Interactive optimization: understanding how designers engage with live performance feedback from multiple surrogate models

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Abstract

The topic of optimization for architectural and structural design has seen significant interest and advancement in recent years, particularly as parametric design methods are becoming more accessible and widespread. Researchers have developed tools for implementing both heuristic and gradient-based optimization techniques in parametric environments, which can be employed as part of an automated process. Depending on how performance is simulated, optimization methods can also be executed interactively, such that designers express preferences while still accessing performance feedback and guidance. To facilitate both improved computational speed in automated optimization as well as live approximations for interactive processes, researchers have turned to surrogate modeling [1]. Surrogate models can use prior computation to replace long simulations with a level of accuracy that is often reasonable for the relative sense of performance required when making decisions during conceptual design [2]. Interest in the use of surrogate modeling and related data science methods has led to proposals for a variety of live design exploration techniques. However, given that much of this research relies on speculative case studies rather than genuine design processes, there is significant need for further investigation of how designers typically interact with these data-enriched environments.

This paper presents the results of a design study testing the output and digital workflow preferences of designers as they engage with a parametric model that relies on live prediction of performance. In the study, participants with backgrounds in architecture, engineering, and building science were provided with a prompt to generate a conceptual design of a long-span athletic center, which they could explore using a previously constructed model. The design prompt included realistic information for early stage design, including the site, program, and other building requirements, as well as guidance on constraints and desired performance outcomes. The computational environment also contained surrogate models trained on prior simulations that predict the structural material quantity and energy usage of the proposed building with effectively real-time response. Participants were given access to different modeling environments in randomized order: a basic parametric model and a parametric model with live feedback for global exploration, and then a tool for interactive gradient-based optimization and a tool for composite, multi-objective, automated evolutionary optimization for local exploration. The design histories for each exploration were tracked along with the "favorite" designs of participants, after which the participants described their experiences through a survey. The results of this study yield significant insights into the effects of such surrogate-based exploration and optimization techniques on the novelty and performance of designs, as well as the preferences of digital designers, which can aid in future design tool development.

References

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