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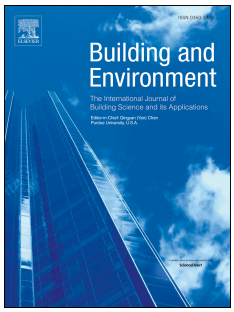

Smart buildings: A monitoring and data analysis methodological framework

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Smart buildings: a monitoring and data analysis methodological framework

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Abstract

This paper proposes a methodology for monitoring and data analysis in buildings, leading the user in the design and implementation of smart environments able to collect information on spaces and the comfort perceived by their inhabitants. A systematic descriptive framework is defined to identify the most convenient strategies for monitoring and data interpretation, driven by the constraints and goals set by how data will be exploited. A wide body of field works has been analyzed and put in relation to the methodology, highlighting the difficulty to extract general guidelines with respect to the same goal and to reveal use case specificity, preventing the possibility to learn from previous solutions. We claim the need to overcome the specific features of each case study to elicit general knowledge, and thus the quest for a unified framework, useful in different scenarios.

Keywords: Monitoring, Smart building, User Comfort, User Behavior, Energy Efficiency, Sensor Data

1. Introduction

Energy efficiency and users' comfort are two of the main drivers for instrumenting buildings to make their management successful; indeed, second generation solutions are taking into account the former aspect with great emphasis, as a counterpart to the primary objective to reduce energy consumption. The final objective can be achieved by means of Home/Building Energy Management Systems (H/BEMSs) for a dynamic and adaptive control of the building, and/or by means of a refurbishment to improve the envelope should the thermal profile have critical performance. The way the building should be instrumented and how data should be collected, processed and analysed strongly depends on requirements (e.g., having a campaign with data for all seasons) and goals (e.g., assessing the users' comfort level on a monthly basis). Today it is easy to disseminate several sensors providing redundant information, since sensors and data storage have decreasing costs. Moreover, wireless technologies allow for a non-intrusive instrumentation of spaces, for short or long periods of time, in existing buildings. We refer to smart buildings as buildings empowered by ICT, with sensors, actuators and embedded systems that allow to collect, filter and produce information to be exploited to provide functions and services. However, the proposal applies to older buildings where the instrumentation is only temporarily applied to collect the needed information.

As a result, it is not so uncommon to produce large amounts of data; to be able to effectively handle them, it is necessary to face a number of challenges, such as i) selection of a sampling strategy, ii) necessity or not to clean data and correct errors, iii) summarization and aggregation strategies.

Indeed, some of these choices are strictly related to the main objective of the monitoring activity. However, since there is no de-facto standard approach, the space instrumentation/setup is usually carried out on the basis of an adapted subset of recommendations from the commonly adopted guidelines [1], personal experience and/or commercially available kits, so that each building setup seems to be a stand-alone, unique use-case. Thus, within the energy-efficient building scenarios, both methodological proposals and case study approaches rely on a customized (often omitted) solutions for monitoring the smart spaces and/or the user comfort.

In particular, given the large set of existing smart building monitoring experiences, it is timely to define a general methodological framework that identifies i) the main choices that are available in designing a monitoring campaign, ii) the alternatives for each identified choice, and iii) the effects on the final data. In fact, there are several works available in literature [2–4] presenting solutions that are possibly tailored for the specific application context, where choices are made based on the experience and rule-of-thumb estimations. Indeed, it is common to collect an excessive amount of data and/or adopt data analysis strategies that are oversimplified with respect to the final use of the collected data.

The main contribution of this paper is the introduction of a methodological and descriptive framework for the design and analysis of monitoring campaigns for buildings, within the context of energy efficiency, comfort and users' behavior analysis. We claim that the approach we

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