3D modeling for as-built buildings

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Abstract. This paper introduces a low-cost and efficient approach to generate 3D models for as-built buildings. Image-based modeling as a passive is an alternative of 3D model generation without a threat of destructive impact to the modeled object. This paper demonstrates the applicability of image-based modeling for as-built buildings in the main campus of National Chung Hsing University. The 3D model of campus was established by image-based modeling technology due to its low cost, time-efficiency, convenience, and low requirement. A consumer camera (Canon PowerShot S100) mounted on a UAV and held in hands was used to capture aerial photographs and side shots. The 3D printed product of NCHU campus as a gypsum statue was generated through a 3D printer, color CometrueJet T52, for demonstration.

Introduction

Traditionally, 3D building models are generated manually by computer aided design (CAD), such as AutoCAD and Sketchup. Currently, various techniques are available for 3D (three dimensional) modeling as-built buildings, such as total station surveying, aerial photogrammetry, Lidar scanning, and image-based modeling [1]. Ground surveying, photogrammetry, and scanning all collect 3D digital data of a real scene to present its relief and appearance through special hardware and software. Comparatively, these approaches are expensive, experience-dependent, time-consuming, and equipment-limited. Recently, image-based modeling becomes more popular due to its low cost, time-efficiency, convenience, and low requirement [2] [3]. Based on computer vision, image-based modeling has been developed for 3D model reconstruction and can be broadly applied in various fields through the generation of 3D point cloud [4] [5]. These 3D digital models can be displayed on computers or mobile devices, be transported through internet, and be transformed into value-added products. This study aims at reconstructing 3D models through image-based by using digital images taken by mobile devices.

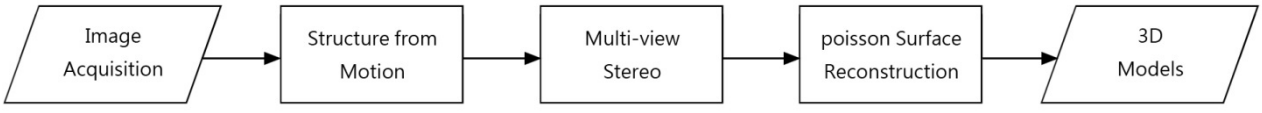

Fig. 1 The process of image-based modeling

Methodology

3D modeling is a digital process of establishing a mathematical representation of objects with 3D surface via vizualized computing processes. As a passive method, image-based modeling includes three major approaches, which are depth-map-based approaches, volume-based approaches, and surface-based approaches. One of the major surface-based approaches to obtain a 3D structure in the state of motion is Structure from Motion (SfM). Image-based modeling employs SIFT (Scale-Invariant Feature Transform) to extract feature points, and adopts SFM for camera self-calibration through, generates dense 3D point cloud through MVS (Multi-View Stereo), including Clustering Views for Multi-view Stereo (CMVS) and Patch-based Multi-View Stereo (PMVS), and links cloud points through Poisson surface reconstruction (PSR), and finally establishes a 3D model by overlaying texture onto polygonal meshes [5]. The process of image-based modeling is shown in Fig. 1, and more detailed description can be viewed in Yang et al., 2013 [5]. In image-based 3D modeling, image quality is one of major factors affecting image interpretation and analysis [6].

Experiment and Results

This paper demonstrates the applicability of image-based modeling for as-built buildings in the campus of National Chung Hsing University (NCHU). A consumer camera (Canon PowerShot S100) mounted on a UAV was used to capture aerial photographs, and a consumer camera held in hands was used to capture side shots. The specification of Canon PowerShot S100 is a maximum resolution with 4000*3000 (12.1 mega) pixels and an equivalent focal length 24~120 mm. A total of 140 photographs with high resolution were obtained to establish the mosaic image of NCHU campus, in which the raw photographs, dense point cloud, and polygon are presented Fig. 2. Through image-based modeling, the 3D color point cloud and 3D model of NCHU campus is shown in Fig. 3.

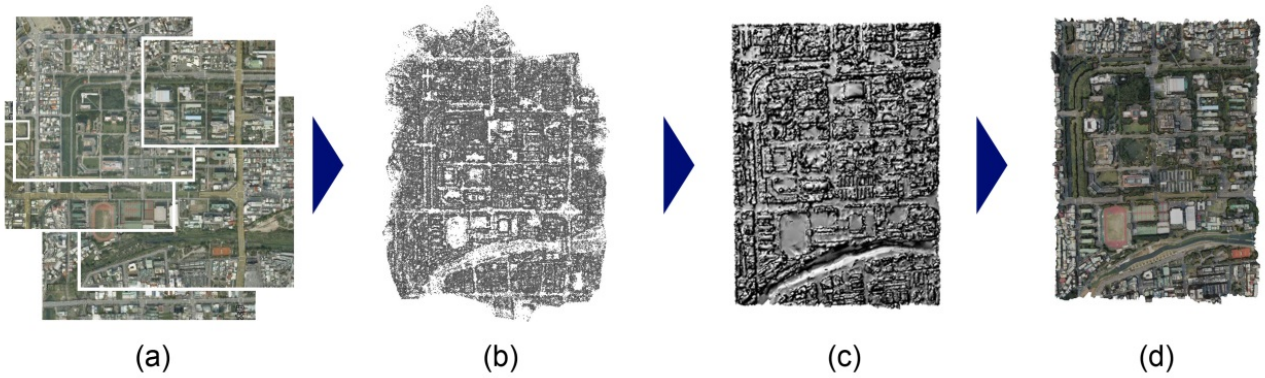

Fig. 2 3D image-based modeling of NCHU campus in (a) photographs, (b) raw point cloud, (c) raw model, and (d) color reconstructed model.

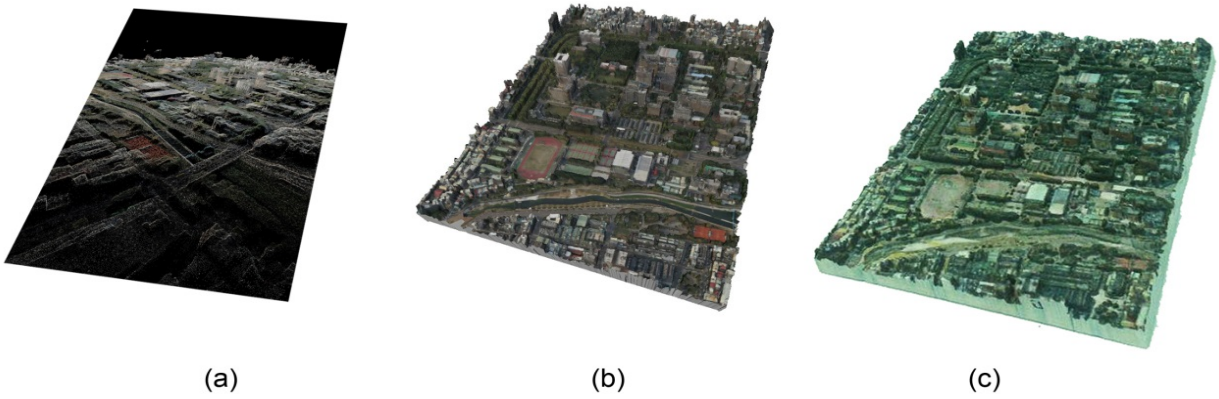

Fig. 3 3D color representation of NCHU campus in (a) point cloud model, (b) digital model, and (c) printed color statue

A gypsum model of NCHU campus was made by a 3D printer based on a digital 3D model generated through the low-cost active approach for demonstration. A valid 3D model must possess a geometric shape and enclose the interior body with boundary surfaces. By slicing the 3D model into many 2D layers, a layer-to-layer physical building process can be executed with a 3D printer. In this experiment, the 3D model was printed in layer thickness of 60~120 μ m and X-Y resolution of 600x500dpi by CometrueJet T52, which is allowed to print an object with a maximum size of 203mmx203mmx254mm. During 3D printing process, support materials were used to support overhanging features during layer-by-layer overlapping, and subsequently were removed or dissolved before printing complement. The 3D printed product of NCHU campus as a statue is shown in Fig. 3. The 3D model can be furthermore professionally customized to add extra value for advance applications.

Summary

This paper demonstrates the applicability of image-based modeling for as-built buildings in the main campus of National Chung Hsing University. The 3D scene model of campus was established by image-based modeling technology due to its low cost, time-efficiency, convenience, and low requirement. A consumer camera (Canon PowerShot S100) mounted on a UAV and held in hands was used to capture aerial photographs and side shots. The 3D printed product of NCHU campus as a gypsum statue was generated through a 3D printer, color CometrueJet T52. In the future, image-based modeling for 3D scene reconstruction could be getting prosperous because of the popularity of mobile devices equipped with a high resolution digital imager. More importantly, 3D models can be used for object and scene visualization in a broad variety of fields, such as science and engineering disciplines, architecture industry, video game industry, filming industry, and education. Furthermore, the integration of 3D modeling and 3D printing enables end-users to own the ability of customization and self-manufacturing [7].

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