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Integrated control and user interfaces for a space

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ABSTRACT

Many of a building's systems, including heating, cooling, lighting and ventilation, work separately with each other as 'isolated islands'. While separate systems do not typically work optimally in terms of total performance, integrated control has the potential to improve energy efficiency, occupant comfort and satisfaction and cost efficiency. Preceding studies also have stressed the needs for individual control and usability in order to achieve occupant satisfaction. First, this paper provides a solution concept for integrated control for a space and describes various inputs and outputs of integrated control. As an example, an optimisation strategy for discontinuous use of buildings is presented. The optimisation strategy was first simulated and then implemented in a real building. Second, modular user interfaces for adjusting environmental conditions are provided in the paper. The user interfaces modules are based on user research and usability testing to avoid the usability problems that have been identified in many studies regarding user control of indoor environments. The modules can be utilised in different user interface configurations for different types of spaces in a building.

1. Introduction

1.1. Need for integration

Buildings have multiple systems that typically work separately with each other as 'isolated islands'. These systems include heating, cooling, lighting, ventilation, automated blinds and access control and other safety systems. Standardisation and shared protocols enable the connection and integration of these systems.

In terms of total performance, separate systems do not typically work in an optimal manner. Instead, integrated control systems have the potential to improve energy efficiency, occupant comfort and satisfaction and cost efficiency. The principal benefits of integration are compiled in Table 1.

An integrated control and optimisation system can achieve significant energy savings while maintaining a high level of indoor comfort. Kolokotsa et al. [1] implemented an integrated indoor environment system in two buildings in Greece. An integrated fuzzy controller was used to control heating/cooling, window opening, shading and artificial lighting. The demonstrated savings amounted to almost 38 percent compared to the existing control system, without compromising indoor comfort.

Guillemin and Morel [2,3] created an adaptive control system for energy and comfort management. The control system continuously adapted itself to the changing environment and room characteristics and controlled the heating system, the artificial lighting and the position of the blinds. This system has been tested in two offices, both occupied by one person. The results showed that the system saved 19 percent of its total energy consumption, while keeping thermal and visual comfort at a high level. However, users expressed frustration with the system because it does not take user wishes into account. For example, if a user does not like the current blind position and moves it, the automatic control switches on again after 1 h and the blinds revert to the position that the user disliked. For better acceptance of automatic control systems, users' wishes should be taken into account (see next section).

Other attempts to achieve integrated building control have included a software tool for simulation of integrated and predictive control [5].

1.2. Need for individual control

From a comfort and satisfaction perspective, it is important that occupants have the opportunity to alter the indoor conditions. According to Raja et al. [6], "availability of controls and their appropriate use is key to better performance of the building and for improving occupant satisfaction".

In particular, there is wide recognition of the need for individual control of thermal environments. It is well known that there are individual differences in experiencing thermal environments [7]. A recent review on thermal comfort by van Hoof [8] concluded that

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