CS 520 Final Project - Implementing an Algorithm for Homeomorphic Surface Reconstruction and its applications to real 3D object

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Abstract

In this project, the problem is to compute a piecewise linear approximation to a surface from a set of sample points extracted from real 3D object. This problem is important in solid modeling, computer graphics and computer vision. An existing algorithm [1] using the Voronoi diagram of the sample points guarantees an output surface which is homeomorphic to the original surface and thus will be used in this project to for homeomorphic surface reconstruction of some example 3D objects.

1 Introduction

A number of applications in CAD, computer graphics, computer vision and mathematical modeling involve the computation of a piecewise linear approximation to a surface from a set of sample points. This point set is usually generated by a laser range scanner, manually with a contact probe digitizer, using medical images like CT or MRI scans, or in any other way. Solutions to general surface reconstruction problem can provide baseline for solving and analyzing specialized problems.

Clearly, it is not possible to compute a surface that is faithful to the topology and geometry of the original unless the sampling is sufficiently dense, so any such analysis must include some assumptions about the sampling density. Given the assumption that the distance between samples is proportional to the distance to the medial axis, a surface reconstruction algorithm based on Voronoi is presented. The output of the algorithm, the crust, is close to the surface S, under the assumption that S is a smooth(twice-differentiable) 2-manifold without boundary and that sampling density assumption mentioned.

In brief, this algorithm consists of two major steps. First, a set of triangles T satisfying three conditions are computed by filtering triangles from the Delaunay triangulation. Then, an acceptable piecewise-linear manifold N can be selected from T by a manifold extraction step in [1].

In the end, some quantitative experimental results between set T and surface N in terms of the number of triangles and processing time will be given. Also, the difference in visualization of set T and surface N on some real 3D objects will be examined.

References

[1] N. Amenta, S. Choi, T. K. Dey, and N. Leekha. A simple algorithm for homeomorphic surface reconstruction. In *Proceedings of the Sixteenth Annual Symposium on Computational Geometry*, SCG '00, pages 213–222, New York, NY, USA, 2000. ACM.