Optimal design of urban patterns to improve the energetic performance of the buildings

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Abstract

The need to save energy at the urban scale leads to study how numerical simulation and optimization methods can help the architects to design buildings and districts having the best possible energetic performances, regarding daylight, warming or cooling, and photovoltaic capacities.

The present work uses a physical model of irradiance and an evolutionary algorithm to optimize the repartition of houses inside a fixed area, in order to improve the total solar radiation received.

Several objectives can be considered in order to save energy: during cold periods or in cold regions, a maximum of solar energy must be received by the buildings, but we could also try to minimize energy consumption for air-conditioning, that means to reduce the solar exposure in hot periods, or we could formulate a multicriteria problem. As a first test, we choose to maximize the irradiance function evaluated during the shortest day of the year, taking into account the influence of the surrounding buildings.

A very simple model of houses is considered: the design variables control the space distribution of hexahedral blocks. Buildings are sets of blocks which can be placed in a finite number of discrete positions defined as a mesh of the available domain; the superposition of blocks defines the height of the building. The problem is stated as a topologic optimization one: how to distribute a given volume on a fixed domain in order to optimize an objective function related to the irradiance received by all the external faces. In a second step, more precise designs are searched by varying the orientation and the dimensions of the buildings. The first step is a global optimization taking into account only discrete design variables, while the second one can be global or local optimization dealing with discrete or continuous parameters.

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