SUMMARY OF Ph.D. DISSERTATION

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Title

Cylindrical Approximation of 3-D Meshes and Its Application to 3-D Model Retrieval

Abstract

Recently, instead of still or video images, advanced expression using 3-D models has come to be used in a lot of fields. At the same time, the huge amount of data of detailed 3-D models is the bottleneck when transmitting or sharing the models via the network. Therefore data compression and progressive data representation for the 3-D models are required and widely being studied.

As an effective technique to satisfy the demands mentioned above, there is a method that projects the 3-D information onto a virtual cylinder surface surrounding the model. Real-time transmission of the data is possible by using this method because of its fast processing feature. However, as the occlusion areas from the cylinder surface are entirely omitted in the projection, sometimes awkward shapes are obtained as a result.

In this thesis, we present two novel cylindrical projection methods with the aim to implement the reconstruction of the occlusion areas and to enhance the processing speed.

One method is to use a projection method called "ray-casting" –which is also used in the conventional methods– that detects the intersection of a model and rays emitted from the cylinder surface. However, to acquire the occlusion areas, a new ray is emitted from a neighborhood point of the detected point with a different angle hierarchically.

Another method is to use another projection method called "Z-buffering" that projects geometry information from the center axis of cylinder contrary to the ray-casting method. As the computational complexity of this method is quite less than that of the ray-casting method, the required time for the projection can be greatly shortened by using this method.

Additionally, to show the effectiveness of our methods for other applications, this study also presents a new 3-D model retrieval method using cylindrical geometry images.

Chapter 1 summarizes the background and purpose of this study.

Chapter 2 describes the basic algorithm of the cylindrical projection, and shows the practically reconstructed 3-D shapes in order to show how the lack of the occlusion region affects the sight of the reconstructed models.

Chapter 3 describes the hierarchical ray-casting method to reconstruct the geometry of the occlusion areas, and shows the way to decide the emission point and angle of the rays.

Chapter 4 describes the cylindrical Z-buffering method to enhance the projection speed, and shows the point that must be improved for the application of Z-buffering to the cylindrical screen.

Chapter 5 describes a 3-D model retrieval method that use 2-D cylindrical image matching as an application of this study. The combination of fast cylindrical projection and fast image matching using principal component analysis (PCA) makes it possible to detect similar models at a speed of 500 times the conventional 3-D model retrieval methods.

Chapter 6 describes the 3-D mesh parameterization as a future work. This method records the 3-D model's coordinates as the color image. In this case, even though the amount of information increases, more detailed shape reconstruction becomes possible, and a new application using these geometry images are also considered. The proposal described here improves the resulting shape furthermore.

Chapter 7 summarizes the results of this study.