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Shading control strategy to avoid visual discomfort by using a low-cost camera: a field study of two cases

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Abstract

Daylighting in offices creates a comfortable and healthy working environment for its users. However, maximizing the amount of daylight can cause visual hindrance. To improve the visual and thermal comfort for the users, designers implement shading systems, which control the transmitted solar and visual radiation. To ensure a comfortable indoor environment, designers need to choose an appropriate control strategy. Different control strategies exist, but the acceptance and satisfaction of the user regarding these strategies remains quite low. Therefore, we developed a control strategy that is based on the comfort requirements of the users. The control strategy aims at avoiding visual discomfort for the user, while optimizing for daylight availability and improving user satisfaction by providing the possibility to override the automated control of the shading system. This is the first study where a shading device is controlled by a controller system with a low-resolution camera. The controller system captures High Dynamic Range images and evaluates a visual comfort parameter, namely the ‘Daylight Glare Probability’. The system controls the actuator of the shading device based on the assessed level of comfort. This paper demonstrates two experimental case studies where the controller system and the control strategy are implemented. The controller system is able to keep the visual hindrance below a predefined limit, while sufficient daylight can still enter the office room.

Keywords: visual discomfort, manual override, control strategy, low-resolution camera, High Dynamic Range, Daylight Glare Probability

1 Introduction

Daylighting in offices creates a comfortable and healthy working environment for its users\textsuperscript{[1]}. Additionally, daylighting has a positive impact on the global energy savings, because it decreases the energy consumption for artificial lighting \textsuperscript{[2]}. Next to providing daylight, another important aspect for the user satisfaction is providing a view to the outside \textsuperscript{[3,4]}. However, maximizing the amount of daylight may cause some issues. In particular, visual hindrance is the most negative side effect from windows. Also, excessive shortwave directly-transmitted solar radiation and longwave indirectly-transmitted energy can result in thermal discomfort and an increased energy demand for cooling. Thus, it is important to control the transmitted solar radiation to improve the visual and thermal comfort for the users. In Northern European climates, designers find it useful to implement shading systems, which can adapt themselves to changing weather conditions. Commonly used adaptable systems are adjustable in either horizontal or vertical direction (e.g. roller blinds, movable panels or venetian blinds). However, the overall performance to improve visual and thermal comfort, depends on their control strategy.

Different shading control strategies exist to achieve a comfortable indoor climate. A widely accepted control strategy for venetian blinds is tilting the slats to their time-dependent cut-off angle. As a result, the slats block the direct incident solar radiation and they allow diffuse light to enter the office space \textsuperscript{[5–7]}. In this case, an outside view for the user is largely preserved. Other control algorithms use control parameters to adjust the shading system. As an example, Thalfeldt and Kurnitski \textsuperscript{[8]} simulate different control algorithms based on their impact on the energy performance and duration of unobstructed view. They propose to use the horizontal illuminance on the working plane as a control parameter during working hours and the temperature of the room as a control parameter for shading control outside working hours. Another study, of Gunay and O’Brien \textsuperscript{[9]}, uses the ceiling illuminance as a control parameter...
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