A Light Intensity Model with Connected Set Algorithm

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Abstract

In this paper, we present a novel algorithm to derive the intensity distribution on a vertical screen with a line-shaped light source, placed horizontally in front of a paraboloidal mirror. Our basic method is discrete numerical simulation, with the help of theoretical derivation. After segmenting line source into independent points, we set up Cartesian coordinates on the paraboloid. Different from the traditional uniform-interval grid, we design a grid based on solid angle, getting a far more accurate modeling of the paraboloid. Our major innovation lies in the motivation and implementation of the "connected-set" idea. There may exist multiple points on the mirror that illuminate one spot on screen. What is worse, one such point may be represented by several nominal coordinates. So we have to group them back into one "reflection point". For implementation, we used the Breadth-First Search, which is linear (rather than the naïve $O(n^2)$) to the number of nominal coordinates. To obtain the intensity distribution on a large screen, we further developed, with detailed proof of correctness, a parallel algorithm to compute the connected-sets for each sampling point on the screen simultaneously. This is substantially faster than the serial algorithm that runs sequentially for each sampling point. Our experiment results show that our model is accurate and efficient.

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