

Chapter 2

Multi-View Stereo Reconstruction Technique

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ABSTRACT

3D modeling of complex objects is an important task of computer graphics and poses substantial difficulties to traditional synthetic modeling approaches. The multi-view stereo reconstruction technique, which tries to automatically acquire object models from multiple photographs, provides an attractive alternative. The whole reconstruction process of the multi-view stereo technique is introduced in this chapter, from camera calibration and image acquisition to various reconstruction algorithms. The shape from silhouette technique is also introduced since it provides a close shape approximation for many multi-view stereo algorithms. Various multi-view algorithms have been proposed, which can be mainly classified into four classes: 3D volumetric, surface evolution, feature extraction and expansion, and depth map based approaches. This chapter explains the underlying theory and pipeline of each class in detail and analyzes their major properties. Two published benchmarks that are used to qualitatively evaluate multi-view stereo algorithms are presented, along with the benchmark criteria and evaluation results.

INTRODUCTION

High quality 3D models have large and wide applications in computer graphics, virtual reality, robotics, and medical imaging, etc. Although many of the 3D models can be created by a

graphic designer using specialized tools (e.g., 3D Max Studio, Maya, Rihno), the entire process to obtain a good quality model is time consuming and tedious. Moreover, the result is usually only an approximation or simplification. At this place, 3D modeling technique provides an alternative and has already demonstrated their potential in several application fields.

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In general, 3D modeling technique can be classified into two different groups: active and passive methods. The active methods try to acquire precise 3D data by laser range scanners or coded structured light projecting systems which project special light patterns onto the surface of a real object to measure the depth to the surface by a simple triangulation technique. Although such 3D data acquisition systems can be very precise, most of them are very expensive and require special skills. Compared to active scanners, passive methods work in an ordinary environment with simple devices and flexibilities, and provide feasible and comfortable means to extract 3D information from a set of calibrated pictures. According to the information contained in images which is used to extract 3D shape information, passive methods can be categorized into four classes: shape from silhouette, shape from stereo, shape from shading (Zhang, 1999), and shape from texture (Forsyth, 2001; Lobay, 2006). This chapter will mainly focus on shape from stereo technique that tries to reconstruct object models from multiple calibrated images by stereo matching. Shape from silhouette technique is also introduced since it outputs a good shape estimate which is required by many shape from stereo algorithms.

In order to generate 3D model of a real object, digital cameras are used to capture multi-view images of the object which are obtained by changing the viewing directions to the object. Once the camera has been calibrated, a number of images are acquired at different viewpoints in order to capture the complete geometry of the target object. In many cases, the acquired images need to be processed before surface reconstruction. Finally, these calibrated images are provided as input to various multi-view stereo algorithms which seek to reconstruct a complete model from multiple images using information contained in the object texture. The major advantage of this technique is that it can output high quality surface models and offer high flexibility of the required experimental setup.

This chapter is structured as follows. Next section gives a brief introduction to camera calibration followed by the section that discusses several issues about how the original pictures should be taken and processed. Then, shape from silhouette concept and approaches are explained in detail, along with a discussion of its applications. After that, a section mainly focuses on the classification of shape from stereo approaches and introduces the pipeline, theory and characteristics of each class. Final section presents two published benchmarks for evaluating various multi-view stereo algorithms.

CAMERA CALIBRATION

Camera calibration is the process of finding the true parameters of the camera that produced a given photograph or video. Camera calibration is the crucial step in obtaining an accurate model of a target object. The calibration approaches can be categorized into two groups: full-calibration and self-calibration. Full-calibration approaches (Yemeza, 2004; Park, 2005) assume that a calibration pattern with precisely known geometry is presented in all input images, and computes the camera parameters consistent with a set of correspondences between the features defining the chart and their observed image projections. While the self-calibration approaches (Hernandez, 2004; Eisert, 2000; Fitzgibbon, 1998) are proposed to reduce the necessary prior knowledge about the scene camera geometry only to a few internal and external constraints. In these approaches, the intrinsic camera parameters are often supposed to be known a priori. However, since they require complex optimization techniques which are slow and difficult to converge, their accuracy is not comparable to that of the fully-calibrated systems. In practice, many applications such as 3D digitization of cultural heritage prefer to fully-calibrated systems since maximum accuracy is a very crucial requirement while self-calibration approaches

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