Shape Representations for Image-based Applications

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Abstract

The mathematical representation of shape and appearance is a key issue in image-based applications. While the primary aim of 3D reconstruction is to reconstruct a geometrically accurate surface, real-time view synthesis requires efficient algorithms for computing plausible but not necessarily physically accurate images. These different objectives impose specific requirements with respect to the underlying shape representations. In this thesis three central problems from the spectrum of image-based techniques are investigated. We developed novel methods of representations and algorithms which on the one hand lead to substantial improvements of existing approaches and on the other hand offer a unified solution to problems that have previously been considered separately.

The first part of this thesis deals with creating animated character models from a set of input images. We propose a deformable, template-based shape representation which enables us to develop new solutions for problems such as camera estimation, shape deformation and tracking, and character reconstruction. We will present a variety of character animations created from single images to full body reconstructions and animations from video.

The second part of this thesis focuses on the difficulty of rendering novel views of general, static scenes instead of dynamic characters. Here, the key component is a generic, particle-based geometry representation which supports an accurate handling of object silhouettes and pixel-accurate rendering of arbitrary scenes. Every step of the process is completely implemented on the GPU in order to allow real-time, unconstrained user navigation through a photorealistic virtual reproduction of the original scene.

Finally, the third part concentrates on accurate 3D surface reconstruction. We will present a new volumetric solution to the problems of multi-view stereo and point cloud reconstruction which allows computing 3D models with a high accuracy as well as being robust to input degeneracies. Additionally, it is shown that the choice of input images is an important factor for optimizing the quality as well as the performance of image-based reconstruction techniques.

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