Fourier Formulation of Illumination Optics and Computer Automated Reflector Design

Robert D. Stock

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School of Computer Science
Carnegie Mellon University
Pittsburgh, PA 15213-3890

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Thesis Committee:
Mel Siegel, Chair
Steve Garoff
Paul Heckbert
Brad Keister
Jim Russ

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ABSTRACT

This thesis solves three major problems related to illumination optics: far-zone, orientation invariant light source characterization for quality control and analysis; near-zone light source characterization for accurate image rendering and raytracing from a general extended source; and computer-automated reflector design, using the near-zone model. The main approach is to combine measurements with Fourier analysis, using judiciously chosen coordinate systems and orthogonal fitting functions.

This approach has several advantages over standard raytracing models: it provides for natural data compression and interpolation, it solves the problem of determining the radiance distribution of a real source by using actual pinhole CCD camera measurements, and it eliminates the computationally intensive ray-filament intersection problem by transforming the source into an equivalent nonuniform spherical radiator. A method for treating the occlusion of rays by the extended filament, with only spherical intersection calculations, is also discussed.

The problem of designing a reflector to cast a desired intensity distribution on a distant screen for a given source is attacked by combining the realistic image rendering properties of the general light source model with a smooth-surface specular reflector model. The problem then becomes a straighforward numerical optimization of perturbations to the base parabolic reflector shape. The minimization method chosen is conjugate variables, which is essentially a multidimensional binary search that is modified to adaptively choose efficient search axes in parameter space. An algorithm to provide a first guess for the perturbations based on the shape of the image perimeters is also described.

Fundamentally, the goal of this work is to develop a general light source model that is physically accurate, intuitively descriptive, computationally convenient, and applicable to real sources.