Global Parameterization and Quadrilateral Meshing of Point Cloud

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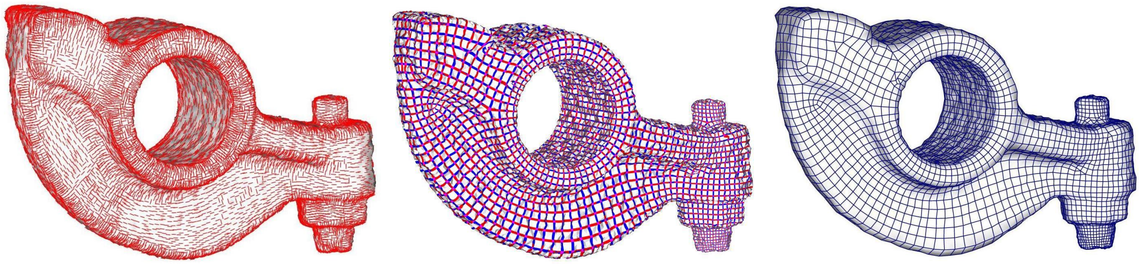

(a) (b) (c)

Figure 1: *Quadrangulation on a point model with noise; (a) direction field after smoothing on the input point cloud ; (b) iso-θ lines (blue) and iso-ϕ lines (red) extracted using the new approach; (c) the final quadrilateral dominated mesh.*

1 Introduction

Point data are basic media for shape information acquisition and representation. A new approach is presented for global parameterization of unorganized point data and application to the meshing of point models with noises. While most of recent researches focus on quadrangulation of mesh models, it is extended to point models in this work, so as to loosely reconstruct the shape model by quadrilateral meshing of curvature isolines. The new approach is guided by principal directions, so as to preserve intrinsic geometric properties. A robust method is applied to estimate curvatures in presence of noise and outliers based on fitting surface normals. The parameterization of [Ray et al. 2006] is then adapted to point data by local Delaunay triangulation. Isolines are extracted by discarding and merging the redundant segments in each local triangle. This method is totally automatic, and a high-quality quadrilateral dominated mesh can be generated, as shown in Figure 1.

2 Method Overview

To provide a robust and flexible framework for quadrilateral meshing of a point set surface, our algorithm proceeds in three steps.

Normal fitting. To calculate principal directions, the curvature tensor is estimated on each point by fitting normal directions of its k-nearest neighbor points. Initial normals are calculated with tangent plane fitting, and they are refined through the relation of principal directions and derivatives of all normal directions. This refinement greatly reduces the effects of noise. To reduce the number of singularities, the direction field is smoothed globally. This is achieved by minimizing variations of the directions between neighbor points.

Global parameterization. The principal direction $\mathbf{K}$ guided parameterization is converted to minimizing an energy function:

$$E = \int |\nabla\theta - \omega\mathbf{K}|^2 + |\nabla\phi - \omega\mathbf{K}^{\perp}|^2$$

To obtain a global parameterization, each triangle is regarded as a chart. Transition coefficients and rotation coefficients are defined on each edge to ensure the continuity between two adjacent charts. As for point cloud, the gradient of parameterization is defined by constructing a local Delaunay triangulation. While in [Ray et al. 2006] θ and ϕ are replaced by $\sin\theta$ and $\cos\phi$ to avoid solving a mixed-integer problem, we use the mixed-integer solver presented in [Bommes et al. 2009] which is more direct and provides more accurate results.

Isoline extraction. The intersections of iso-θ lines or iso-ϕ lines with Delaunay triangles may produce line segments in some triangles. Corrections are needed on the connection between segments, since triangles are built locally. In practise, this happens only when two triangles overlap. Therefore, each intersection of segments is detected, and some segments are merged and discarded, until there are no redundant segments. The meshing process becomes easy with an exact connection of all segments.

3 Results and Conclusion

A framework is presented and implemented for global parameterization of point data and application to a direct conversion of a noisy point model into a quadrilateral dominated mesh. Experiments show the efficiency of this work on a point model *rocker* with random Gaussian noise in Figure 1. In the further work, new techniques would be utilized to approximate gradients on point data.

Acknowledgements

Special thanks to INRIA Project ALICE for data and for software *Graphite*. This work is supported in part by National Natural Science Foundation of China No. 60970093, 60672148, 60902078, and 60872120, and in part by the National High Technology Development (863) Program of China No. 2008AA01Z301.

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SIGGRAPH Asia 2009, Yokohama, Japan, December 16–19, 2009.
ISBN 978-1-60558-858-2/09/0012