Interactive Image-Based Modeling and Walkthrough Planning

by

Subhajit Sanyal
Department of Computer Science and Engineering

Submitted
in fulfillment of the requirements of the degree of
Doctor of Philosophy

to the

Indian Institute of Technology Delhi
January 2006

Certificate

This is to certify that the thesis titled " Interactive Image-Based Modeling and Walk-through Planning" being submitted by Subhajit Sanyal to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy, is a record of bona-fide research work carried out by him under our supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

Subhashis Banerjee
Department of Computer Science and Engineering
Indian Institute of Technology Delhi
New Delhi 110 016

Prem K. Kalra
Department of Computer Science and Engineering
Indian Institute of Technology Delhi
New Delhi 110 016

To my family
for their unwavering love and support

Acknowledgments

I take this opportunity to thank all those who helped me in my Ph.D project. First and foremost, I would like to express my gratitude to my supervisors Dr. Subhashis Banerjee and Dr. Prem Kalra for their untiring help and guidance. Our interaction, right from the very first day, was more as friends. They gave me the complete freedom to explore whatever caught my fancy.

I would also like to specially thank Parag, Anup, Basant, Rohit, Ajay Agarwal, Jamshid, Uma, Vaishali, and Ayesha for those wonderful time we spent in the Visualization Lab. I learnt a lot from them and they always helped me in every possible way.

Throughout my years of study I have been greatly helped by several of my undergraduate friends at our institute. It was wonderful interacting with them and learning a lot in the process. I would like to specially mention the help and insights provided by Akash, Mayank, Adarsh, Saurabh and Aneesh. Also, I would like to thank Mohit, Kanishka, Gaurav and Sriram for their help in implementing the Humayun project.

I would like to thank Mr. K. Kaushik of our Vision and Graphics Lab who would go to any extent to help anybody in our lab.

I am greatly indebted to my mother and my father for their unconditional love and support in everything I did. Last but not the least I would like to thank my wife Pritha, who has been extremely patient and understanding throughout my years of research work.

Subhajit Sanyal

January 2006 Subhajit Sanyal

Abstract

In this thesis we present image-based techniques to model and render real objects and scenes. In the first part of the thesis we present techniques for recovering 3D information from images and in the second part we address issues related to designing high quality walkthroughs. Our techniques are semi-automatic and meaningful inputs from the user are sought to obtain the solutions to the problems we address.

Our work on recovering 3D geometry from images addresses reconstruction of both structured scenes and free-form surfaces. For structured surfaces we present an interactive reconstruction framework based on a single view of an object. The framework enables setting up of a world coordinate system and complete recovery of the imaging parameters (camera intrinsics and extrinsics) based on simple, interactively specified constraints. We incorporate robust methods for recovering the geometry of arbitrarily oriented planar surfaces and surfaces of revolution. Our scheme allows inter-registration of reconstructed geometry from multiple views to ensure completeness of the model or to enhance the recovered structure.

We use the shading information in images for modeling free-form surfaces. Our shape from shading (SFS) approach handles different shading and illumination models in a unified manner. In contrast to most existing methods we allow for presence of specularities and shadows in the images. We use a game-theoretic optimization scheme to solve for the shape of the object. User interaction, in terms of providing an initial seed to the solution and occasional correction in the solution evolution phase, helps us to avoid the problems of local minima which is a severe delimiting feature of most existing schemes. Our results obtained with real images illustrate the efficacy of our

scheme.

The first part of the thesis describes object centric, image-based 3D reconstruction schemes. In the second part we give a framework for designing high quality walkthroughs. Our framework aids the content creator in designing tours where one sees interesting objects for the most part of the tour. Further, the speed of the tour is controlled by what is shown. In walkthroughs of a photo-textured scenario, the quality of rendering is directly influenced by the quality of the acquired images. We present a simple tool to plan acquisition of images such that they meet a certain quality threshold.

Contents