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Generative Design at Hogwarts: Using Tech Instead of Magic

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Learning Objectives

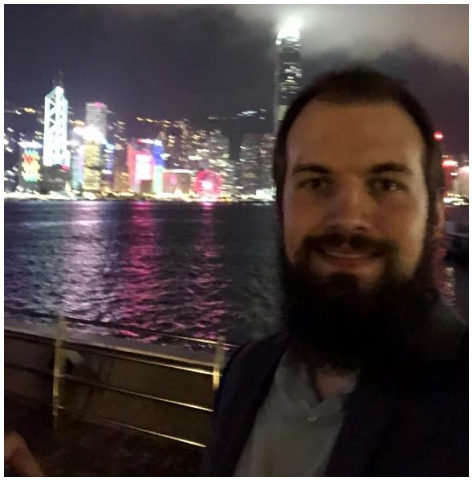
- Learn how to create optimal solutions when faced with competing goals and inputs by using generative design.
- Learn how to build viable quantification systems in both relative and finite scope to define successful results.
- Learn how to compare multiple viable solutions at various scales to ensure projects move forward with confidence.
- Discover a sampling of options for review/decision without requiring significant rework.

Description

While it's not directly shown, it's likely that the teachers at Hogwarts used a lot of magic to make quick work of the mundane prep for their classes. This session will review applications of generative design from the standpoint of the graph author rather than the user. Using Generative Design in Revit software, we'll use our own brand of magic to find the optimal seating chart in potions (Revit integration), lay out the care of magical creatures OWL on the Hogwarts grounds (FormIt 360 software), and design the layout for the campgrounds at the Quidditch World Cup (Civil 3D software). This magic may not be as old as what the students at Hogwarts learn, but it will still help move your Revit, FormIt 360, and Civil 3D work to the next level via Generative Design in Revit!

About the Speakers

Alexandra Nelson
Alexandra currently works as a member of the Design Technology team at Perkins Eastman where she acts as a firm-wide representative focused on advancing the efficacy of the firms design initiatives in the execution of its projects and global design technology strategy. She previously worked at Grimshaw Architects as one of two BIM specialists in the New York office. Her research is focused around automation and data collection from Revit models, with a current focus in space analytics and generative design.



Jacob Small
After attaining his Bachelor of Architecture degree from Wentworth Institute of Technology, Jacob began his work at a small firm on the north shore of Massachusetts, before joining CBT architects in Boston where he gained exposure to larger scale projects. In 2017 he joined Autodesk as a Designated Support Specialist, where he puts his 10+ years of experience in the AEC industry and expertise with Revit, AutoCAD, and Dynamo to help enterprise priority customers adopt computational design into their daily workflows.

Separating the "Buzz" from the reality.

While it's often viewed as a 'trend', Generative Design has been a long time coming. While modern applications in products like Grasshopper have public facing histories dating back 10+ years, most AEC technology companies which date back to the early CAD applications in the 80's have contemplated entering the space of 'having the computer do the design work for you' at some point, with varying degrees of success. These early studies tended to focus on 'single solutions', which may have a requirement of the computational resources available at the time. This is partially where parametric tools such as the railing tool in Revit comes into play: Alter a variable such as the 'start' of a ballister pattern' and you'll get a new (if not somewhat expected) result.

Generative Design, the newest entry into this marketplace, certainly has much in common with these other tools. One of the biggest aspects of this is that the tool will only explore in the way which the graph author has told it to. The term graph author in that sentence is intentional – the bulk of Dyanmo expertise is on the technical rather than design side operations. We have a litteral army of users who can write graphs which update all parameter values based on data pulled from the web in real time, but we have very few who understand how Dyanmo can be used to define and shape space – to design as it were.

This is likely the biggest hurdle towards Generative Design moving into the mainstream. Despite the term having been one of if not the biggest 'wave maker' in AU since 2014 when the MaRS project was first publicized, there has not been as much of an uptick in the number of users who are applying computational principals to design as there has been for automation of repetitive tasks – of the top 20 topics on the Dynamo forum over the last year, generative design is only applicable to two, with nearly every other topic focused on getting to the known outcome in a faster way with less esposure of code to end users. For generative design towork in a meaningful way we will need more users to adopt Dynamo at a high level, which will take time.

This isn't to say that Generative Design is not going to be a success – quite the opposite, I think this will be an 'assumed deliverable' like renderings within 10 years – and BIM has taken even longer. Oddly enough, that is about the same timeframe which it took in-house created computer generated renderings took to become 'the norm'. It's likely that much like rendering, there are going to be a lot of 'wow' moments followed by disapointments as the industry comes to an understanding on how to use this technology. And much like the visualization artists had to evolve their position form the pen and pencil renderings of yester year, a similar evolution into a computationally driven design process will likely unfold over a few generations. Hopefully this paper and the associated presentation will help to not only accelerate that process by opening new doors while preventing some of the stumbles along the way.

Finding optimal solutions when faced with competing goals

Let's start with a thought experiment:

> Imagine you're a house cat who's trying to find a perfect spot for a nap. There are many options at your disposal – your human companion's lap; the laptop which has the little fan that blows warm air on your tummy; the empty box in the hall that looks to be too small but you're certain you can fit into if you exhale deeply first; or the bed in the guest

room that's supposed to have the door shut so it stays free of your hair… While all of these options are nice, it's a nice sunny winter day at the moment, so you'd like to nap on the rug in the living room so that you can absorb some of the sun which is coming in from the south facing window.

However there are a few problems with this location. Firstly, this particular location has a significant draft which comes in under the door. Staying clear of that location puts you closer to the spot where the smaller and louder humans dry their snow gear after they go sledding, which is inevitable today. If you position yourself mid-way between the two you'll be both wet AND cold, which is a worst case outcome, but there will be good light. This can be minimized to some aspect by moving closer or further from the window, but these options reduce if not completely remove the precious sun…

So what's a cat to do? You can risk water and cold for the joy of a few sunbeams; or you could reduce the joy in favor of staying warm and dry; either way there isn't a readily visible happy medium, and that pesky sun is moving all day long…

There clearly isn't a 'perfect' outcome here – it's a risk vs reward situation without a perfect answer. Anyone who's ever owned a cat knows how the situation is dealt with though. They lay in one spot for a bit, and slowly roll and tuck and sprawl and slink around on the rug until it's time for the next task in their busy schedule (the 'too small box' challenge), or there is an external force (such as the children's return).

Design optimization and option generation tools like the ones presented by Generative Design are the cat in the modern designer's toolbox. Instead of the designer having to lay in one spot, find some data, and then reposition themselves in a better location or orientation, the computer will sample a variety of outcomes to ensure that decisions are made with as much data as possible – after all most design problems aren't built around a context which the designer's had a lifetime's worth of experience with.

Building a quantification systems to drive successful results

One of the key aspects of letting the computer explore the design space for us is finding a to evaluate the outcome. Much of the content learned in both design school and practice falls very squarely into subjective and objective categories. The former are weighted entirely by personal feelings, taste or opinions. These aren't really quantifiable – what makes one painting more beautiful than the next? There isn't a way to easily, quickly, and effectively measure this, and designers instead rely on a lifetime of refined intuition to make such decisions. Generative design cannot readily help with these types of evaluations – and as such can't 'offset' the need for the designer. They can however make quantifiable decisions, such as 'which option has more units with a perfect view of the waterline?' These systems are often in conflict with each other, such as in the case of the cat in our thought experiment. If spot is dry, give it a 10. If it's not cold, give it a 10. If it's sunny, 10. If shaded 10. But if it's sometimes sunny, sometimes wet, sometimes shaded, and sometimes cold… well how does that score? Does the amount of wet matter? What if it was one paw a little wet but otherwise perfect? What matters in the quantifiable often winds up being subjective as well.

This is where weighting comes into play. For some cats any amount of water not in their water dish winds up being far too much, just as for some designers any result which produces a single unit without that perfect view is a horrible result. That designer might score any unit without the perfect view as a 0, while for another the resulting 99 percent of units with a pefect and all units having ideal solar performance may be a more desirable outcome. The weight given to any one outcome is what drives the result.

Comparison of viable solutions at various scales

Weighting of these variables can be performed in a few different ways. Penalties can be added to all scores when a certain objective is met. The water adverse cat may multiply all scores by a billion and six (cat math is odd), and the view driven designer would likely provide a similar number for the outcome with a single bad view. What separates the designer from the cat is the end application. While the cat only has to please itself, the designer has to sell the owner on the ideal of ‘perfect views’, which is hard to do. Even worse, owners are known to change their minds often due to market coniditons and other factors outside of the control of the designer (much like the sun and children cannot be controlled by the cat).

In order to ensure that these metrics of unknown and varying importance can be reviewed at any time and with any weighting, Generative Design provides a litany of options and filters. The important aspect to remember isn’t just that they can be filtered, but the cats and owners who are the ones who put their fate in the outcome of the design can now be given insights into WHY one design is the right option for them. Modern designers are already incorporating such metrics into many typologies – think of selling a manufacturer on a layout which reduces assembly line ‘pinch points’ by 20%, allowing them to be 20% more efficient in their manufacturing. However in most typologies this data is only exposed after being carefully curated, and is subject to confirmation bias – the designer expects this spot on the rug is ideal, and as such fully develops that spot without considering the one on the other end… this bias is not presented to the owners (nor is it likely something the designers are aware of), but it does hold an inmeasurable sway over the design processes developed and taught even today. Having the larger and complete set of curated and filtered metrics for a more complete sampling of outcomes can help designers become aware of their confirmation bias, which results in better outcomes and more capable designers.

Selection of the ‘best’ from limitless options

Eventually an option must be selected – no building is built 10,000 times, even if we had 10,000 pieces of trace which lead to that outcome. The difficulty in this aspect of design is often in the selection. Opton A may out perform C in one metric but have the inverse bet true for another metric. Perhaps there is a ‘happy medium’ which the computer has discounted for poor performance in a third metric, but eventually there has to be ‘one’ option which is selected, right? While this is true, there is nothing which say that you must go ‘all in’ with option A – take the good from it (say the location on the rug), and mix in a few aspect of option C to get that option B back. Just because the computer says ‘turn left here’ doesn’t mean you should drive directly into the lake any more than it means you should ignore your intuition and ‘do what the computer says’. In the end all of these outcomes are produced by a Dynamo graph that only

knows how to do one thing – you're the trained designer; user your years of experience and the new data points which the computer has given you.

Towards a new reality

Design cannot be perfectly quantified with modern tech, nor can the tech of yester year scale up to meet the needs of tomorrow. Generative Design as either a product or a process is something which will eventually settle into what will be a new reality, where designers are not only looking to meet the tastes and feelings of their patrons, but ensure that the buildings they produce perform towards the patron's preferred metrics. This is not going to be a quick, painless, or readily achievable reality. It will require a shift in the mindset of an industry, a development of new tools, and an upskilling of an as of yet unidentified group of users.

Until the day when those pieces are in place, we'll have trail blazers providing examples and glimpses into the future that has yet to become the normal. Much like the professors in the Harry Potter stories, these individuals will initially be looked upon as wizards of a stature which we may think unattainable. Should such doubts asail you as you venture into such technology, I find it best to remember the sentiment JK Rawling's character Ginny Weasly expressed in Harry Potter and the Half-Blood Prince: "The thing about growing up… is that you sort of start thinking anything's possible if you've got enough nerve."