EVOLUTIONARY MODELING AND BUILDING ENERGY EFFICIENCY:

How can building performance evaluation be integrated early into an ever-accelerating design process?

SUMMARY

With the increasing demand for energy efficient buildings, designers have begun to face a new challenge—how can performance evaluation be integrated into the ever-accelerating design process? The design and performance evaluation of a building are, in most cases, divorced. The designer will often have to halt, freeze the design, and wait for performance results to filter back. That gap between freezing the design and awaiting results can be weeks. In that time the design may have changed dramatically and the results made useless. In other instances, the final design is submitted to be evaluated, results are received, and critical, irrevocable errors are discovered.

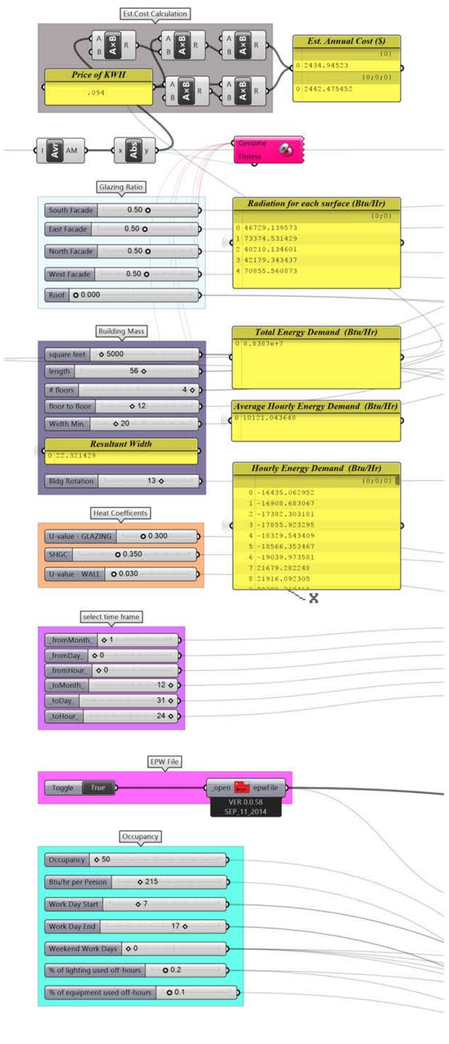
To tackle the aforementioned challenge, the project team utilized evolutionary modeling software to develop the basis for a tool for designers to use at the

SOFTWARE

sofware used UPDATE TEXT

VARIABLES & RESULTS

The designer has control of almost all the basic variables of the building. .....



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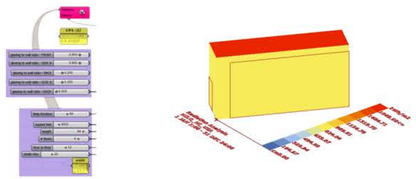

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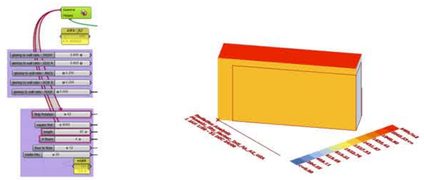

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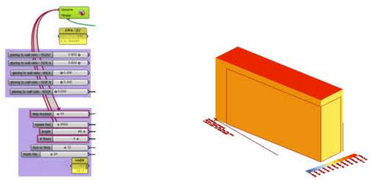

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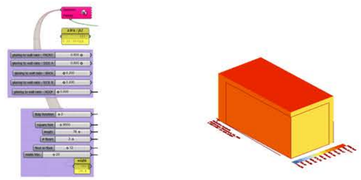

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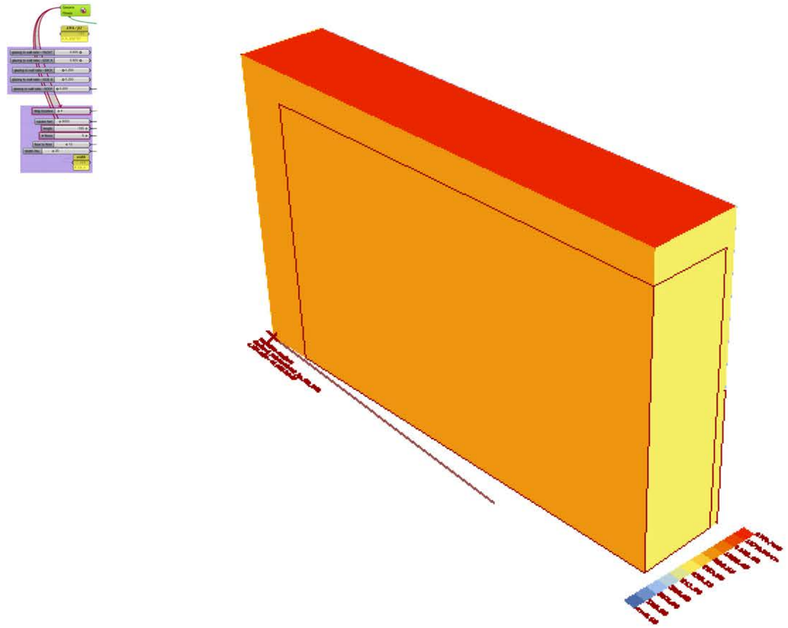

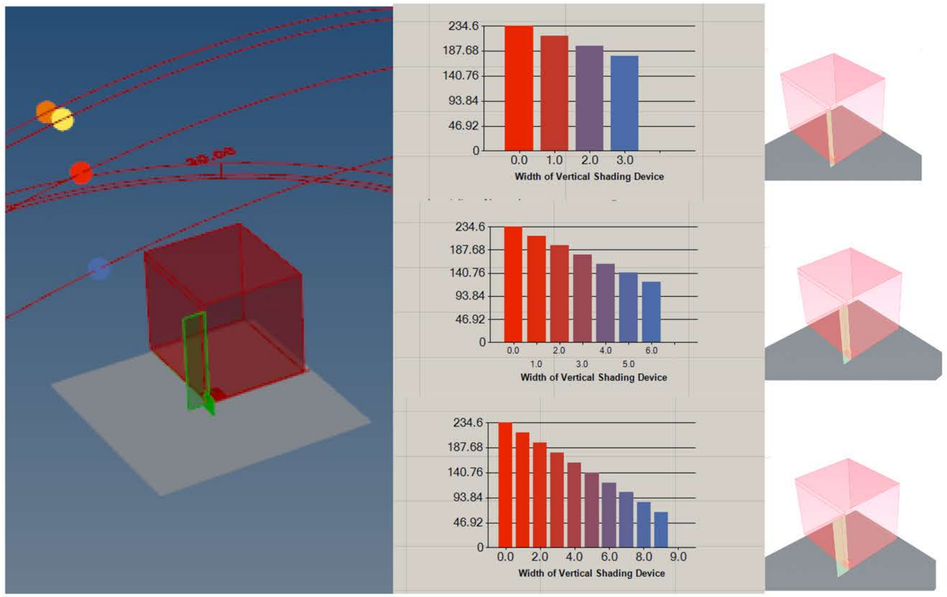

Research Overview

With the increasing demand for energy efficient buildings, designers have begun to face a new challenge—how can performance evaluation be integrated into the ever-accelerating design process? The design and performance evaluation of a building, in most cases, are divorced. The designer will often have to halt, freeze the design, and wait for performance results to filter back. That gap between freezing the design and awaiting results can be weeks. In that time the design may have changed dramatically and the results made useless. In other instances, the final design is submitted to be evaluated, results are received, and critical, irrevocable errors are discovered.

With increasing demand from clients to see performance data, architects need to be efficient in evaluating building designs. This research and develo pment project analyzes these issues critically, and proposes an alternative process that integrates performance evaluation and design process more seamlessly. Specifically, the team has researched the relationship between performance-evaluating software and evolutionary modeling software and how and when they can be integrated into the design process efficiently. The hope is to arrive at a theoretical process that integrates, in essence, a live 'performance meter', allowing designers to design freely while being guided by this 'meter'.

Methodology

In this research project, parametric modeling software was utilized to develop an experimental performance evaluation 'meter'. Specifically, Rhinoceros 3d paired with a plug-in called Grasshopper were the two programs selected to generate the meter. Rhinoceros 3D (Rhino) is a 3d modeling program that is commonly used in the architectural field. Grasshopper is a parametric modeling tool for Rhino. It utilizes mathematics to generate three-dimensional objects. Two additional programs were also used: Ladybug, a weather data plug-in for Grasshopper and Galapagos, an evolutionary computing function within Grasshopper.

This software was selected because of its open-ended nature and flexibility. Grasshopper is a free, open-source plug-in that has the potential to generate any tool desired by a designer. The flexible, open-ended nature of the software allowed for countless ways to approach the problem.

Grasshopper Definition

The tool that was developed functions by several variables that are located on sliders within Grasshopper. The sliders, or variables, consist of (but are not limited to): building square footage, building length, number of levels, floor-to-floor height, glazing ratios, building orientation, u-values, location, and occupancy. These sliders can be manipulated by a designer as desired. Along with the sliders are real-time energy results that a designer can refer to as he or she manipulates the variables.

The tool developed in this research project provides designers with the ability to quickly look at how well a certain building mass will behave in terms of energy efficiency. Designers can play with each slider and quickly see how it effects the overall efficiency or he or she can run the Galapagos function and see what it thinks is the most efficient massing. When Galapagos is run it will test all the variables inputted, against an overall energy demand output, until it finds the most efficient option. The tool's open-ended nature allows for countless possibilities. It can easily be manipulated to meet the designer's needs and (with the right know-how) can easily be expanded to include more variables to cater to special project needs.

The generative nature of the tool is also unique. Other performance evaluation software are test-based which means a designer must first create a massing model and subsequently test it with evaluation software. This generative tool can create a mass for the designer and, in this way, guide the designer. This characteristic is key in creating performance evaluation software meant to be used early in the design process. Early on, designers do not have a model to test or may not have time to create a model. Using this generative method, designers can quickly go to the function and find the ideal massing for a given site that can guide initial design decisions.

Limitations& Future Potential

The tool in its current state is also limited in its function. First of all, it can only test onesimple, rectangular volume. As the function is developed further, the hope is that it could test more complex volumes. Secondly, there is a somewhat steep learning curve when utilizing the Grasshopper software. When using the function, it would be ideal to have both a designer and someone who is familiar with Grasshopper present. Thirdly, the function utilizes general rules of thumb when computing energy calculations and does not account for anomalies.

The function also has the potential to expand the number of variables. The ability to add sun shades to the design is one example that was explored in the research but not yet successfully integrated into the function. A real-time graphic display of energy demand throughout the year is another future potential of the function that was explored but not yet integrated. When this is integrated, a designer can quickly see when energy demand is at its highest or lowest and make design adjustments accordingly.

Next Steps/Conclusion

Throughout the development of the tool, the team has learned that computing energy analysis is a very complex task with many variables. As this tool is developed further, additional testing and revising will be required. Individually, we also gained a better understanding of the concepts and mathematics that goes into energy analysis.

The team also discovered that a generative nature is akey characteristic in the creation of a toolthat is to be used early in the design process.As mentioned earlier, designers often do not have a lot of time early in the process to generate a model and evaluate its performance. The generative ability can be very useful when a designer just needs a quick snapshot of how the design is performing in terms of energy efficiency.

Despite the fact that the tool is meant to be used early in the design process, it could also be developed to run analyses of more complex designs later in the process. The fact that it also utilizes evolutionary computing would make it stand out from typical performance evaluation software which rely on manual modifications and tests.

Overall, the team believes this research project only scratches the surface of the potential of a tool that guides designers, in terms of energy efficiency, early on in the design process through parametric modeling and evolutionary computing. The open-ended nature of this software lends itself to countless possibilities and customization. The next challenge, as this tool becomes more complex and robust, is to maintain this open-endedness and potential for possibility. For example, as the tool is developed to also include analyses of complex designs, will two separate tools need to be developed, or is there a way to maintain a singular tool that does it all?