INTERACTIVE DAYLIGHTING VISUALIZATION IN SPATIALLY AUGMENTED REALITY ENVIRONMENTS

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ABSTRACT

Incorporating appropriate daylighting into building design is an effective method for reducing electrical lighting consumption and providing healthy living and working spaces. However, it is often difficult to create successful daylighting designs due to the non-intuitiveness of complex light reflection and weather conditions, and the time consuming process of generating sufficient amounts of physically accurate data for daylighting analysis. Efficient and accurate computer-aided tools are urgently needed to help architects with daylighting design.

This thesis investigates creating interactive, faithful daylighting visualization systems with interactive rendering, optimization, parallel computing, and spatially augmented reality. The most important technical contributions of this thesis are the theory and practical solution for faithful visualization in multi-planar projection environments by interactively canceling the unintentional light scattering between projection surfaces. To cancel the inter-reflection without requiring negative light, I formulate a bound constrained optimization problem. Both linear and perceptual error metrics are introduced to compute the optimal projected image such that the actual total illumination and color most closely match the desired appearance. I also present efficient optimization solvers to interactively compute the solution by leveraging the parallel computing ability of graphics cards.

My global illumination cancellation algorithms are applied to our architectural daylighting visualization system. In this system, users can sketch their designs with a set of design primitives. Our system can automatically create a geometry to match the current design and interactively produce the global illumination rendering. The daylighting solution is then displayed on the physical design primitives by projectors. The daylighting visualization system has several advantages over traditional daylighting simulation tools and can be used for practical architectural design and education.