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Surface Reconstruction Using Scattered Cloud Points

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Abstract— ***Surface reconstruction means that retrieve the data by scanning an object using a device such as laser scanner and construct it using the computer to gain back the soft copy of data on that particular object. Surface reconstruction is a reverse method. It is very useful when in a particular object original data is missing without doing any backup. Hence, by doing so, the data can be recollected and can be stored for future purposes. We develop a system for image reconstruction from scattered cloud points. Crust algorithm with umbrella Filtering will be implemented and compared for time taken by the algorithm for surface reconstruction. The main aim of the algorithm is to filter out left insignificant data while preserving an acceptable level of output quality.***

Keywords— ***Surface Reconstruction, crust algorithm, umbrella filtering, point clouds.***

I. INTRODUCTION

Surface reconstruction is the process to achieve three-dimensional complex surface model quickly and accurately from three-dimensional data collected as a sample, and it is widely used in reverse engineering. Three-dimensional data collected by measuring device is usually dense, so it is called Point Cloud data.

Point cloud data can be considered as an aggregation of the points in three-dimensional space, and each point cloud data has three coordinates of x, y, z.

According to the different forms of data, point cloud data can be divided into two forms:

I. Ordered point cloud
II. Scattered point cloud.

Reconstruction of ordered point cloud is that constructing the surface of points sample from the verge of object to approximate the original surface most. In practice, due to the limitation of gathering devices or the difference of collecting ways, there is no specific type of the points, so these points are called scattered point cloud. For scattered point cloud, if the reconstructed surface can show the shape of the original point cloud, we regard it as the result of the surface reconstruction.

II. SURFACE RECONSTRUCTION PHASES

Surface Reconstruction phases include:
Phase 1: Initial Surface Estimation
Phase 2: Mesh Optimization
Phase 3: Smooth Surface Optimization

Phase 1: Initial surface estimation: From an unorganized set of points, phase 1 constructs an initial dense mesh. The goal of this phase is to determine the topological type of the surface, and to produce an initial estimate of its geometry.

Phase 2: Mesh optimization: Starting with the dense mesh created in phase 1, phase 2 reduces the number of faces and improves the fit to the data points. We cast this problem as optimization of an energy function that explicitly models the trade-off between the competing goals of accuracy and conciseness. The free variables in the optimization are the number of vertices in the mesh, their connectivity, and their positions.

Phase 3: Smooth surface optimization: In phase 3, the surface representation is changed from a piecewise linear one (meshes) to a piecewise smooth one. We introduce of a new piecewise smooth representation based on subdivision. These surfaces are ideal for surface reconstruction, as they are simple to implement, can model sharp features concisely, and can be fit using an extension of the phase 2 optimization algorithm.

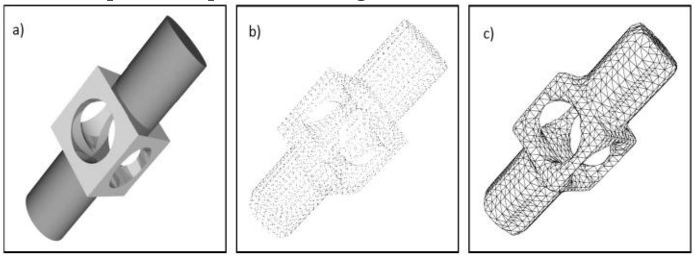

Fig 1 The result of the Phase 1 a) original object; b) point cloud; c) surface reconstruction.

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III. SURFACE RECONSTRUCTION APPLICATION FIELDS

Surface reconstruction methods are very useful to recover the shape of real objects through reverse engineering. However, each application has its own requirements for the model to be achieved.
For example:

- In CAD applications, the user is interested in obtaining a very accurate model for the real object.
- In medical applications, the scanning devices used are the computerized tomography (CT), magnetic resonance scanners (MRS), or 3-D ultrasounds.

IV. CRUST ALGORITHM

The Crust Algorithm is a recently proposed algorithm for surface reconstruction problem. This is the algorithm used for reconstruction of surfaces of arbitrary topology from unorganized sample points in 3d.The Crust algorithm for surface reconstruction, also called Voronoi filtering. All the new algorithms are based on voronoi diagrams and their Delaunay triangulation.

A. 2-DIMENSION (2D)

Crust algorithm computes the Delaunay triangulation. In 2D version of an algorithm, the crust connects the centers of the circum circles produces the Voronoi diagram. This technique has several strengths like: the construction of surface in 2D ensures the homotopy type. However, a similar result does not hold in 3D.

B. 3-DIMENSION (3D)

In 3D, the first step is pre-processing where the data is input, organized, and partially analysed to prepare for the remaining operations. Pre-processing includes data input, sorting, determination of a neighbourhood for each point, and computation of an approximate normal vector to the surface at each point. The second step is extracting feature points from the data. This process is accomplished by detecting areas where there is an obvious edge based on the distribution of points in the neighbourhood or areas where there is significant variation in approximate surface normal within the neighbourhood. The final step of mesh generation consists of extraction of additional points as needed, generation of edges, generation of polygons from the edges, and triangulation of the polygons. The Crust Algorithm for the surface reconstruction from unorganized cloud points in 3D. In this algorithm the output guarantees to be topologically correct for a given point clouds from a smooth surface and as the sampling density increases it moves towards a common point to the original surface. According to the definition of a good sample the sampling density varies locally, strictly captures the intuitive notion so that the featureless areas can be reconstructed from fewer clouds. The algorithm is mainly based on the three-dimensional Voronoi diagrams and Delaunay triangulation.

V. UMBRELLA FILTERING

Umbrella filtering is used to iterate over candidate triangles and remove those not included in the umbrella. The structure of the vertices in well-approximated surfaces resembles that a topological disk is the so-called umbrella. A topological structure resembling an umbrella is also used for detecting the boundaries of the surface, i.e., holes in the under sampled regions. The described method fills up the holes to make surface watertight.

VI. RELATED WORK

Surface reconstruction is an important problem in computational geometry, computer aided-design, computer vision, graphics, and engineering. Most existing reconstruction algorithms can be classified into two main categories, i.e., the explicit and implicit method.

A. **EXPLICIT METHOD:** Explicit methods are mainly local geometric approaches based on Delaunay triangulation and dual Voronoi diagram. These methods derived from computational geometry to extract a triangulated surface for an input point set. Some examples include the Alpha Shapes, the Power Crust algorithm and the Cocone algorithm An advantage of explicit method is that given a sufficient sampling density, the restricted Delaunay triangulation of data set points is homeomorphic to the original surface, which suggests a sound approximation of the original surface Another advantage is that the resulting homeomorphic sub-complex, i.e. the restricted Delaunay triangulation, has a structure of triangular surface mesh, which is preferred in many applications due to its simplicity, its efficiency to approximate the original surface, and its convenience as the boundary input for further volumetric mesh generation or other processing.

However, undersampling, non-uniformity, and noises introduced during the data acquisition stage are likely to destroy the desirable homeomorphic sub-complex, hence make reconstruction problems ill-posed and cause various difficulties

ALPHA SHAPES: Alpha shapes approach to formalize the intuitive notion of "shape" for spatial point sets. It is used for shape modeling to create shapes out of point sets and gives the hierarchy of the shapes. It is also used for reverse engineering. It generalizes the convex hull of a point set. The smallest convex set that contains the entire point set

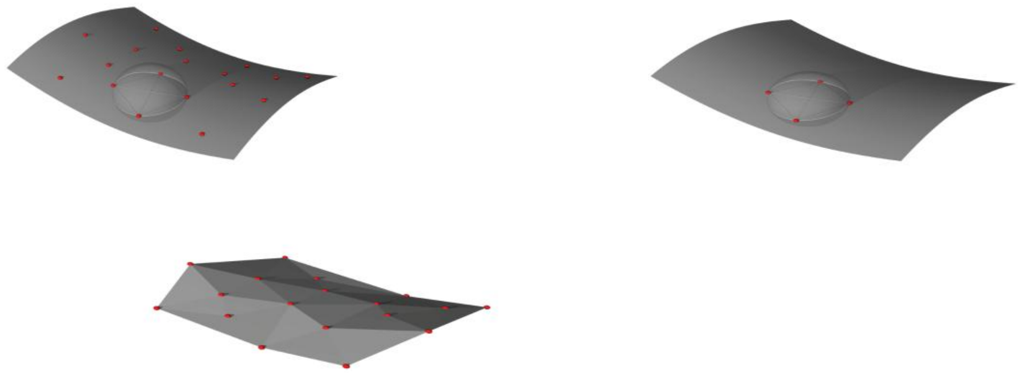
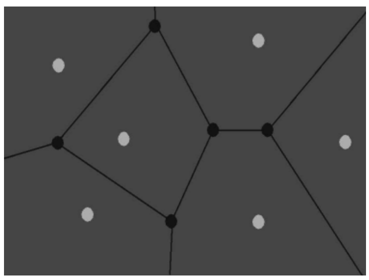
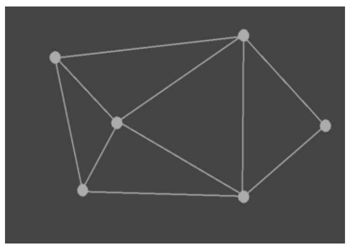


Fig 2 (a) The shown tetrahedron must be part of the alpha shape. (b) By adding more points one gets an alpha-sampling of the surface. (c) The outer boundary of the alpha- shape is a correct surface reconstruction.

DELAUNAY TRIANGULATION AND VORNOI DIAGRAM: The Delaunay triangulation D of a set of point S is a tessellation of the space into triangles with vertices of point S.

Points closest to each sample form cells. Cell boundaries have more than one closest sample. Adjacent cells define adjacent samples. Delaunay triangles connect adjacent samples.





B. IMPLICIT METHOD: The implicit approaches aim to find an implicit function that best fits the data by using algebraic surfaces; level set method, moving least squares fitting, variational implicit surfaces using radial basis functions.

POWER CRUST ALGORITHM: Poisson surface reconstruction algorithm is used to create 3D heart model because original data has a lot of noise and without normal vector information. This algorithm has good robustness for noisy and irregular point cloud data. Poisson surface reconstruction algorithm correct the shape by removing or adding points from the model surface to perfect the heart model, and reconstruct the new model by Power Crust algorithm based on the correctional surface point cloud data with normal vector, which is quick, accurate and efficient and very suitable for fast model correction. The results not only accurately display the spatial relationship of the heart, but also can be discretionary scaling and rotation in 3D space. The visual 3D graphical structures of the reconstructed heart model can display diseases and enable catheter navigation in real time, which can help doctors to detect and diagnose diseases effectively, and improve the accuracy and security of medical diagnosis.

GRAPH CUT METHOD: This method is used for reconstructing open surfaces from unordered point sets In this method the open surface problem is translated to a watertight surface problem within a restricted region through a Boolean operation on the crust. Integrating the variational model, Delaunay-based tetrahedral mesh and multiphase technique, the proposed method can reconstruct open surfaces robustly and effectively. Furthermore, a surface reconstruction method with domain decomposition is presented, which is based on the new open surface reconstruction method. This method can handle more general surfaces, such as nonorientable surfaces. The algorithm is designed in a parallel-friendly way and necessary measures are taken to eliminate cracks and conflicts between the sub domains.

VII. CONCLUSION

In this paper crust algorithm optimizes the surface reconstruction system from scattered cloud points. Crust algorithm plays an important role due to its guaranteed quality of mesh generation. Some applications medical imaging, geographic data processing, and interactive surface sketching, can take advantage of the technology to compute the digital model of a geometric shape with reconstruction algorithms.

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