Research Statement

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I am interested in the design, implementation, and analysis of computer algorithms for creating visual information. I am also involved in interdisciplinary research projects aimed at evaluating the communication content of computer generated imagery.

In conducting research I have recognized the importance of four fundamental skills. Implementation skills are useful for developing and demonstrating the practical utility of image generation systems. Analytical and experimental skills are necessary to assess a system's performance. Interdisciplinary collaboration provides new perspectives that can lead to unanticipated discoveries. Research combining these skills is the most satisfying and the most effective for achieving my goal of enhancing the communication content of computer generated imagery.

Interests

I am investigating the area of abstract rendering in the field of computer graphics. A photorealistic computer graphics image is created by simulating the physics of light in mathematically modeled scene. The goal is to create images that are indistinguishable from photographs of the real world. In contrast, abstract rendering is used to create images, animations and interactive applications whose visual style is tailored to the communication goal of the imagery.

In many applications abstract imagery has an advantage over photographs. Visual abstraction can aid in communication by: focusing a viewers attention on relevant features; omitting extraneous detail; clarifying, simplifying, and disambiguating shape. Stylization is often used to evoke the perception of complexity in an image without explicit representation. The control of detail in an image for the purpose of enhancing communication is becoming the hallmark of abstract rendering.

Photorealistic rendering contains an inherent mission statement, "Create images that are indistinguishable from photographs." This mission statement gives photorealistic rendering a visual Turing Test and a successful image metric. The ability to quantitatively compare images is most likely responsible for the early adoption and subsequent interest in photorealistic rendering by the computer graphics community. Measuring the communication content of an image can be done only in an indirect way by observing the results of task performance based on visual stimulus. The ability to evaluate the effectiveness of an abstract imagery could prove to be a useful metric. In order to test this hypothesis I am currently leading an interdisciplinary research team who are investigating the effectiveness of abstract imagery using perceptual experiments.

Goals

The long term goal of my research is to examine, analyze and synthesize mechanisms for effective image production. Vision is the high bandwidth channel to the mind, and seeing is one of our most highly developed skills. My research aims to unravel the mental processes which occur in the cognitive gap between observation and comprehension. I will then leverage this knowledge to build tools for creating more effective images. In particular, I am working on the following issues.

Image Reproducibility – Fully shaded three dimensional computer models may not render well in a technical journal printed in black and white, or on a low resolution screen such as a PDA. The *Interactive Technical Illustration* [1, 2], and *Human Facial Illustration* [3] project teams that I lead created images which reproduce and communicate well on paper and at low resolution.

Volume Visualization – Abstract rendering algorithms can be used to intensify the impact of interactive visualizations of volume data. I am currently working on two visualization projects: representing the computational error in a volumetric data set using abstract rendering techniques, and visualizing phase boundaries in the parameter spaces of NP-Complete problems.

Evoking the Imagination – In a photorealistic image, everything in the scene is rendered in fine detail, leaving little to the imagination. In comparison a non photorealistic image allows the viewer to share in the interpretive process by not depicting every detail. The *Interactive Artistic Rendering* [4] project I worked on produced a system that automatically altered the level of detail in an interactive computer application.

Animation – When creating an animation it is necessary to focus the attention of the audience on the relevant actions and elements in the scene. A viewer inspecting the fine details of a photorealistic scene can miss the big picture. Most non-photorealistic techniques employ an economy of line, limiting the detail in a scene, which makes it easier for an animator to direct the attention of the viewers. The *Artistic Composition* [5] project that I lead attempted to direct the attention of a viewer by automating object placement and the images viewpoint. In addition, the human visual system expects realistically rendered characters to behave realistically. Non-photorealistic methods allow animators to express ideas beyond the physical and logical norm in a way that is acceptable for a general audience.

Compression – By not depicting the level of detail required for photorealistic images, non-photorealistically rendered computer graphics images typically take less time to create, take less time to render, and take up less storage space. For example half-tone images yield identical shape from shading cues as traditionally shaded images when viewed from a slight distance. However, the half-tone images generally require two orders of magnitude less storage space. The digitally simulated oil paintings produced by my *Artistic Vision* [6] project commonly produced two orders of magnitude in compression.

Communication of Design or Process Completeness – Photorealistic rendering implies an exactness and perfection which may overstate the fidelity of the simulated scene to a photograph. A non-photorealistic image aids the viewer in understanding that what they are being shown is only an approximate depiction of a scene. An excellent example of this phenomena is architectural rendering. Architects have found that on-site building conditions and variations in regional building codes can lead to last minute changes in building plans. If clients are shown photorealistic images of the proposed building these last minute changes can come as a shock leading to angry disappointed clients. However, if clients are shown non-photorealistic images of the proposed building they tend to accept the design process as incomplete and the plans as somewhat plastic. Therefore, on-site changes are usually accepted by clients. The *NPR Walkthrough* [7] project I worked on uses the sketchy quality of the lines in a virtual world to represent the level of confidence in an archeological reconstruction or the completeness of an architectural design.

The scope of my interests requires interaction with faculty in many areas, including art, architecture, behavioral and cognitive psychology, and radiology. Solutions to the problems we address significantly benefit from a variety of perspectives. Collaboration among faculty and students from multiple areas is often critical to the success of our work. In addition, I have found that devising solutions to problems encountered in other fields often leads to the solution of general computer graphics problems. For example, the silhouette extraction methods that we developed for technical illustration are currently being used to compute shadow volumes and to model contact in haptic (touch based) rendering.

Referenced Publications

1. *Interactive Technical Illustration*
   Bruce Gooch, Peter-Pike J. Sloan, Amy Gooch, Peter Shirley, Richard Riesenfeld.
   ACM Interactive 3D 1999.

2. *A Non-Photorealistic Lighting Model For Automatic Technical Illustration*
   Amy Gooch, Bruce Gooch, Peter Shirley, Elaine Cohen.
   ACM Siggraph 1998.

3. *Human Facial Illustration*
   Bruce Gooch, Erik Reinhard, Amy Gooch.
   Submitted to Transactions on Graphics.

4. *Interactive Artistic Rendering*
   Matt Kaplan, Bruce Gooch, Elaine Cohen.
   Non-Photorealistic Animation and Rendering 2000 (NPAR '00).

5. *Artistic Composition for Image Creation*
   Bruce Gooch, Erik Reinhard, Chris Moulding, Peter Shirley.
   Eurographics Rendering Workshop 2001.

6. *Artistic Vision: Painterly Rendering Using Computer Vision Techniques*
   Bruce Gooch, Greg Coombe, Peter Shirley.
   Non-Photorealistic Animation and Rendering 2002 (NPAR '02).

7. *NPR Walkthroughs*
   Kristin Potter, Amy Gooch, Bruce Gooch, Peter Willemsen,Richard F. Riesenfeld, Peter Shirley.
   Submitted to ACM SIGGRAPH 2003 Symposium on Interactive 3D Graphics(I3D 2003).