ABSTRACT

ENHANCED MODELS FOR SURFACE REPRESENTATION

Surface Representation deals with the digital representation of surfaces. The surface from which the data are sampled is known in some form such as a real model and the goal is to get a computer-based description of exactly this surface. Mesh generation is a key component for the computer simulation of physical and engineering problems. In surface representation, random elevation data is taken and this is approximated with a mesh of triangles also known as a triangulated irregular network or TIN. The popular Delaunay triangulation of a vertex set simultaneously optimizes several of the quality measures: maxmin angle, minmax circumcircle, and minmax min-containment circle over all possible triangulations of the same point set. It favours equiangular triangles. An algorithm for surface representation should accurately approximate the original model and use as few triangles as possible. It should take care of various constraints such as different sample densities and breaklines that prevent surfaces from crossing over a linear feature, such as a road edge or a cliff. Often a large number of samples will have to be handled, typically varying from 1000 to 100,000. The time needs to increase modestly as the number of samples increases for a technique to be suitable. The samples are often obtained in an incremental procedure. Hence, one should be able to add the new points to the surface obtained, instead of recomputing the surface from scratch. For each vertex, three coordinates and other connectivity information about the triangulation are required. Hence the data structure should be efficient in terms of storage. In essence, the algorithm should be fast, memory-efficient and robust.

Towards this end, it was proposed to solve this problem in the following stages:

- Development of a fast divide-and-conquer algorithm, which shall triangulate a given set of points using minimum resources.
- Development of an insertion routine that shall insert any additional points to an existing TIN and then compute the optimal triangulation.
- The algorithm shall be enhanced to take care of the constraints.
- Development of fast TIN manipulation routines to help in accurate representation of the surface.

The efficiency of a triangular mesh generator rests on its triangulation algorithm and data structure. Five data structures, namely Quad-edge, Triedge, Triplet, Biedge and TIN, have been implemented and their performance studied. Algorithms for the Incremental Insertion of points, the Divide and Conquer strategy, insertion of Constrained Edges, Saving the Triangulation and Loading the Triangulation have been implemented. The DTM model is output as coordinates of triangles. The DTM created has been used to calculate the quantity of earthwork in cut and fill applications.

A mesh must conform to the object or domain being modeled. The important issues in the triangulation process are the shape and size of the elements. Algorithms have been developed to improve the shape and number of the triangles.
The data structures and algorithms have been used for surface representation with success. They have been implemented in C++. Also dlls in .NET framework have been created. Several tests have been made to test the robustness and efficiency. They have been run on both 32-bit and 64-bit machines and different PDAs. The results indicate a rough parity in speed among the machines.

Despite the fundamental differences between the data structures, the implementations are consistent triangulations. All breaklines are honored and an accurate representation is obtained without any manual editing of the created surface. They cope with almost all aspects of many surface data sets, and readily lend themselves to grid and contour generation as well as 3D rendering.

The characteristic set of operations by which the application is dominated is to be identified and an appropriate data structure which supports the efficient implementation of these operations is to be chosen.

With this capability to create a digital terrain model on a PDA, one can visualize a survey at site, saving valuable time in cases where some important data point has been missed out. The limited memory constraints of the surveying instruments can be overcome. This could revolutionize the future of surveying. It has the potential of provoking even more radical changes in work practices and encourages an even greater level of mobile work and distributed collaboration.