Faculty of Electrical Engineering & Computer Science
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Simulation, Investigation and Optimization of Optical Measurement Approaches to Characterize Solar Control Materials Using Ray-Tracing Techniques.

ABSTRACT - Masterthesis

The characterization of solar-shading fabrics is essential in designing energy-efficient buildings. Fraunhofer ISE has been investigating the optical behavior of light re-directing and shading fabrics to develop solar control materials. To evaluate the performance of materials in complex window and facade systems, improved and optimized measurement methods are needed. According to an international investigation coordinated by my supervisors at Fraunhofer ISE, there are serious problems in measuring the optical characteristics of light-scattering or diffusing materials. There are deviations ranging from ±20% to more than ±100% in the measurement results from different laboratories around the globe. These problems should be overcome, so that reliable and reproducible data becomes available as a basis to design and select appropriate solar control devices.

My focus in this M.Sc. thesis is to investigate and quantitively analyze problems in measuring the optical characteristics of scattering and light-redirecting materials using integrating spheres and a photogoniometer. The goal is to characterize the accuracy of the measurement equipment for different types of measurements, identify errors and recommend suitable setup conditions for reliable measurements. The capability of simulation tools to solve increasingly complex problems in less time has improved. Therefore, my tasks include modeling the measuring equipment with all the geometrical and optical details of integrating spheres, test samples, light sources and detectors, and producing a virtual measurement result using a ray-tracing program like Radiance. Radiance is a suite of programs for the analysis and visualization of lighting in design. Simulation results may be displayed as color images, numerical values and contour plots. These simulations help to identify the difficulties and limitations of the instruments while dealing with complex materials. To build trust in a simulation model, several validation tests were performed by comparing the virtual measurements with available measurement results and furthermore the model was evaluated with more complex materials to identify the limitations of the simulation and the actual instruments.