Introduction

What is Image-Based Modeling and Rendering?

And What is Image-Based Lighting?

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A principal endeavor of computer graphics research has been the pursuit of photorealism. Early two-dimensional computer graphics gained a sense of depth by combining the simple algorithms for drawing lines with the mathematics of perspective projection. The wireframe look of such drawings fed a desire for a more solid appearance, which inspired the development of hidden surface removal algorithms. Shading algorithms allowed rendering surfaces with varying brightness levels as if they were being illuminated by sources of light, and shadow calculation techniques allowed objects to realistically cast shadows on each other. Techniques for representing and displaying curved surfaces expanded the variety of shapes that could be rendered, and we created modeling tools to help us generate complex models. Renderings that look as realistic as photographs have finally been achieved by using ray tracing and radiosity to simulate the myriad complex paths that light can take as it travels from its sources to the viewer.

The evolution of tools for modeling and rendering scenes with photorealistic fidelity - much of it represented in the twenty-six years of the SIGGRAPH conference - is a monumental achievement that has had an inestimable influence on the visual medium. Nonetheless, the tools for creating complex models require a great deal of effort and skill to use, and the algorithms for rendering such images with accurate illumination remain computationally intensive and are still somewhat experimental. To wit: modeling is hard, and rendering is slow. As a result, achieving truly compelling photorealism is extremely difficult.

Suppose, for example, that we wanted to generate a photorealistic image of the cathedral of Notre Dame in Paris. We could start by figuring out the dimensions of the cathedral, perhaps by borrowing the architectural plans from the most recent restoration project, or by conducting our own surveying. We would then build up the towers and the rose window, brick by brick and pane by pane, and assign appropriate reflectance properties to each surface. We could use L-systems to generate synthetic trees in the adjacent garden, and we could specify an appropriate distribution of incident light from the sky. We could then use a global illumination algorithm which, with a great deal of computation, would simulate how light would bounce around the scene to generate a rendered image of the cathedral.

Alternately, we could simply visit the cathedral and take a picture of it. Taking the picture would not only require far less effort, but the picture would almost certainly be a far more convincing rendition of the scene - it is, by definition, photorealistic. But while a single photograph gives us an amazing amount of information about the scene's structure and appearance, it is a static frozen image. What we have lost is the ability to look in different directions, to move about in the scene, to collide with its surfaces, to change the light, to add objects, and to modify the scene itself. If we had constructed the computer model, all of this would have been possible, if not realistic.

Image-based modeling and rendering is about leveraging the ease with which photographs can be taken, the speed at which they can be displayed, and their amazing power to communicate, while at the same time transcending their limitations. The various forms of IBMR transcend the limitations by deriving some sort of representation of the scene from the photographs, and then using this representation to create renderings. The principal reason that image-based modeling and rendering is interesting is that these representations do not need to be as complete as traditional computer graphics models in order to transcend many of the limitations of photographs. To remove the restriction that it is impossible to look in different directions, we can take photographs of the scene looking in all directions, assemble the photographs into a panorama, and then allow the user to look around by displaying different sections of the panorama. To remove the restriction that one can't move about the scene, we can take many images of the scene from different locations, and then display the various images depending on where the user wants to go. To reduce the number of images necessary, we can derive geometric representations of the scene through image correspondence, interactive photogrammetry, or active sensing, and then render this geometry from the desired viewpoint with colors projected on from the original photographs. As the techniques for deriving representations become more sophisticated, the fewer limitations there are.

Image-Based Modeling and Rendering is a relatively new field, but it has already produced degrees of interactivity and levels photorealism previously only dreamed of. With its current level of interest, it promises to continue to amaze us in the years to come. Furthermore, IBMR has the potential to fundamentally change the way we understand computer graphics. By starting with the answer - photorealistic renderings in the form of photographs and video - and discovering what it takes to transform them into models and then back into renderings, we have no choice but to gain an understanding of every perceptually relevant aspect of image synthesis.

This course is based on the course organized at last year's SIGGRAPH by myself and Steven Gortler, whose excellent efforts last year have made creating this year's course much easier. The major new aspect to the course this year is the inclusion of material on Global Illumination and Image-Based Lighting, which can link image-based techniques to traditional computer graphics both in theory and in practice. To this end, it's a pleasure to have Michael Cohen and François Sillion, authors of two prominent books on global illumination, as speakers this year.

This had already been an exciting year for computer graphics and for image-based techniques in particular. Another excellent offering of innovative papers on image-based techniques is appearing in the papers session. Several new image-based software packages and hardware solutions have become available and will show at the exposition. *3D Photography*, a new SIGGRAPH course offered by Brian Curless and Steve Seitz, is a companion to this image-based modeling and rendering course. And perhaps most visibly, advanced image-based techniques have already been employed in several feature films this year, including *What Dreams May Come*, *The Prince of Egypt*, and *The Matrix*, each of which offers an entirely different visual aesthetic. As the film industry helped inspire much of this recent image-based research by popularizing matte painting, environment mapping, and morphing (all forms of "image-based rendering" developed well before the term was in use), it's wonderful and fitting to see recent results from the research community help out in visual effects as well.

A central goal of this course is to give a basic understanding of the variety of techniques that have been developed in image-based modeling, rendering, and lighting. But the more important goal is to present the larger picture in which this variety of work can best be understood. To achieve this, an effort has been made to cover not just core material such as image warping and light fields, but to also present what lies near the frontier, such as movie maps, morphing, image-based human figure animation, and artistic applications. The result, I hope, will be a learning experience for all of us.

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