This dissertation explores algorithms for rendering optimization relatable within a modern, complex rendering engine. The first part contains optimized rendering algorithms for ray tracing. Ray tracing algorithms typically present simplicity and robustness that is highly desirable in computer graphics. We offer several novel contributions to the problem of interactive ray tracing of complex lighting environments. We focus on the problem of maintaining interactivity as both geometric and lighting complexity grows without effecting the simplicity or robustness of ray tracing. First, we present a new algorithm called occlusion caching for accelerating the calculation of direct lighting from many light sources. We cache light visibility information sparsely across a scene. When rendering direct lighting for all pixels in a frame, we combine cached lighting information to determine whether or not shadow rays are needed. Since light visibility and scene location are highly correlated, our approach precludes the need for most shadow rays. Second, we present improvements to the irradiance caching algorithm. Here we demonstrate a new elliptical cache point spacing heuristic that reduces the number of cache points required by taking into account the direction of irradiance gradients. We also accelerate irradiance caching by efficiently and intuitively coupling it with occlusion caching.

In the second part of this dissertation, we present optimizations to rendering algorithms for participating media. Specifically, we explore the implementation and use of photon beams as an efficient, intuitive artistic primitive. We detail our implementation of the photon beams algorithm into PhotoRealistic RenderMan (PRMan). We show how our implementation maintains the benefits of the REYES rendering pipeline, with proper motion blur and depth of field. We detail an automatic photon beam generation algorithm, utilizing PRMan shadow maps. We accelerate the rendering of camera-facing photon beams by utilizing Gaussian quadrature for path integrals in place of ray marching. Our optimized implementation allows for incredible versatility and intuitiveness in artistic control of volumetric lighting effects. Finally, we demonstrate the usefulness of photon beams as artistic primitives by detailing their use in a feature-length animated film.

Educational Career:
Bachelor's of Computer Science, BS, 2005, University of Utah
Master's of Computer Science, MS, 2007, University of Central Florida

Committee in Charge:
Charles Hughes, Chair, EE and CS
Hassan Foroosh, UCF/EE and CS
Marshall Tappen, UCF/EE and CS
Peter Shirley, University of Utah/School of Computing

Approved for distribution by Charles Hughes, Committee Chair, on February 22, 2012.

The public is welcome to attend.