Abstract

The objective of this study is to develop an avatar creation system on Virtual Reality (VR) spaces and to study effective interface for VR to enhance human activities and avatar creation in "Metaverse". In particular, I aimed to study the creation of anime-like avatars, which has traditionally been challenging.

In recent years, the evolution of Head-Mounted Displays (HMDs) and smart glasses has enabled us to experience the virtual world as a three-dimensional space. The virtual world, which takes place just like the real world, is referred to as the **Metaverse**. Interactions within VR spaces offer various merits and are expected to become increasingly major parts in communication in the future.

In the Metaverse, a 3D model acting as a user's alter-ego is named **avatar**. While there is demand for photo-realistic avatars in Metaverses to emulate the real world, there is also demand for anime-like avatars that allow users to embody characters, particularly in online games and social networking services (SNS). Currently, anime-like avatars are predominantly created manually by experts after a long period of works. The process needs a wide range of skills, from design to engineering, making it difficult to be automated. Thus, creating an anime-like avatar that has both individuality and high-quality appearance is a tremendous challenge.

Learning from experts' skills has been a major theme in machine learning. While remarkable achievements are being reported one after another in fields such as image generation, applications of these methods in the field of 3D computer graphics (3DCG) are limited to relatively simple objects. Particularly, as far as I know, no method has been established to generate high-precision anime-like avatars. A significant reason for this is the data structure inherent to 3D data. The structure of 3D data, including the number of vertices, their positions, and the order in which they are connected, is known as **topology**. As each piece of 3D data possesses a different topology, it is challenging to perform uniform analysis.

In this study, I developed a method to unify the differences in topology possessed by these 3D data and generate a high-quality data set. Specifically, I unified the diverse topologies of each model by standardizing the template at the low-polygon level. By matching the landmarks of the template among the training data, I was able to learn the features of each model while maintaining a common topology. Subsequently, I adapted to the training data while increasing the number of polygons, enabling us to extract features

with high detail. Similarly, for texture images, I took the same approach to unify different texture images into a common topology by performing template matching on UV maps. Mesh and texture data, which were originally closely combined with each training data, were extracted separately. They are allowed to operate independently and combined each other.

In addition, in this study I developed an application that allows users to generate avatars in a VR space by utilizing the created data set. By operating a controller in the VR space, the user can create an avatar while watching the avatar change in real time. The results of user studies showed that the interface for creating avatars within the VR space is more effective in reducing work time than the conventional interface for manipulating on 2D screen.

Next, to verify effective interfaces within the VR space, I developed three types of applications: a physical interface in which operations are completed in the controller, a pseudo-button interface that emulates a conventional mechanical device, and an interface that falls between the two. The results of user studies showed that the physical interface, in which operations are completed in the controller, is effective in reducing operation time and increasing the percentage of operations that the user concentrates on. On the other hand, however, it was also found that users' concentrated operation in the VR space could be burdensome depending on their custom, especially without appropriate guides to assist them.

In short, I established a topology-independent data analysis method for anime-like avatars, which are among the avatars needed for activities in the metaverse. I also developed an application that generates avatars in VR using this technology, demonstrating its advantages over conventional software. I also conducted detailed comparative studies on interfaces within the VR space, verifying the efficiency of the user interface and identifying its issues. Through these contributions, this research contributed to the development of knowledge science.

Keywords : Avatar, Computer Graphics, Creation Assistant, Human Computer Interaction, Virtual Reality