User Driven 3D Reconstruction Environment

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Abstract. An intuitive image-based 3D reconstruction tool based on inaccurate user strokes is presented in this paper. The combination of fast image segmentation method together with user knowledge about reconstructed scene forms a novel low-polygonal editor suitable for architecture reconstruction. The user interaction is minimized thanks to propagation of strokes among input photographs. The final model geometry is created by innovative algorithm. The input to the tool is a set of calibrated photographs together with a sparse pointcloud. The output is a structured low-poly 3D model.

1 Introduction

Inspired by well known 3D editors for low-polygonal image-based modelling (like ImageModeler, PhotoModeler) we propose a novel editor reducing amount of user interaction. We present a combination of state-of-the-art techniques and intuitive interaction methods for geometry construction. Our approach opens new ways for 3D reconstruction focused on low-poly output which is well suited for internet presentation. The user interaction brings also advantages for 3D reconstruction in low-textured or occluded areas where automatic methods often fail. This reconstruction tool is suitable for architecture reconstruction or other

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Fig. 1. Program workflow overview
areas where planar structures dominate. Calibrated photos (known camera positions) and sparse pointcloud (reconstructed during camera calibration phase) constitute the input of the method. We have successfully used both Bundler [1] and APERO [2] project as suitable calibration engines.

The core of our approach is geometry primitives fitting based on source photo segmentation, see Fig. 1. The structure of the paper corresponds to individual algorithm steps. The graph-cut image segmentation is driven by inaccurate user strokes (Section 3). The image segmentation is then used for labelling of sparse pointcloud points and is also propagated to close photographs (Section 4). Various geometry primitives are then fitted on labelled points (Section 5). Thanks to user-defined relations between adjacent geometrical structures (Section 6), final polygonal geometry is computed (Section 7).

2 Related Work

The image-based 3D modeling is studied over last 15 years. Several systems were developed over this time, and all of them have common properties. The user works with a set of photographs and selects interesting parts of objects for the reconstruction.

One of the first work was Facade by Debevec et al. [3] which later gave rise to a commercial product called Canoma. The system provided several 3D primitives like prisms, cuboids and pyramids. The user placed the primitives into photographs and improved positions of the primitives in other views. Since the scene was continuously calibrated by user added objects, the system tended to be unstable. Later, other commercial products were inspired by Canoma software, like PhotoModeler by Eos Systems, ImageModeler by RealViz (now Autodesk) and the PhotoMatch component of Google SketchUP. The calibration of input photographs was shifted to user in those systems.

Other systems estimate the camera calibration using automatic methods based on SFM. Some programs have developed their own calibration core (VideoTrace by van den Hengel et al. [4], system for architectural modelling by Sinha et al. [5]). Other works benefit from external SFM calibration tools (like MatchMover by RealViz, Boujou by 2d3 or Bundler) and suppose calibrated scene as input (Habbecke et al. [6], Paczkowski et al. [7]).

Other works try to get as much information from one photo as possible [8–10]. The one photo calibration is based on finding vanishing points constraints and on the fact that all architectural buildings have parallel lines and the building blocks are build in Manhattan layout [11]. Vanishing points are used even in modelling from more photographs like Sinha et al. [5], Cipolla et al. [12] and Wilczkowiak et al. [13].

Sinha et al. [5] shows that the combination of unordered photo set, detected vanishing points and vanish lines and auto-calibration using SFM leads to user friendly free-polygonal modelling. The user draws lines to the image. The lines are snapped to the direction of vanishing lines and then the lines are extruded to the face in the direction of plane perpendicular to the line in user selected