe a common three-dimensional model by installing a VRML browser because it is independent of the OS. Therefore, it is a language that can recycle other systems.

3. Movement evaluation experiment

In this research, a finger movement model was constructed using an action unit. For the muscle of the finger, a parameter known as the “shrinkage ratio” is set. The shrinkage ratio shows how much the muscle shrinks. The actual movement influences the movement angle of the joint where the muscle is located. The parameter

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is set between 0% and 100%. Furthermore, the inflection and extension as well as the outward and inward swings are calculated. Extension and inward swing occur when the parameter nears 0%, and inflection and outward swing occur when the parameter nears 100%.

A finger movement involving a change in operation through an increase in musculature was undertaken. Both soft and solid objects were evaluated by the constructed model. Moreover, synthetic movement was also evaluated. The change in operation through an increase in musculature verified whether it would become a natural operation when the number of muscles used was increased. The movements of the finger change with soft and solid objects. Therefore, the model was constructed to incorporate this feature and experiments were conducted. When two different movements were synthesized, the evaluation of the synthetic movement varied, whether the synthesis of the proposed technique with the action unit was effective or not.

3.1 Change in operation through an increase in musculature

10 tests evaluated it in the experiment. The average point of each method of five stage evaluation is shown. Looking to nature is five points and unnatural is one point. It experimented by the following four methods because the amount that used the muscle because of operation where the paper was made and the operation that changed from the paper was large. (model 1: paper-scissors-paper, model 2: paper-rock-paper, model 3: paper-rock-scissors-paper, model 4: paper-Hafe paper-paper) Fig. 1 shows the experimental result. The model in which the outward and inward swing muscles are introduced gives a high value of evaluation. It can be inferred from this that the model in which the outward and inward swing muscles are introduced has a more natural operation. Moreover, the correlation diagram of the evaluation value and the musculature is shown in Fig. 2. It can be inferred from this result that the operation will become more natural by increasing the musculature.

3.2 Evaluation of finger movements with soft and solid objects

It was chosen that 10 people look natural. The number of people that the spindle of figure selected is shown. Fig. 3 shows the experimental result. It was shown by the model that many people added speed to the action unit while grasping the soft object. Moreover, the model showed that it adds a trembling to the action unit while grasping the solid object. Therefore, speed is an operative factor in the soft object model, while trembling is an operative factor in the solid object model. The trembling that is born of the repulsion power when the object is gripped is an action of the muscle for the solid body model. The consideration of speed concerning the soft object model is not an action of the muscle. However, the result did not deteriorate by adding speed.

3.3 Evaluation of synthetic operation

It was chosen that 20 people look natural. The number of people that the spindle of figure selected is shown. Fig. 4 shows the experimental result. In terms of a proposed technique, it is understood that there is a positive result of synthesis. Moreover, the appearance of the synthesis of the proposed technique is shown in Fig. 5. Fig. 6 shows the appearance of the synthesis of the conventional technique. Since the outward swing element had been greatly reflected in the parameter average when the finger was extended in the conventional technique, it became an unnatural movement. In the proposed technique for synthesizing, this was found on the basic movement, which was assumed to be an extension movement. Furthermore, since the outward swing
element had been added to the basic movement, it became a natural movement.

4. Conclusion

In this research, an ‘action unit’ model that arranged the muscles at the correct positions within the anatomy was introduced. As a result, the movements of a natural finger were easily replicated. Changes in the operation by an increase in musculature confirmed the operation to be natural. In the finger movements together with soft and solid objects, the soft object model was able to achieve a natural movement by adding speed. Moreover, the solid object model was able to achieve a natural movement by adding a trembling. In the evaluation of the synthesis, an experiment that synthesized two different movements was conducted. In terms of conventional technique, movement was not synthesized well. However, a natural synthetic result was obtained in the synthesis of the proposed technique. The problem for the future is to integrate the finger action unit with other action units. In that case, it will be necessary to consider the interaction of the muscles.

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References

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