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Building Energy Assessment Based on a Sequential Sensitivity Analysis Approach

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Abstract

Sensitivity analysis has been widely used in building energy assessment to provide reliable analysis of importance ranking for input variables in buildings. Most of previous studies used one single batch simulation models to obtain sensitivity indicators. To conduct robust analysis, this paper implements a sequential sensitivity analysis to assess the convergence of sensitivity indicators for two global sampling-based sensitivity analysis methods (standardized regression coefficients and meta-modelling Sobol) in an office building. The results indicate that this sequential method can be more effective and robust. In contrast, a single batch sensitivity method for building energy assessment may lead to non-convergence results due to smaller number of simulation models or over-convergence results due to larger number of simulation models. It is also found that the convergence rate for standardized regression methods are slower than that for the meta-modelling Sobol method.

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Keywords: Sensitivity analysis; building simulation; sequential method; building energy

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1. Introduction

Sensitivity analysis can provide insight on priority of energy saving measures for both new and existing buildings [1]. Hence, sensitivity analysis has been widely implemented in building energy analysis for various purposes, such as optimization [2], uncertainty analysis [3], building retrofit [4], and model calibration [5]. The methods of sensitivity analysis can be divided into two types: local and global [6].

Global sensitivity analysis has been becoming more popular since they can analyze complicated non-linear relationships between inputs and outputs in buildings [7, 8]. Yang et al. [7] compared the advantages and shortcoming of four global sensitivity analysis methods applied in the field of building energy analysis. Hughes et al. [9] identified the wall U-values and demand temperatures as the most significant parameters using two global methods: elementary effects and a variance-based method. Hemsath and Alagheband [10] applied both local and global sensitivity analysis to assess the effects of building geometry on energy use. Ostergard et al. [11] employed a global meta-model sensitivity analysis to explore multidimensional design space in buildings for informed decision-making. However, most of previous sensitivity analysis only used one batch simulation models, which means a fixed number of building energy models are used to obtain the results of sensitivity analysis. The convergence of results from sensitivity analysis are not properly diagnosed using formal statistical methods. This may lead to unreliable and incorrect ranking importance of variables influencing building energy use.

Therefore, this paper implements a sequential sensitivity analysis in order to provide more robust sensitivity analysis. An office buildings is used to demonstrate the application of this sequential method by using two global sensitivity analysis approaches: standardized regression coefficient and meta-modelling Sobol method. EnergyPlus program [12] is carried out for building energy simulation because the IDF (input data files) for EnergyPlus are ASCII files to be easily edited using computer languages. This research uses the R statistical program to create and run EnergyPlus models for this sequential sensitivity analysis. Two performance indicators used in this paper are annual heating and cooling energy use normalized by floor area (unit: kWh/m^2).

2. Methods

This section firstly describes the construction of building energy models. Then a sequential sensitivity analysis method will be discussed in detail based on two global sensitivity approaches: standardized regression coefficient and meta-modelling Sobol method.

2.1. Building energy models

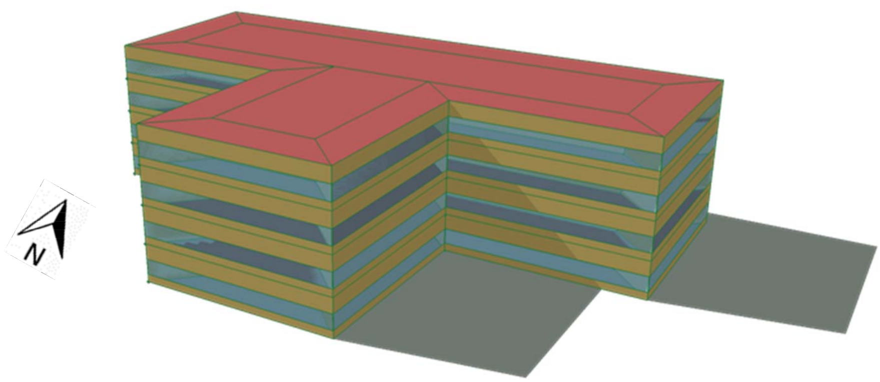

Fig. 1. An office building shown in Google Sketchup.