Automatic Reconstruction of Multi-layer Building 3D Contour Model From Airborne LiDAR Point Clouds

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Abstract:

A novel method for multi-layer building three-dimensional(3D) contour model reconstruction from airborne LiDAR point clouds is presented. The method includes three steps, Firstly, using the algorithm of region growing, the building data sets and hierarchy information are extracted from the triangulated LiDAR point clouds; then, the building roof boundaries are extracted from the building data sets, and the regularization of each boundary is carried out with the restriction of roof dominant orientation; in order to ensure the consistency of boundaries between two neighboring roofs in the horizontal projection plane, the consistency processing of roof boundaries is carried out at last with the building structure hierarchy information. In the proposed method, the first and second step adopts the existing algorithms, and the third step is mainly discussed.

After step one, the building roof data sets and hierarchy information of building structure can be extracted from LiDAR point cloud synchronously, as shown in Fig. 1:

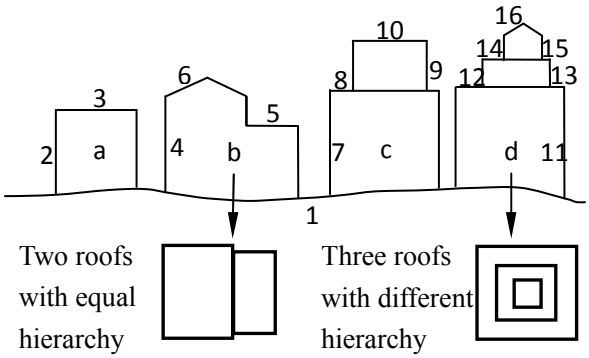

Fig. 1 Schematic diagram of multi-layer buildings region growing

The building structure hierarchy information is generated using the region growing order and adjacent relationships between roof surfaces and wall surfaces. Only roofs with an equal hierarchy need further processing in step three.

Data sets extracted in step one are roof surface triangles which are connected to one another via the triangles' adjacencies. And the coarse roof contour boundaries can be further extracted from the adjacent relationship of triangles. The regularization of coarse roof contour boundaries in step two is carried out using existing algorithm based on the restriction of dominant orientation. After that, the consistency processing of adjacent contours boundaries in horizontal projection plane are classified into three forms with the building structure hierarchy information and dominant orientation of each roof, through rotating or translating the outlines or inflexion points of the roof boundaries as shown in Fig. 2, the roof boundary regularization error can be obviously reduced.

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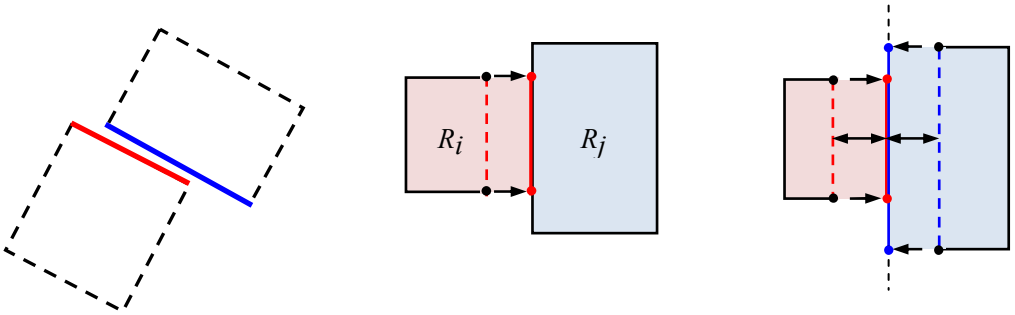
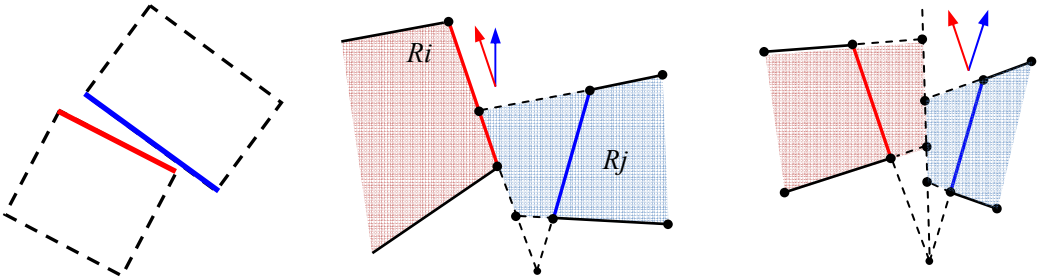


(a)-1 Adjacent form 1 (a)-2 $H_{Ri} > 1.5 \times H_{Rj}$ (a)-3 $H_{Ri} \approx H_{Rj}$

(a) Parallel contour boundaries

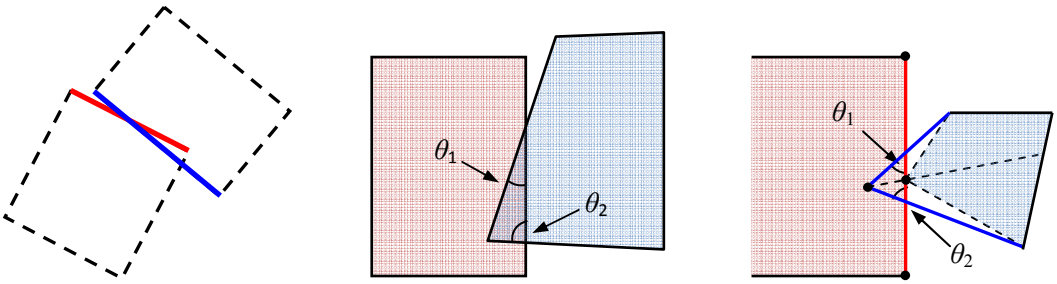


(b)-1 Adjacent form 2

(b)-2 Only one roof direction is consistent with its dominant direction

(b)-3 All roof directions are consistent or inconsistent with their dominant direction

(b) Nonparallel and disjoint contour boundaries



(c)-1 Adjacent form 3

(c) -2 At least one angle is less than 45°

(c) -3 All angles are greater than 45°

(c) Intersecting contour boundaries

Fig. 2 Schematic diagram of consistency processing of adjacent roofs contours boundaries

Experiments showed that the proposed method can automatically reconstruct the building 3D contour Model with high correctness and completeness, especially for the irregular and complex multi-layer structure, and the mean error (≈0.46m) and root mean square error (≈0.52m) of building contour model are all less than the average spacing (d≈0.68m) of LiDAR points, and the maximum displacement of contour inflection point (≈1.18m) is less than two times of d. The reconstructed building 3D contour model is shown in Fig. 3.

Fig. 3 Reconstructed Building 3D contour model