Interactive 3D Modeling based on Point-Clouds with Reflectance Image

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1. Introduction

Mid-range and long-range laser scanners can capture dense point-clouds of indoor and outdoor environment. However, such point-clouds are measured only from a few sides and large portions of the data are missing. In this paper, we propose a method for generating 3D models from incomplete point-clouds by applying image-based modeling techniques, since recent laser scanners can output the reflectance value at each point as well as coordinates.

2. Overview

Fig.1 shows our modeling approach. In the case of mid/ long-range scanners, the direction of a laser beam can be represented using an azimuth angle θ and an elevation angle ϕ. Therefore, the coordinates of points can be mapped on the θ-ϕ plane by Mercator projection. Since shapes are unnaturally distorted in Mercator images, we generate perspective images from the Mercator image by selecting a region of interest. When the users create 3D models, they interact with perspective images interrelated with point-clouds.

3. Modeling Method

3.1. Smoothing of Point-Clouds

Since mid/long-range scanners cannot avoid so-called mixed pixels, which received reflected energy from two different surfaces. Mixed pixels result in outliers. We apply a smoothing method similar to MLS projection. However, we robustly estimate based on Tukey's bi-weight instead of the least-squares method, because the original MLS projection is sensitive to outliers.

3.2. Coordinate Systems

The perspective image is suitable for users' interaction, because straight lines are always mapped to straight lines. However, the perspective image is valid only within about 40 degree, while the Mercator image can represent all points on a sphere. Therefore, the user specifies the region of interest in the Mercator image for defining a modeling range.

3.3. Structured Point-Clouds

Fig.1 (d) shows three coordinate systems, which are interrelated each other. We introduce structured point-cloud for quickly searching point data that can be related to user's drawing.

To deal with huge number of points, the Mercator image is divided into a rectangle grid so that each cell contains less than 100 points. Point data are loaded into memory from each cell when necessary. In addition, we calculate adjacency relationships among points by locally applying Delaunay triangulation on the Mercator image and maintain neighbor points for each point. Adjacency relationships are used for region growing, which detects base surfaces.

3.4. Modeling of Primitive Shapes

In our system, the user first defines a base surface by selecting a seed region, as shown in Fig. 2(a). Then the system detects points in the region by searching the structured point-cloud, and calculates the initial surface equation. To calculate the equation as precisely as possible, we apply the region growing method, which extends the boundary of the region by checking if neighbor points satisfy the surface equation. In the current implementation, base surfaces include plains, cylinders, cones and spheres.

After the user defines the base surface, he/she draws a polyline on the perspective images (Fig.1(b)). Each line is projected on the base surface, as shown in Fig. 1(d), and swept to the perpendicular direction (Fig.1(c)). Finally, 3D models are generated. Other types of surfaces, such as cylinders, can be also modeled by interactively sweeping the top and bottom surfaces.

4. Example

Fig.3 shows examples of 3D models of a famous mosque.

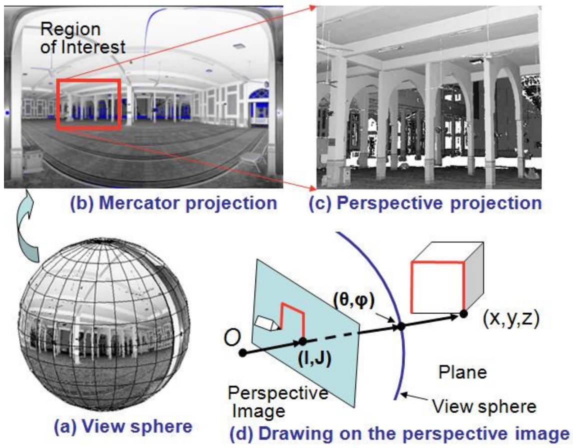
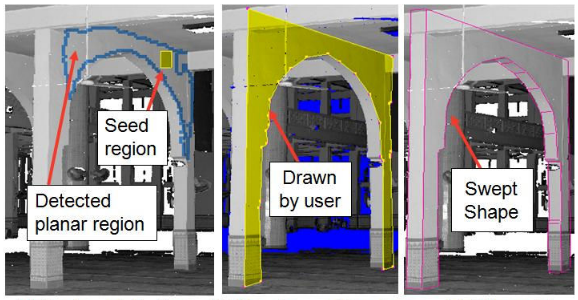
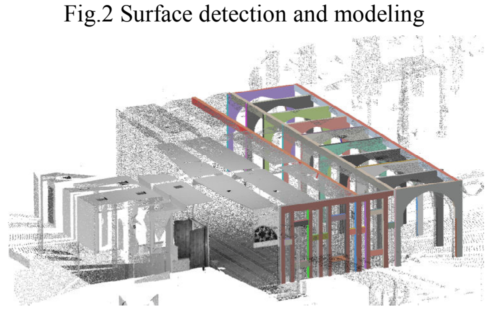


Fig.1 Coordinate systems

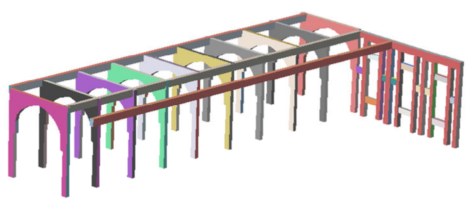


(a) Surface detection (b) Drawing on the plane (c) 3D model

Fig.2 Surface detection and modeling



(a) Point-clouds and 3D solid model



(b) 3D solid model only

Fig.3 3D solid modeling from point-clouds of a mosque