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A decision support system for the multicriteria analysis of existing stock

Corneli A.[a*], Meschini S.[a], Villa V.[b], Di Giuda G.M.[c], Carbonari A.[a]

[a] *Polytechnic University of Marche, DICEA, via Brecce Bianche n. 12, Ancona, Italy*
[b] *Polytechnic of Turin, DISEG, corso Duca degli Abruzzi n. 24, Torino, Italy*
[c] *Polytechnic of Milan ABC, via Ponzio n. 31, Milano, Italy*

Abstract

Owners of any large building stock, such as public administrations, usually have to manage a huge variety of buildings with a limited budget. For this reason, targeted refurbishing actions are needed to ensure that those buildings comply with the latest standards, to preserve the stock and also keep it in good condition. As a result, most public administrators have to make important decisions regarding what part of their stock should be refurbished first.
In this paper a new methodology regarding an objective assessment of the quality of large building stock is suggested, as it could help prioritize refurbishment actions. The methodology is based on a decision support system, that is capable of semi-automatically evaluating the compliance of existing buildings with a set of rules by means of the application of Bayesian Networks. The main findings of this research led to the identification of relevant parameters to be used for that assessment; the re-use of those parameters to build a multi-criteria analysis tool; the identification of criteria and requirements to interface this decision tool with BIM models of the stock under consideration. A rough estimation of costs needed to refurbish those buildings that are not compliant, in order to include budget concerns, will be dealt with in the next research step. Finally, a preliminary application of the decision support system to evaluate two Italian school buildings – selected as case studies - will be reported.

Keywords: Multi-criteria analysis, Bayesian networks, decision networks, building stock, BIM

Nomenclature

E_n	Random variable	W_i	Weight of area of interest/index
R	Ranking value	HTC	Heat transfer coefficient
A	True value of 'level of compliance' index	SEP	Seasonal energy performance

* Corresponding author. Tel.: +0039-339-4343006.
E-mail address: a.corneli@pm.univpm.it

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1. Introduction

One of the most important responsibilities of Public Building Administrations is the prioritization of refurbishment actions on large building stock, for example schools. The majority of public buildings are outdated and informed planning, according to real priorities, means detecting any lack of compliance with respect to current legislation, in terms of comfort, energy performances, accessibility, seismic vulnerability, etc. While sticking to large building stock, the aim of this research work is to develop a decision support tool based on a Bayesian Network that can extract relevant information directly from a BIM database of the building stock and evaluate the compliance of the stock to some pre-determined technical requirements.

The decision support system was developed so as to be compliant with two BIM-based models of two schools located in Melzo (Milan), which are used for Facility Management (FM) and which acted as test cases in this research work. The whole decision support system includes a multi-criteria assessment of some performance indicators, each of them relative to a specific area of interest. Finally, the system was arranged so as to be expandable with the additional feature of estimating the budget needed to improve the status of non-compliant buildings, which will be implemented in the next research step and is expected to lead towards a cost-benefit analysis of potential scenarios.

To sum up, this tool was conceived as a tool to support a methodology for Public Administrations that have to schedule three-year plans of Public Works in advance within budget and quality constraints, while expeditiously evaluating benefits from technical improvements. In fact, the standard current methodology usually requires, as a first step, a preliminary survey on the state of the art of buildings through the creation of a repository, possibly a BIM repository, where all the information is accommodated in a structured database. Then, a second tailored survey is expected to complete the information framework and help the assessment phase. The accomplishment of these two steps, however, requires huge time and cost efforts, which can barely be afforded when strict budget constraints are posed, hence strategic management for the efficient selection of actions should be preferred. For this reason, the decision support tool reported in this paper would be functional for supporting informed choices in several situations, e.g. for the execution of new school buildings, the renovation of existing properties, small maintenance interventions, diagnostic investigations, securing and retrofitting existing buildings.

2. Scientific background

Decisions for building maintenance require integration of various types of information and knowledge created by different members of teams involved in design and construction [1]. A gradual and incremental approach towards the use of BIM has been experienced over the last decade within the construction industry as a way to increase productivity and collaboration [2]. In 2012 attention was drawn to the crucial role of BIM in this phase of building life, stating that the initial costs of inserting BIM systems into the processes are justified only if meant to support operation and maintenance [1]. Although the need for BIM in Facility Management (FM) has been acknowledged by researchers and practitioners, BIM is still not being effectively utilized in this phase, even if refurbishment activities are often carried out [3]. Also, it was highlighted that some studies on “BIM in Building Refurbishment and Maintenance” are focused on applications at an FM level, whereas just a few studies are related to BIM applications in either maintenance or refurbishment. Some other research focused on the choice of what information is needed in order to make models significant to maintenance, and on handling uncertainty due to incomplete building documentation [4]. Since BIM is becoming a project standard, FM is expected to be based on information related to the BIM model database. In addition, FM managers could use this knowledge to evaluate the quality of buildings and to rank refurbishment priorities, provided that the decision issue among the several involved parameters has been solved. Hence, this paper deals with the development of a decision support tool based on the use of Bayesian Networks to evaluate the performance parameters of existing buildings, whose inputs are retrieved from BIM models, which may not be fully detailed but just limited to the level of available information about the existing stock [5]. The results from this evaluation are used as inputs for multi-criteria evaluation of the quality of the analyzed stock. Finally, this paper contributes to the definition of the minimum level of information that must be included in BIM models in order to support performance evaluation.