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Parametric office building for daylight and energy analysis in the early design stages

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Abstract

This paper introduces technology analysis and optimization method. Rhinoceros, an architectural modeling program, is used, along with its graphical algorithm editor Grasshopper and its plug-in, ladybug and honeybee, with a simplified tool for building thermal evaluation for the purpose of minimizing the energy consumption and maximize the useful daylight illuminance of an office building in China Beijing. The introduction of technology analysis and optimization methods, provides a generation of practical global optimization and solution strategy for building design for different majors.

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Keywords: Energy consumption; illuminance; architectural design; Grasshopper; ladybug and honeybee;

1. Introduction

A parametric representation of a design is one where selected values within the design model are variable. Usually in terms of a dimensional variance. But any other attribute like color, scale, orientation could be varied parametrically, through as a parameter. To design parametrically means to design a parametric system that sets up a design space which can be explored through the variation of the parameters(Khidmat, 2013).

Parametric design technology is not only able to achieve highly complexity design, but also can optimize the existing architectural design workflow. So architectural simulation analysis technology and parametric optimization technology are very important for the building design that can be used to solve the problem of environmental. Xing

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Shi (Shi, 2011) used mode FRONTIER, a commercially available optimization program, and integrated energy simulation program EnergyPlus to study the optimal insulation strategy for an L-shape, one story building. Essia Znouda (Znouda, Ghrab-Morcos, & Hadj-Alouane, 2007) have developed an optimization algorithm coupling the genetic algorithms' techniques to the thermal assessment simplified tool for Mediterranean buildings CHEOPS. Chronis (Chronis, Liapi, & Sibetheros, 2012) integrated climatic and site data into a dynamic model of a large student housing complex project using parametric and optimizing technique.

High glazing ratios for each side of single skin office buildings are designed by architects to be airy, light and transparent with more access to daylight, but their energy efficiency has become more and more questioned, as there is risk of a high total thermal energy demand. Based on the present situation, the objective of this study is to explore the uses of parametric design method in an office building, which has one window on each wall with a constant total window area. The design is to find the window area on each wall to minimize the energy consumption and maximize the useful daylight illuminance.

2. Methods

This research is classified as a simulation and modeling research. Simulation research involves controlled of studying the dynamic interaction within that setting. We select Grasshopper and its plug-in ladybug and honeybee as the modeling program to study the office building design with simulation analysis technology and use the Galapago to achieve the control of optimization. The grasshopper is a graphical algorithm editor tightly integrated with Rhino's 3D modeling tools. Ladybug and Honeybee (Roudsari, 2014) are two open source environmental plugins for Grasshopper to help designers create an environmentally-conscious architectural design. Ladybug imports standard EnergyPlus Weather files (.EPW) into Grasshopper and provides a variety of 3D interactive graphics to support the decision-making process during the initial stages of design. Honeybee connects Grasshopper3D to EnergyPlus, Radiance, Daysim and OpenStudio for building energy and daylighting simulation.The Honeybee project intends to make many of the features of these simulation tools available in a parametric way. Galapagos(Rutten, 2014) is a module of grasshopper which provides a generic platform for the application of Evolutionary Algorithms to be used on a wide variety of problems by non-programmers. Galapagos has the advantages of simple operation, fast speed of calculation results. It allows the search for one goal at once, producing a range of optimized solutions.

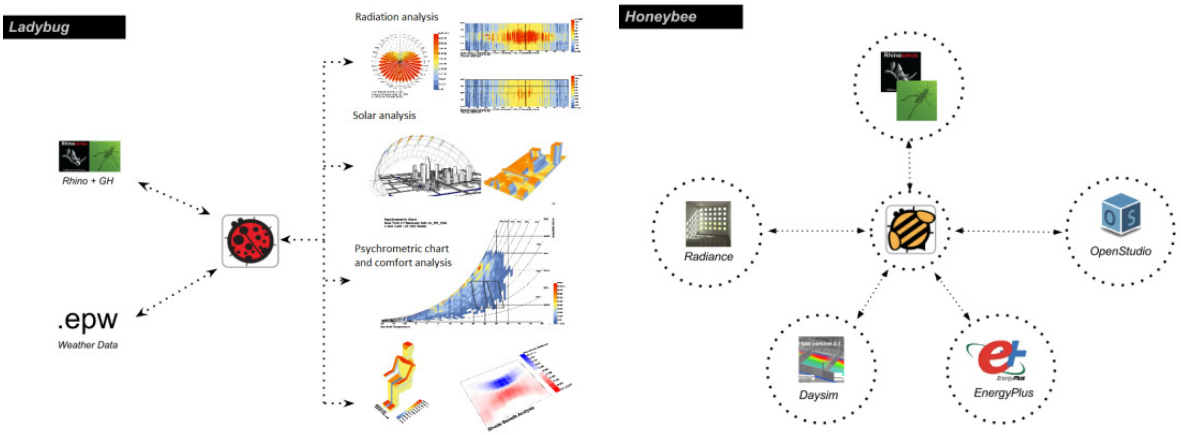

Fig. 1. Ladybug and Honeybee work scheme Source: (http://www.grasshopper3d.com/group/ladybug)