Research Article

Advances in Modeling and Simulation Tools

ThermalOpt: A methodology for automated BIM-based multidisciplinary thermal simulation for use in optimization environments

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Abstract

This paper describes ThermalOpt —a methodology for automated BIM-based multidisciplinary thermal simulation intended for use in multidisciplinary design optimization (MDO) environments. ThermalOpt mitigates several technical barriers to BIM-based multidisciplinary thermal simulation found in practice today while integrating and automating commercially available technologies into a workflow from a parametric BIM model (Digital Project) to an energy simulation engine (EnergyPlus) and a daylighting simulation engine (Radiance) using a middleware based on the open data model Industry Foundation Classes (IFC). Details are discussed including methods for: automatically converting architectural models into multiple consistent thermal analytical models; integration/coordination of analysis inputs and outputs between multiple thermal analyses; reducing simulation times; and generating consistent annual metrics for energy and daylighting performance. We explain how ThermalOpt can improve design process speed, accuracy, and consistency, and can enable designers to explore orders of magnitude larger design spaces using MDO environments to better understand the complex tradeoffs required to achieve zero energy buildings.

Keywords

multidisciplinary design optimization (MDO),
conceptual building design,
energy simulation,
daylighting simulation,
interoperability,
process integration,
design automation

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1 Introduction

Reducing the environmental impacts of buildings is urgently important. The American Institute of Architects (AIA) in the Architecture 2030 Challenge (AIA 2011) and the Federal Government in the Energy Independence and Security Act (FEMP 2007) both call for net-zero energy (NZE) consumption for new building designs by the year 2030. Maximizing energy performance, however, has proven elusive to industry for many years. The greatest opportunity to reduce energy consumption lies in the concept design phase, when orientation, massing, materials, components, and systems and their properties are defined.

Thermal design processes are complex multi-criteria problems that require structured and systematic definition and exploration of design spaces (Ross and Hastings 2005; Lewis et al. 2007; Bazjanac 2008; Papamichael et al. 1997). Performance-based design (Becker 2008; Oxman 2008) requires that designers possess information about the performance trends and interactions of the potential design spaces available to them (Mourshed et al. 2003). However, according to surveys of AEC design firms, architects and engineers generally take over one month to generate and analyze a design alternative. Due to the limited time available for design, each project often achieves as few as three such iterations. The majority of professionals surveyed indicated that they spend less than half of their time doing "value-adding" design and analytic work, and used simulation tools primarily to validate a chosen design alternative, not to explore multiple alternatives (Gane and Haymaker 2010;

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