学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（情報科学）　　氏名　盧　子祥

学　位　論　文　題　名

Study on Calculation Method of Computer-Generated Hologram for Volume Data
（ボリュームデータの計算機合成ホログラム計算法に関する研究）

Currently, volume data, which represents three-dimensional (3D) objects, are widely used in many areas, such as in biomedical science and geology. Volume data are composed of a series of voxels, which is the fundamental element of volume data. A voxel represents a value on a regular grid in 3D space. Generally, volume data can be generated by many measuring instruments, including magnetic resonance imaging (MRI), computed tomography (CT), and meteorological instruments.

To make volume data easy to understand, many excellent visualization technologies have been proposed in the computer graphics (CG) area, such as surface rendering, maximum intensity projection (MIP), and volume rendering. According to different purposes of volume data, we can select different visualization method to use. The visualized images are very clear and easy to understand, but they are projections of CG models in a 2D plane, not real 3D images.

Holography is an ideal display technology that can satisfy all human physiological and perceptual requirements. Holography can record and reconstruct three-dimensional images by using the diffraction and interference of light. Nowadays, by using a computer, hologram data can simulate the interference patterns of holograms, which are called computer-generated holograms (CGHs). Several methods to generate holograms that represent volume data have been proposed. For example, the Voxgram system proposed by S. Heart et al. has been very successful in medical imaging. It proved that holograms can be used in medical science and are better than conventional 3D medical-display methods. The hologram is recorded on a photographic plate as a 3D image created by multiple exposures of each equal depth layer of volume data. Holoxica proposed a holographic display system for medical images. Y. Sakamoto proposed a volume rendering method that can generate CGHs from volume data. The reconstructed images were 3D, but these methods cannot display holographic animations.

In this research, I used an electro-holographic display device as the reconstructed device. Holographic animation and viewpoint movement can be realized. And I have proposed three CGH calculation methods for volume data: polygon-based, MIP-based, and volume rendering based CGH calculation methods. In the polygon-based CGH calculation method, there are two operations: surface extraction and CGH calculation with polygonal data. Volume data were transformed to the polygonal models by surface extraction. The CGHs of polygonal data were generated using a ray tracing method. Unlike the polygon-based CGH calculation method, the MIP-based CGH calculation method is a direct volume rendering method for volume data. In the MIP-based CGH calculation method, I used a modified ray tracing method to generate holograms of MIP models. In volume rendering based CGH calculation method, I used the direct volume rendering method and point light based method to generate holograms for volume data. And I applied the concept of transparency for voxels in volume rendering based

CGH calculation method. When I calculate the intensity of the reflected light, the diffuse reflection is calculated as the Lambert reflection.

The polygon-based CGH calculation method can obtain clear reconstructed images, and I can combine the polygonal models with my own ideas by using the 3DCG software. The color and material of polygonal models can be designed independently. Compared with the polygon-based CGH calculation method, the MIP- based CGH calculation method can only generate a single-color hologram. Using the same series of volume data, the polygon-based CGH method can generate a variety of holograms, can express the 3D sense of objects better than the MIP-based method. In addition, the materials of objects can be correctly expressed by the polygon-based method. The volume rendering based CGH calculation method can display the transparent objects and multi-layer objects well. Compared with polygon-based and MIP-based methods, the detail of holograms calculated by the volume rendering based CGH calculation method is better. For the computing speed, the MIP-based method is much faster than the polygon-based CGH method. It was possible to generate the CGHs in real-time. The calculation time of volume rendering based method is very long. To increase the speed of calculation, I proposed an approximate volume rendering based CGH calculation method with elemental holograms. There were no major effects on the reconstructed images between the volume rendering based CGH calculation method and volume rendering based CGH calculation method with elemental holograms. And the calculation time of volume rendering based CGH calculation method with elemental holograms can be greatly shortened.