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A Pareto-based multi-objective optimization algorithm to design energy-efficient shading devices

Marina Khoroshiltseva [a,*], Debora Slanzi [b,a], Irene Poli [b,a]

[a] European Centre for Living Technology, Ca' Minich, S. Marco 2940, 30124 Venice, Italy
[b] Department of Environmental Science, Informatics and Statistics, University Ca' Foscari, Cannaregio 873, 30121 Venice, Italy

HIGHLIGHTS

- We present a multi-objective optimization algorithm for shading design.
- We combine Harmony search and Pareto-based procedures.
- Thermal and daylighting performances of external shading were considered.
- We applied the optimization process to a residential social housing in Madrid.

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ABSTRACT

In this paper we address the problem of designing new energy-efficient static daylight devices that will surround the external windows of a residential building in Madrid. Shading devices can in fact largely influence solar gains in a building and improve thermal and lighting comforts by selectively intercepting the solar radiation and by reducing the undesirable glare. A proper shading device can therefore significantly increase the thermal performance of a building by reducing its energy demand in different climate conditions. In order to identify the set of optimal shading devices that allow a low energy consumption of the dwelling while maintaining high levels of thermal and lighting comfort for the inhabitants we derive a multi-objective optimization methodology based on Harmony Search and Pareto front approaches. The results show that the multi-objective approach here proposed is an effective procedure in designing energy efficient shading devices when a large set of conflicting objectives characterizes the performance of the proposed solutions.

1. Introduction

Amongst the several strategies for improving energy efficiency in Europe, buildings must be considered as the prime objective since they are responsible for about 40% of the energy consumption in Europe. The current EU building energy efficiency directives (Directives 2002/91/EC, 2010/31/UE, Nearly Zero Energy Building) impose new requirements in the renovation of existing residential buildings in order to transform them into nearly zero-energy buildings. In the renovation of existing buildings, intelligent strategies are essential to optimize building envelopes in order to minimize energy consumption while assuring thermal and lighting comfort for inhabitants [1,2].

Solar gains can greatly contribute to the building's thermal energy performance positively, in the sense of energy gains, or negatively, as energy demand. The incoming direct solar radiation may increase the solar comfort in the interior of building during the cold months and at the same time decrease the heating demand. But during summer the opposite effect occurs, since the solar radiation might cause overheating and thus increase the cooling demand. An efficient and cost effective way of avoiding the unwanted solar thermal gains in a building is the installation of shading devices. Shading devices can be categorized under interior and exterior shades [3].

The interior shades, though quite efficient with respect to glare reduction, are less likely to contribute to the thermal comfort of a building since they block the incoming radiation after it has already passed through the fenestration glazing. The exterior shades instead can block the direct solar radiation through the windows and reduce the heat transmission in the building, therefore can contribute to the thermal comfort regulation as well as to

* Corresponding author.
E-mail addresses: marina.khoroshiltseva@unive.it (M. Khoroshiltseva), debora.slanzi@unive.it (D. Slanzi), irenpoli@unive.it (I. Poli).

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