Chapter 1

Introduction

3D model representation is getting more and more popular in the field of multimedia. There are two kinds of data structure that people used to store the 3D model information. One is the volumetric representation. It fully retains all the information of 3D models. For some important occasions, researchers can complete the experiments perfectly by the accurate information. Medical images, for example, use the representation to store the 3D information of a human brain. The researchers working in the field observe the structure of a human brain, and try to simulate the functions of a human brain. Although the volumetric representation has the ability to provide relatively complete information to user, is sometimes would be considered verbose. In the field of computer vision or computer graphics, a 3-D solid (volumetric) representation is not as important as it is in the field of medical applications. Therefore, people tend to use a surface representation that only shows the outside of a 3-D object. The most commonly adopted 3-D surface representation is the mesh representation. Usually people consider polygonal representation a general case of mesh representation. In a polygonal representation, the surfaces of a 3-D model are sampled by a number of polygons. The more the vertices used, the finder the 3-D model is approximated.

With a 3-D mesh-based representation, one can conduct research on different directions and make the developed software commercially useful. For example, a mesh-based 3-D representation scheme can be perfectly applied to the field of 3-D games. When one talks about 3-D games, the resolution used to represent a 3-D model is a crucial issue. It is well-known that an object with finer resolution will need more sampling points to represent it. Therefore, there are a large number of researchers denoted themselves to the issue of surface simplification. In addition, to appropriately control the amount of information to be transmitted via the network is also an important issue that attracts extensive attention in recent years. The researchers working in this area devoted themselves to cut down the size of transmitted data while maintaining the quality. For example, algorithm designed for surface compression is a good means to cut down the size of data for transmission.

Among the above mentioned research directions, most of the developed algorithms require that the input data should be a manifold one. Therefore, a preprocessing stage that is able to detect ”non-manifold” data in advance is indispensable. With this detection mechanism, we can ”detect” and then ”convert” these non-manifold data into manifold ones. Usually, a manifold surface is designed as a surface without topological singularities and geometrical degeneracy. Topological singularity means there are some special topological connections existing in a 3-D mesh, e.g., non-manifold connectivity. The existence of topological singularities always hinders people from developing valid 3-D mesh-based algorithms. Some 3-D model processing algorithms such as surface simplification algorithm, surface compression algorithm and progressive transmission algorithm are all algorithms of this kind. Therefore, solving the topological singularity problem is the first issue that we have to work on.

As to the second issue, the geometrical degeneracy problem, we discuss it as follows. Geometrical degeneracy means a 3-D mesh containing holes and self-intersection. There are two causes for a hole: inconsistent surface normal orientation and the loss of geometric information. In the field of rendering 3-D computer graphics, normal vectors are most commonly used to calculate reflection and shadow effect. Hence, if the normal vectors of a 3-D model are not consistent, it is possible to generate some holes while executing rendering. On the other hand, it is also possible to form holes if some geometric parts are missing in the rendering process. As to the self-intersection problem, it means the faces of a same model intersect to each other. Usually, this effect occurs most frequently during the imaging process, e.g., when using a 3-D scanner to grab the information. In this chapter, we intend to propose new ways to fix the above mentioned topological singularity and geometric degeneracy problems. Now, we put our emphasis on how to integrate different kinds of strategies and then implement a system that has the ability to fix 3-D mesh-based models. Among a great number of mesh-related issues, we plan to work on two important ones: topological singularity and holes caused by loss of geometric information. Propose new fixing strategy by integrating existing fixing algorithms into a more powerful fixing tool. Having this new fixing tool, the users can execute modelling and editing more efficiently.

The rest of this thesis is organized as follows. In chapter 2, we shall discuss the topological problems, including how to remove topological singularity by cutting. As to the holefilling problem, we shall use a triangulation algorithm to fill the holes in a mesh model and the content will be addressed in chapter 3. In chapter 4, we shall report some experiment results and the concluding remarks of this thesis will be drawn in chapter 5.