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Generation of Lattice Points of 3-D Object from Scattered Range Data
3 次元物体の計測離散点群データから格子状分布点列の創成

S. J. Wang 王 生進　Y. Cai 蔡 奕　R. Takamatsu 高松 亮　M. Sato 佐藤 誠　H. Kawarada 河原田 弘

Precision and Intelligence Laboratory, Tokyo Institute of Technology
東京工業大学 精密工学研究所

1 Introduction

In many scientific and technical endeavors, a 3-D object must be reconstructed from scattered range data. Raw range data are hard to be employed for 3-D display in realtime because the number of them is too enormous. Although triangular patch representations proposed in traditional methods up till now are used for reconstructing a 3-D object [1][2], they take too many patches. In this paper, generation of lattice points from scattered range data by re-sampling method is proposed. Using the proposed method, fewer lattice points and patches on 3-D object surface can be obtained for 3-D object modeling.

2 cube-based segmentation

2.1 Cube generation

Range data of a 3-D object is delivered from an optical measuring machine. Analyzing the scattered range data, the position and volume of an outline which encloses the object can be obtained[3]. Then, making cross sections along the directions of X, Y, Z axes in 3-D object space, a group of hexahedrons are generated. We call a hexahedron a cube. As a result, the object is segmented and the scattered range data are divided into certain cubes. The data inside a cube is regarded as a patch.

2.2 Pattern of patches inside cubes

The patches segmented in cubes are polygonal surface patches. Re-sampling will deal with these surface patches.

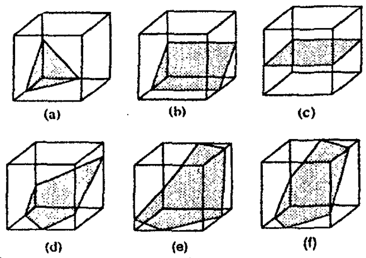

Fig. 1 Patterns of patches in cubes.

To assume that the size of cubes is small enough, so that the patterns of patches inside cubes are restricted to six kinds shown in Fig. 1. They are triangle (a), quadrangle (b), (c), pentagon (d), and hexagon (e), (f). Since only triangle and quadrangle are used for lattice points generation in the next step, the pentagon and hexagon should be re-segmented once more. Pentagon is re-segmented into a triangle and a quadrangle. Hexagons are re-segmented into two quadrangle patches. The new boundary which re-segments pentagon and hexagon can be generated according to the processing mentioned in **3.2**.

3 Generation of lattice points

3.1 Generation of lattice points on patch apexes

There are 12 edges on a cube. $O(x_0, y_0, z_0)$ shown in Fig. 2 is a cube vertex. The shading area is object surface. A vertical $x-y$ plane of straight line L is divided into four areas. If the projections of scattered range data can be found in in four areas, it is regarded that the edge contained in L crosses with surface. Let $n(0, 0, \Delta_z)$ indicate the vector of L and $O(x_0, y_0, z_0)$ indicate a point on L, a equation of L is determined. Then, selecting three points D_1, D_2, D_3 which are the nearest to L among scattered range data, a plane can be determined by them. An intersection of L and plane is given by

$$(O + n \cdot t - D_1) \cdot [(D_2 - D_1) \times (D_3 - D_1)] = 0. \quad (1)$$

The obtained intersection is regarded as a lattice point on patch apexes.

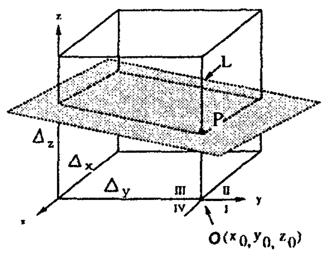

Fig. 2 Generation of lattice point on patch apexes.

3.2 Generation of lattice points on boundary

The points P_1, ..., P_6 in Fig. 3 are previously obtained lattice points on cube edges. The point O_i and the normal vector n are determined by

$$O_i = P_1 + (i-1) \times \frac{P_4 - P_1}{M-1}, \quad i = 1, 2, ..., M \quad (2)$$

$$n_a = \frac{(P_3 - P_1) \times (P_2 - P_4)}{\|(P_3 - P_1) \times (P_2 - P_4)\|}, \quad (3)$$

$$n_b = \frac{(P_4 - P_6) \times (P_1 - P_5)}{\|(P_4 - P_6) \times (P_1 - P_5)\|}, \quad (4)$$

$$n = \frac{n_a + n_b}{\|n_a + n_b\|}. \quad (5)$$

With the obtained O_i and n, lattice points can be generated according to eq. (1).

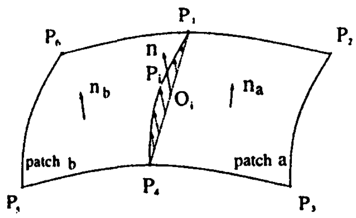

Fig. 3 Generation of lattice points on boundary.

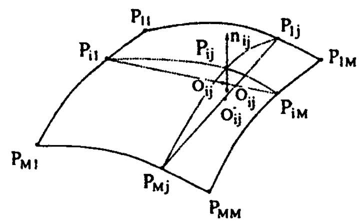

Fig. 4 Generation of lattice points inside patch.

3.3 Generation of lattice points inside patch

Based on obtained lattice points on boundary, lattice points inside patch shown in Fig. 4 are generated as follows:

$$O'_{ij} = P_{i1} + (j-1) \times \frac{P_{iM} - P_{i1}}{M-1}, \quad (6)$$

$$O''_{ij} = P_{1j} + (i-1) \times \frac{P_{Mj} - P_{1j}}{M-1}, \quad (7)$$

$$O_{ij} = \frac{O'_{ij} + O''_{ij}}{2}, \quad (8)$$

$$n_{ij} = \frac{(P_{iM} - P_{i1}) \times (P_{1j} - P_{Mj})}{\|(P_{iM} - P_{i1}) \times (P_{1j} - P_{Mj})\|}. \quad (9)$$

Using O_{ij} and n_{ij}, the $M \times M$ re-sampling points P_{ij} can be generated according to the eq. (1).

4 Experimental results

Two experimental results are given here. Fig. 5(a) is 3-D display of a head of golf bar's range data. Fig. 6(a) shows a parts model's range data. The generated lattice points of two objects are shown in Fig. 5(b) and Fig. 6(b). The intersections of wire frame act as lattice points. Each of object consists of 12 patches and patch has 9 × 9 lattice points.

5 Conclusion

Using the proposed technique, a 3-D object can be represented with fewer points and patches. The technique can be considered as an interface between optical measuring machine and 3-D CG/CAD system.

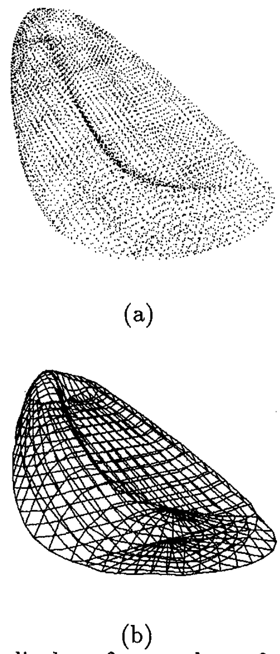

Fig. 5 (a) 3-D display of range data of a golf bar. (b) Lattice points.

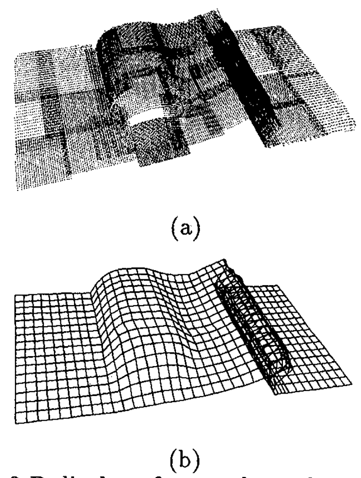

Fig. 6 (a) 3-D display of range data of a parts model. (b)Lattice points.

References

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