



**University
of Victoria**

Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

LI JI

BEng (Shanghai Jiaotong University, 2008)

“Image Composition in Computer Rendering”

Department of Computer Science

Tuesday, September 13, 2016

10:00 A.M.

Engineering and Computer Science Building
Room 468

Supervisory Committee:

Dr. Brian Wyvill, Department of Computer Science, University of Victoria (Co-Supervisor)

Dr. Amy Gooch, Department of Computer Science, UVic (Co-Supervisor)

Dr. Lynda Gammon, Department of Visual Arts, UVic (Outside Member)

External Examiner:

Dr. Ergun Akleman, Department of Visualization, Texas A&M University

Chair of Oral Examination:

Dr. Francis Lau, School of Health and Information Science, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

In this research, we study image composition in the context of computer rendering, investigate why composition is difficult with conventional rendering methods, and propose our solutions. Image composition is a process in which an artist improves a visual image to achieve certain aesthetic goals, and it is a central topic in studies of visual arts. Approaching the compositional quality of hand-made art work with computer rendering is a challenging task; but there are scarcely any in-depth research on this task from an interdisciplinary viewpoint between computer graphics and visual arts. Although recent developments of computer rendering have enabled the synthesis of high quality photographic images, most rendering methods only simulate a photographic process and do not permit straightforward compositional editing in the image space. In order to improve the visual quality of the digitally synthesized images, the knowledge of visual composition needs to be incorporated. This objective not only asks for novel algorithmic inventions but also involves research in visual perception, painting, photography and other disciplines of visual arts.

With examples from historical painting and contemporary photography, we inquire why and how a well-composed image elicits an aesthetic visual response from its viewer. Our analysis based on visual perception shows that the composition of an image serves as a guideline for the viewing process of that image; the composition of an image conveys an artist's intention of how the depicted scene should be viewed, and directs a viewer's eyes. A key observation is that for a composition to take effect, a viewer must be allowed to attentively look at the image for a period of time. From this analysis, we outline a few rules for composing light and shade in computer rendering, which serve as guidelines for designing rendering methods that create imagery beyond photorealistic depictions. Our original analysis elucidates the mechanism and function of image composition in the context of rendering, and offers clearly defined directions for algorithmic design. Theories about composition mostly remain in the literature of art critique and art history, while there are hardly any investigations on this topic in a technical context. Our novel analysis is an instructive contribution for enhancing the aesthetic quality of digitally synthesized images.

We present two research projects that develop our analysis into rendering programs. We first show an interpolative material model, in which the surface shading is interpolated from input textures with a brightness value. The resultant rendering depicts surface brightness instead of light energy in the depicted scene. We also show a painting interface with this material model, with which an artist can directly compose surface brightness with a digital pen. In the second project, we ask an artist to provide a sketch of lighting design with coarse paint strokes on top of a rendering, while details of the light and shade in the depicted scene are automatically filled in by our program. This research project is staged in the context of creating the visual effects of foliage shadows under sunshine. Our software tool also includes a novel method for generating coherent animations that resemble the movements of tree foliage in a gentle breeze. These programming projects validate the rendering methodology proposed by our theoretical analysis, and demonstrate the feasibility of incorporating compositional techniques in computer rendering.

In addition to programming projects, this interdisciplinary research also consists of practices in visual arts. We present two art projects of digital photography and projection installation, which we built based on our theoretical analysis of composition and our software tools from the programming projects. Through these art projects, we evaluate our methodology by both making art ourselves and critiquing the resultant pieces with peer artists. From our point of view, it is important to be involved in art practices for rendering researchers, especially those who deal with aesthetic issues. The valuable first-hand experiences and the communications with artists in a visual arts context are rarely reported in the rendering literature. These experiences serve as effective guidances for the future development of our research on computer rendering. The long term goal of our research is find a balance between artistic expression and realistic believability, based on the interdisciplinary knowledge of composition and perception, and implemented as either automated or user-assisted rendering tools. This goal may be termed as to achieve a staged realism, to synthesize images that are recognizable as depictions of realistic scenes, at the same time enabling the freedom of composing the rendering results in an artistic manner.