

Depth-layer Architecture Reconstruction From Image Collections

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Abstract

An image-based modeling method is presented to generate a textured 3D model of architecture with a structure of multiple floors and depth layers. In the domain of image-based architecture modeling, it is still a challenging problem to deal with architecture in multilayered structure. We propose a statistic-based top-bottom segmentation algorithm to divide the 3D point cloud generated by structure-from-motion (SFM) method into different floors. For each floor with depth layers, we present a repetition based depth-layer decomposition algorithm to separate the front and back layers. Finally, architecture components are modeled to construct a textured 3D model. Our system has the distinct advantage of producing realistic architecture models with true depth values between front and back layers, which is demonstrated by multiple examples in the paper.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Image-based Modeling—architecture modeling; 3D point data segmentation; image decomposition

1. Introduction

Realistic and flexible 3D architecture models are very important for many applications including culture heritage protection, games, movies and augmented reality navigation etc. Depth images from 3D scanners or color images from digital cameras are the two most popular data sources to model the architecture. Obviously, digital cameras are more common and inexpensive, and also provide rich color texture information which is very important for realistic modeling. Therefore, we focus our work on the problem of image based architecture modeling. Many works have been proposed for this problem, e.g. [SSS*08], [JTC09], [XFT*08]. However, both of them can not deal with architecture with front and back depth layers and get the accurate depth value between these layers automatically. Front-back depth layers are very common in architecture, many buildings own a front layer with pillars, such as ancient Greek architecture and this style also exist popularly in modern architecture. This property is particularly worthy of being modeled. We handle this problem only with digital images especially for decomposing layers with irregular boundaries as one of our contributions.

Given image collections of one building, our goal is to generate a visually compelling 3D model, in which accurate architecture components segmentation is critical. Although high resolution texture information can be acquired from images, but it is hard to segment the components in the image space solely. A common case is that different components which are occluded by each other may have the same material. 3D point cloud can be generated from multiple images by structure-from-motion (SFM) method, but these 3D points are too sparse to be segmented into architecture components directly. The complementary characteristics of these two data sources are combined to handle more complex architecture modeling problems in this paper. We first propose a statistic-based top-bottom segmentation algorithm and divide the sparse 3D point cloud to several horizontal floors vertically along the ground plane normal. For each horizontal floor with depth layers, we propose a repetition based depth-layer decomposition algorithm and divide the sparse 3D points and images in one floor to several repetitive components. The key observation of our depth-layer decomposition algorithm is the parallax-shift (as in Figure 1 (a)) among repetitive structures in a single image or images from different views. Finally, textured architecture component models are reconstructed by the segmented sparse 3D points and texture parts to make up the complete 3D architecture model.

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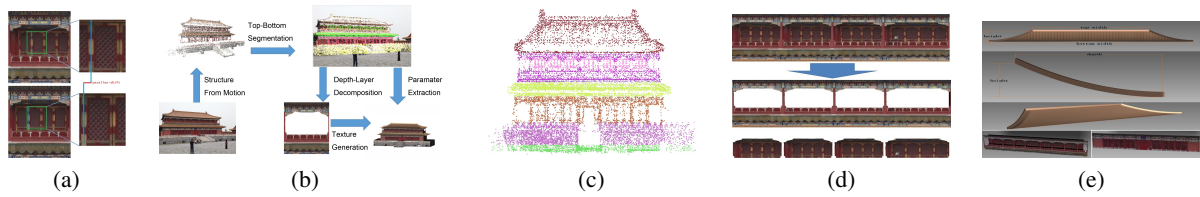


Figure 1: (a) Parallax-shift. (b) Pipeline. (c) Top-bottom segmentation. (d) Front-back decomposition. (e) Textured components

2. Reconstruction Algorithm

The pipeline of our architecture modeling method is shown in Figure 1 (b) and composed of four major stages.

1) 3D point cloud from SFM From the captured images, a sparse 3D point cloud is reconstructed by SFM method, then outliers removing and normals estimation are performed and the results are used as our input for the following segmentation.

2) Top-bottom floors segmentation Manhattan directions are first estimated from the normals of the 3D points. Along the direction which is parallel to the normal of the ground plane, the 3D points are partitioned vertically to different horizontal floors. For some horizontal floors, 3D points are further partitioned to different layers according to their depth values as in Figure 1 (c).

3) Depth-layer decomposition For the candidate decomposition floor, 3D points in different layers are projected back to images and help us to detect the horizontal repetition at different layers respectively in the image space. Then, for each repetitive region, per-pixel parallax-shift values are estimated using SIFT-flow method, and the region is further decomposed into front and back layers by solving a per-pixel label-assignment optimization problem. The result is shown in Figure 1 (d).

4) Architecture components modeling Parameters are extracted from the corresponding 3D points clusters and their projection images to generate the geometry of the architecture components. Then the components' textures are repaired from the multi-view segmented images, and a textured 3D architecture model is reconstructed finally. The 3D textured architecture components' models are shown in as Figure 1 (e).

3. Results

We demonstrate the results of our approach with three data sets: the HongYi Ge (Figure 2 top row), the Chairman Mao Memorial Hall (Figure 2 center row) and the Hall of Central Harmony (Figure 2 bottom row). The reconstruction result of the Hall of Central Harmony proves that our depth-layer decomposition algorithm can also be applied to non-repetitive architecture.

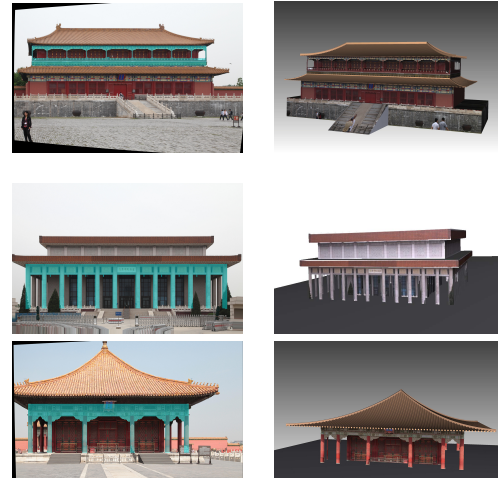


Figure 2: Reconstruction results.

4. Acknowledgements

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