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Efficient sunlight collection from asymmetric light couplers in tree-structured light guiding network for direct indoor lighting

Wei-Feng Hsu
National Taipei University of Technology, Taiwan

Directly transporting sunlight for use in indoor lighting applications is an efficient way to utilize solar energy. This application requires a system including sunlight collectors, a light guiding network, and light exits. This study proposes a tree-structured light guiding network (TLGN) to collect sunlight and transport it for indoor illumination. The use of asymmetric light couplers in a TLGN increases the amount of accumulated sunlight because the coupling efficiency of the trunk guide is higher than that of the branch guide. An analytic ray tracing model of the asymmetric coupler is proposed to present the angle and height distributions of the propagated rays. The cutoff angles were derived and this cutoff condition was defined to identify which rays are able to travel through the coupling region. Simulations of the couplers with coupling angles (θ_{coup}) of 30° and 50° were conducted using MATLAB and Light Tools. The large θ_{coup} coupler provided high coupling efficiency (0.450). Large f-number optical components can be used to collect sunlight and increase coupling efficiency; however, the cone angle of the transmitted rays increases which impedes further propagation in the trunk guide. The orthogonal incidence method was adopted to increase coupling efficiency (0.646 for θ_{coup} = 50°), and subsequently the amount of accumulated sunlight. The coupling efficiency and amount of accumulated sunlight (using 20 collectors) were increased by 44% and 31%, respectively. Finally, we present two optical setups for implementation of the proposed method, both of which are expected to further increase the amount of accumulated sunlight.

Biography

Wei-Feng Hsu received his doctoral degree from the Signal and Image Processing Institute at University of Southern California in 1996. He is currently Associate Professor of Department of Electro-optical Engineering, National Taipei University of Technology, Taiwan. His research specialty and interest include Fourier optics, diffractive optical elements, speckle characterization and reduction, and light guiding for indoor lighting.

whsu@ntut.edu.tw