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POINT CLOUD MODELING USING ALGEBRAIC TEMPLATE

Jyun-Yuan Chen, Hung-Jui Lai and Chao-Hung Lin

Department of Geomatics
National Cheng-Kung University
No. 1, University Road, Tainan 701, Taiwan
linhung@mail.ncku.edu.tw

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Abstract. *Point cloud reconstruction is a fundamental and important research topic with many applications in the fields of geomatics and computer graphics. In this paper, a novel approach for reconstructing point clouds by a hierarchical template model is presented. The template model is composed of three types of primitive geometric shape in a hierarchical manner. Compared to previous approaches which are based on an iterative fitting process, the primitive shapes are represented in algebraic form and fit to a point cloud by solving a least-square linear system. This non-iterative process makes the proposed approach feasible and robust for modeling huge amounts of point data. Furthermore, some geometric constraints are integrated into the least-square fitting system to retain the geometric relations between the primitive shapes in the template model, which can improve modeling quality. The experiment results for various point clouds show that the proposed approach is capable of handling point clouds with both noise and sharp features.*

Keywords: Point cloud reconstruction, Least-square fitting, Light detection and ranging (LiDAR)

1. **Introduction.** Digital scanning devices such as light detection and ranging (LiDAR) have recently become affordable. They are capable of acquiring high-accuracy and high-resolution point clouds. Point cloud modeling has thus received increasing attention and has become an important and popular research topic, with applications such as 3D geographic information systems (GIS) and urban modeling and planning [1-3]. Approaches for reconstructing polygonal surfaces from point clouds face a common problem of how to deal with the inherent noise in the point cloud. Besides, it will be a challenge to reconstruct point clouds that contain sharp features (for example, a point cloud sampled from buildings) since noise and sharp features were ambiguous mentioned by Fleishman et al. [4]. Most point cloud reconstruction techniques are based on either constructing an implicit surface [4-6] or growing a surface [7,8]. These approaches perform well only for noise-free point clouds, making them unsuitable for handling data acquired by LiDAR, which always contains a lot of noise (see Figures 1 and 7). Thus, surface reconstruction from point clouds with inherent noise and sharp features is a challenging problem.

In this paper, the goal is to reconstruct point clouds sampled from buildings by a terrestrial or airborne LiDAR (see Figure 7). The main idea is to fit a hierarchical algebraic template to a point cloud using least-square fitting. The proposed approach can hand point clouds with both noise and sharp features, and the non-trivial processes of noise removal and sharp feature detection are avoided. In the fitting process, by representing the template model in algebraic form, we solve a least-square linear system instead of a nonlinear one, which makes the approach efficient (a non-iterative process) and stable (do not need to specify initial values) for point cloud modeling. The template model is composed of three types of primitive geometric shape, that is, plane, sphere and cylinder,