Karlstad Applied Analysis Seminar (2023)

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Freeform Reflector Design with a Scattering Surface.

Abstract

In this talk, we shall derive a model of surface light scattering suitable for use when solving the inverse problem of reflector design within the field of computational illumination optics, i.e., the problem of finding a freeform reflector (curved mirror) such that a given source light distribution is transformed into a specified target light distribution. This problem has been extensively studied for the case of specular reflectors (perfect mirrors) but literature unifying freeform reflectors and surface scattering effects is exceedingly rare.

The scattering model relies on concepts from optimal transportation theory, and can be formulated by endowing a smooth curve/surface (representing the reflector) with so-called microfacet surface roughness. The microfacets are small, tilted, specular (mirror-like) sections superimposed on the macroscopic reflector. By prescribing their orientations along the reflector, a model of surface roughness may be formulated.

In two dimensions, which will be the main focus of this talk, the final expression for the scattered light is a convolution integral, whilst the equivalent expression in three dimensions takes the shape of a Fredholm integral of the first kind. After deriving the convolution integral, we shall show how to go from the theoretical model to the practical application by computing a few reflector surfaces with varying amounts of scattering.