A Data Driven Approach for Smart Lighting

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Abstract. Smart lighting for commercial buildings should consider both the overall energy usage and the occupants' individual lighting preferences. This paper describes a study of using data mining techniques to attain this goal. The lighting application embraces the concept of Office Hotelling, where employees are not assigned permanent office spaces, but instead a temporary workplace is selected for each check-in staff. Specifically, taking check-in workers' light requirements as inputs, a collective classification strategy was deployed, aiming at simultaneously predicting the dimming levels of the shared luminaries in an open office sharing light. This classification information, together with the energy usages for possible office plans, provides us with lighting scenarios that can both meet users' lighting comfort and save energy consumption. We compare our approach with four other commonly used lighting control strategies. Our experimental study shows that the developed learning model can generate lighting policies that not only maximize the occupants' lighting satisfaction, but also substantially improve energy savings. Importantly, our data driven method is able to create an optimal lighting scenario with execution time that is suitable for a real-time responding system.

1 Introduction

Smart lighting, which aims to improve on both the overall energy usage and the occupants' individual lighting comfort, has been identified as a potential market of 4.5 billion dollars in revenue by 2016[1]. Such smart lighting is of importance, not only for the "green" concept in terms of energy efficiency, but also for "personalized" office space.

Recent research has shown that buildings consume one-third of the total primary energy in the U.S., and of which, lighting, in particular, accounts for about 30% [9,10]. To cope with this increasing operational expenditure, modern lighting systems aim to be designed to minimize the energy consumption. Equally important, modern lighting also needs to take into account the occupants' lighting preferences. Studies have indicated that lighting comfort, for example, can dramatically impact workers' moods and thus productivity [8,13,14]. This is especially true under the context of Office Hotelling, where a company does not assign permanent office spaces for employees; instead it selects a temporary

[1] http://www.nanomarkets.net/

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workspace for each check-in staff. As a result, in addition to minimizing energy saving, introducing personalized lighting for occupants in commercial buildings is also of great importance [4].

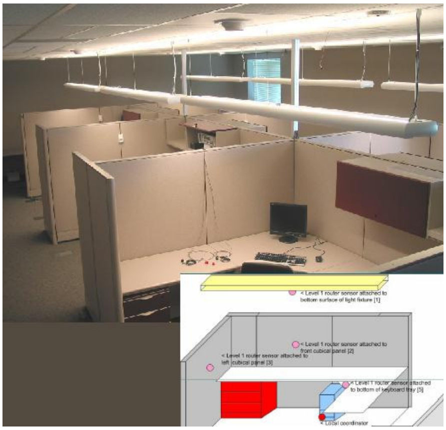

Fig. 1. The mock-up smart lighting office with six cubicles

This paper discusses a study of using a data driven approach to attain the above goals. Specifically, we apply recent data mining techniques to generate lighting scenarios for an open office sharing light, within the context of Office Hotelling. Figure 1 depicts the demonstration laboratory being set up for this application. This laboratory includes six cubicles, and sensors were installed in various positions of each cubicle in order to measure the environmental data such as temperature and light level. The sensor positions are shown at the bottom-right corner of Figure 1. The nine (9) shared lights are on the ceiling, and can be adjusted by either the computer in each cubicle or the center control system installed. The lighting policy generating unit here takes aim at creating lighting scenarios that not only minimize energy consumption but also satisfy users' light requirements, based on occupants' lighting preferences.

To generate a lighting scenario, the light requirements for the six desks are first obtained and used as inputs for the smart lighting system. Next, the dimming levels for the nine lights on the ceiling are determined by a machine learning classification model. By doing so, such classification information will be able to provide us with lighting scenarios that can both match users' preferred lighting and save energy consumption, provided that we have the energy usages for possible office plans. To this end, to obtain the various energy usages of potential office arrangements, we shuffle the workplaces of the employees, which is a practical approach within the office hotelling context where workers typically have different offices each time they check in. In this way, an energy saving lighting scenario, for instance, could be assigning closer offices to workers with similar lighting preferences. When compared with four other alternative lighting control strategies, our study shows that the developed data driven learning model can