~~Artificial~~ intelligence:

Human and Digital Intelligence in Design

College of design
School of Architecture
Lewis Honors College Thesis project

Submitted in partial fulfillment of the
requirements for Lewis Honors at the
University of Kentucky

Lainey Barschak and Hannah Whitley
Advisor: Professor Gary Rohrbacher

Table of Contents

Introduction *4*

Introduction

What is Artificial Intelligence? *6*

About AI

Three Boxes analogy

Types of AI

Dynamo Deconstruction

Sandwich Analogy

Using Artificial Intelligence *20*

Workflow Experiment

Steps

Conclusion

Why Use Artificial Intelligence? *28*

Too Much Information

Misconceptions of Artificial Intelligence *30*

Myth

Reality

More Than One Artificial Intelligence *32*

It Takes a Village

Accountability and Artificial Intelligence *34*

Open Minded Thinking

Conclusion *36*

Introduction

Introduction:

New ideas and concepts are often met with fear, criticism, and dismissal. This is particularly true in large-scale projects like architecture that involve many moving parts. Artificial Intelligence software, in particular, is a very controversial topic within the discourse of architecture.
The implementation of these tools divides practitioners. Some embrace AI as a way to propel architecture into the future, leading us to design more intelligent, more efficient buildings. However, some view AI as a "shortcut." Resulting in buildings that are disconnected from the human experience and degrade the profession as a whole.[1]

Those who have spoken out against AI technologies include Sebastian Erraziriz, who claims the implementation of AI will result in the disappearance of the architectural profession.[2] His words encapsulate the thoughts and fears that many designers are unwilling to put on record.

In contrast, Nate Miller, the founder and CEO of Proving Ground (a digital design agency), has spoken out in favor of AI, claiming, "But where it's applied, it isn't used as a replacement for human thinking or problem-solving. It's meant to be an accelerator that positions the computer to handle certain things that a computer is really good at."[1] He explained how AI is not a replacement for a human designer but a tool to help them accelerate their design process.

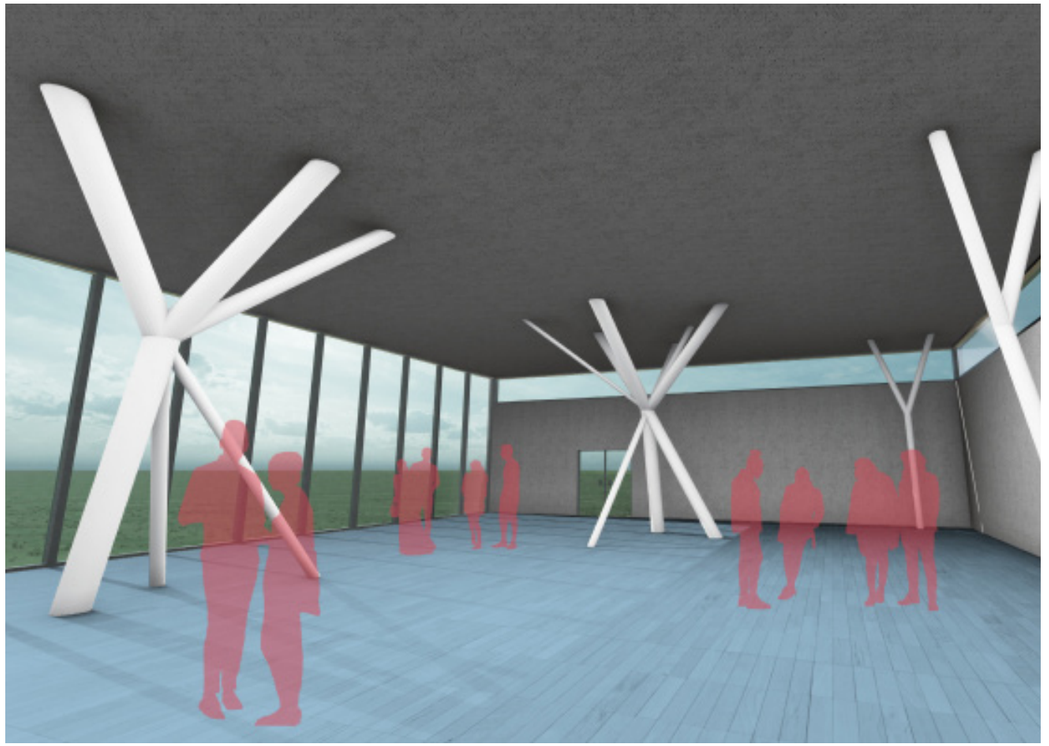
Within this document, we seek to educate about the potentials of AI and debunk misconceptions. We challenge those who are skeptical to evaluate their biases and approach new technology with an open mind. We strive to accomplish this through a series of deep dives and experiments after first explaining what AI is in design through various technical descriptions and analogies and finally addressing accountability.

---

1. *O'Donnell, Kathleen M. "Embracing Artificial Intelligence in Architecture." The American Institute of Architects, https://www.aia.org/articles/178511-embracing-artificial-intelligence-in-archit:46.*

2. *Fairs, Marcus. "Rise of Artificial Intelligence Means Architects Are 'Doomed' Says Sebastian Errazuriz." Dezeen, Dezeen, 22 Oct. 2019, https://www.dezeen.com/2019/10/22/artificial-intelligence-ai-architects-jobs-sebastian-*

What is Artificial Intelligence?

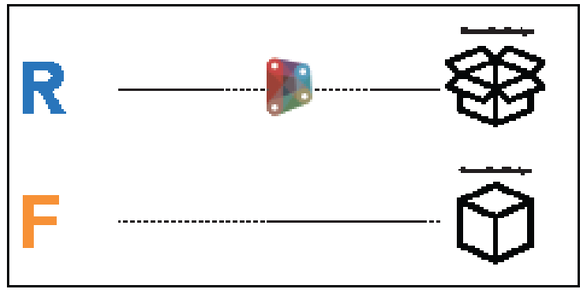


About AI:

AI can be broken down into four groups or phases. They include: Reactive Machines, Limited memory, Theory of Mind, and Self- awareness. [3]

Reactive Machines:	**Do not have an internal concept of the world. Advanced methods of "smart" computation. (ex. siri)** [3]
Limited memory:	**Make decisions based on observations of the world (self driving cars)** [3]
Theory of Mind:	**Concrete operational understanding of the world. That the world is made up of autonomous players; objects, people, animals, etc). The Ability to have feelings.** [3]
Self- awareness	**The ability to predict feelings, process abstractly**[3]

3. Hintze, Arend. "Understanding the Four Types of Artificial Intelligence." GovTech, GovTech, 23 Apr. 2021, https://www.govtech.com/computing/understanding-the-four-types-of-artificial-intelligence.html.



Barschak , Lainey and Hannah Whitley . "Diagram of User Customization in Autodesk Revit and Fusion 360". Autodesk. "Dynamo Logo." Dynambim.org, https://dynamobim.org/a-world-of-user-groups/.

The Three Boxes:

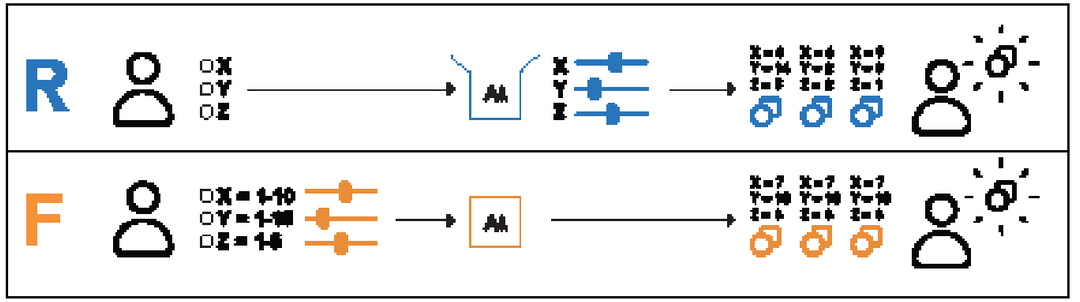
As of 2021, three of the most dominant Building Information Modeling softwares are Revit, Rhino, and Fusion 360. People celebrate these programs for enabling designers to design more efficiently and precisely. Each has its respective computational or generative design interface. While we are only utilizing Fusion 360 and Revit in our process, comparing all three of these computational interfaces is an excellent way to view the current utility of these tools.

Revit 2021 generative design offers a variety of tools that address unique optimization based on lighting and views, etc. These tools can be edited, or you can develop your own scratch. Revit offers computation through dynamo, and parameters and generative design are linked.

Fusion 360 (2021) has a generative design work/space that uses AI to run material optimization scenarios. This is also an excellent tool; however, you have more limited control over the process than you do in dynamo. Fusion has a single pre-programmed tool that cannot be edited. Fusion addresses computation by the parameters feature within the native workspace; however, this is separate from generative design. Parameters are not leveraged in generative design. You can make a parameter for "window height," but you must set the window height before doing a generative design study. Generative design does not manipulate the variables. You must manually manipulate them before running a study. Unlike Dynamo, Fusion is not helping you find an optimal combination of all the prescribed parameters. You can prescribe design parameters; however, you cannot create your own parameters within the AI.

Rhino offers a computational workspace through grasshopper. Grasshopper allows you to build your own workflows manually using parameters and some grasshopper plugins (such as Dodo[4] ,Quelea[5] ,Zebra [6] ,Galapagos [7] and Octopus [8]) feature AI tools that you can incorrate into your workflows. In a way, this is much like dynamo; however, dynamo is more powerful because you can leverage the information hierarchies that exist in Revit and use these smart object properties as parameters in the AI tools you build.

The level of openness of the boxes in the graphic Illustrates the design control you have over the computational or generative processes within each of the softwares under consideration, Revit and Fusion 360.



Barschak , Lainey and Hannah Whitley . "Diagram of Parameters in Fusion and Revit" . Clockwise from top left, Lopez, Elizabeth. "Person." The Noun Project, n.d., https://thenounproject.com/icon/person-4380616/. Accessed 8 Dec. 2021. ; Cresnar, Gregor. "Objects." The Noun Project, https://thenounproject.com/icon/objects-3555239/. Accessed 8 Dec. 2021.; Samoylov, Yaroslav. "Loading." The Noun Project, n.d., https://thenounproject.com/icon/loading-125928/. Accessed 8 Dec. 2021. ; Schmitzer, Ralf. "Faders." The Noun Project, https://thenounproject.com/icon/faders-1345599/. Accessed 8 Dec. 2021.

Types of AI and how we will be using them:

The tools we are using fall into the first two phases of AI, Reactive Machines and limited memory. As we will be using it, AI is a systematic way to evaluate the hundreds of thousands of iterations of a set of parameters produced via computation. It is a method of curation or hierarchy based on prescribed fitness criteria.

The Dynamo Deconstruction:

Dynamo enables designers to push back on a model directly using the Revit Application Program Interface in addition to the vast (but fixed) set of functions provided by the software. This pushes Building Information Modeling into unprecedentedly powerful territory regarding control/ customization, parameterization, computation. With knowledge of python and Revit, a designer can intelligently design a dynamo workflow to approach a design problem. Workflows of a specific structure utilize AI to curate permutations (iterations) based on "fitness" prescribed by the designer.

Using AI in dynamo is more powerful than a computational grasshopper script because it includes curation. This eliminates tedious work for the designer and frees up more time and energy in the design process to focus on big picture issues.

AI in dynamo is more powerful than AI in Fusion because the designer can customize AI workflows.

Parameterization in dynamo is more powerful than in grasshopper and fusion because you can leverage the fact that the program already understands objects as architectural elements.

---

4. **Dodo AI Machine learning** *"Dodo - Scientific Tools and AI for Grasshopper." Raphos, 2 Jan. 2021, http://raphos.com/geometry/dodo-scientific-tools-and-ai-for-grasshopper/.*
5. **Quelea AI Agent Simulation** *"Quelea - Agent-Based Design for Grasshopper." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/quelea-agent-based-design-grasshopper.*
6. **Zebra AI Agent Simulation** *"Zebra." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/zebra.*
7. **Galapagos AI Evolutionary Algorithm** *Rutten, David. "Galapagos." Grasshopper, https://www.grasshopper3d.com/group/galapagos.*
8. **AI Evolutionary Algorithm** *Vierlinger, Robert. "Octopus." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/octopus.*

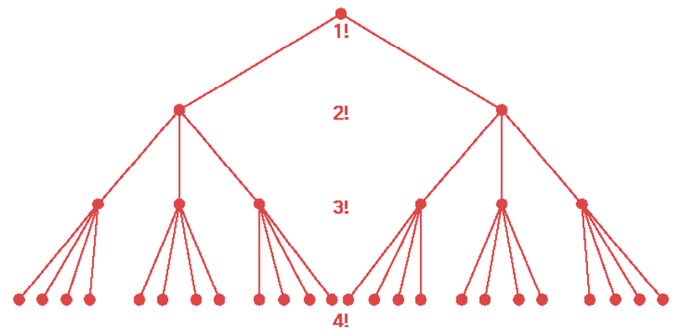
How is Artificial Intelligence Like a Sandwich?

...but first factorials

Understanding Parametric models in Building Information Modeling through Factorials:

Factorials are the product of all positive integers less than or equal to n

Factorials: $n!$



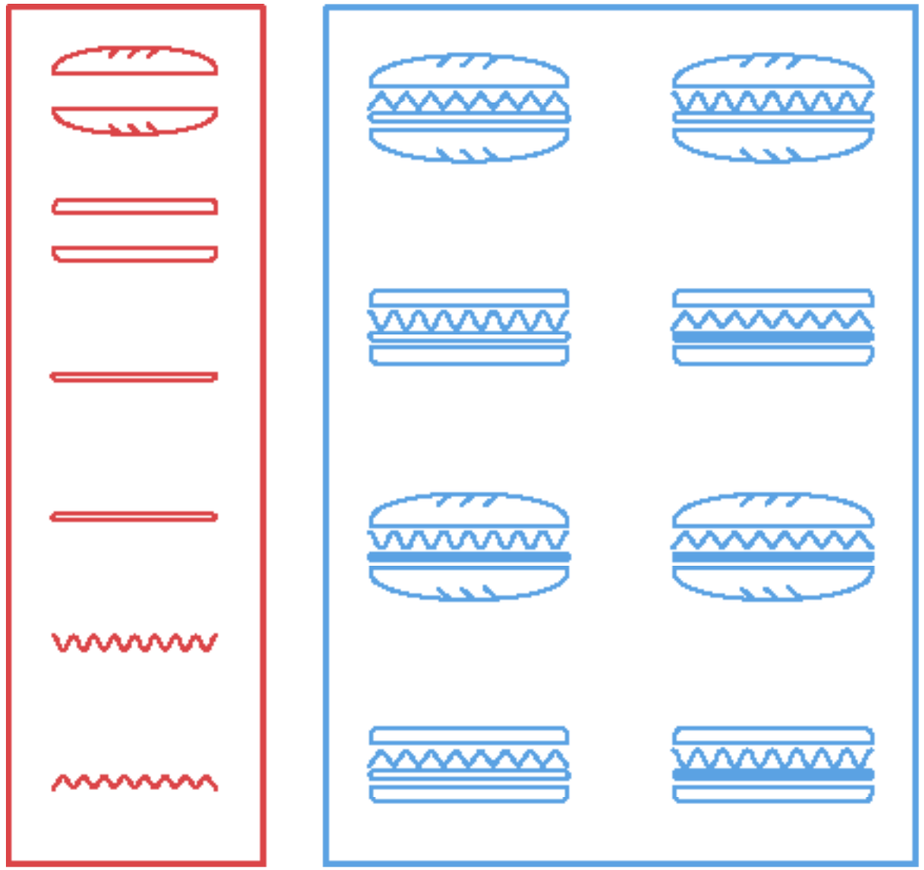
$$n!=n \cdot (n-1) \cdot (n-2) \cdot (n-3) \cdots 3 \cdot 2$$

$$10!= 10 \cdot 9 \cdot 8 \cdot 7 \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2 \cdot 1$$
$$10!= 3,628,800$$

Think of computing all possible iterations given a range of parameters as opposed to manually manipulated sliders (in computation) as factorial process.

Factorials are used in the equations for Combinations and Permutations.

The Artificial Intelligence: Sandwich Analogy



Barschak, Lainey and Hannah Whitley . "Sandwich Diagram" .

SANDWICH INGREDIENTS:

COMBINATIONS 8 UNIQUE SANDWICHES

$$nCr = \frac{n!}{r!(n-r)!}$$

A combination is a selection of items from a set that has distinct members, such that the order of selection does not matter

Combinations:

Imagine you are hungry and want a sandwich. You have two types of bread, two types of meat, and two types of cheese in your pantry. In your quest for the perfect sandwich, you might run through all the apparent possible combinations before selecting the perfect sandwich. However, you did not have a systematic approach for assembling all the possibilities. This is the difference between combinations and permutations. You can create eight combinations with those ingredients... but are there more?

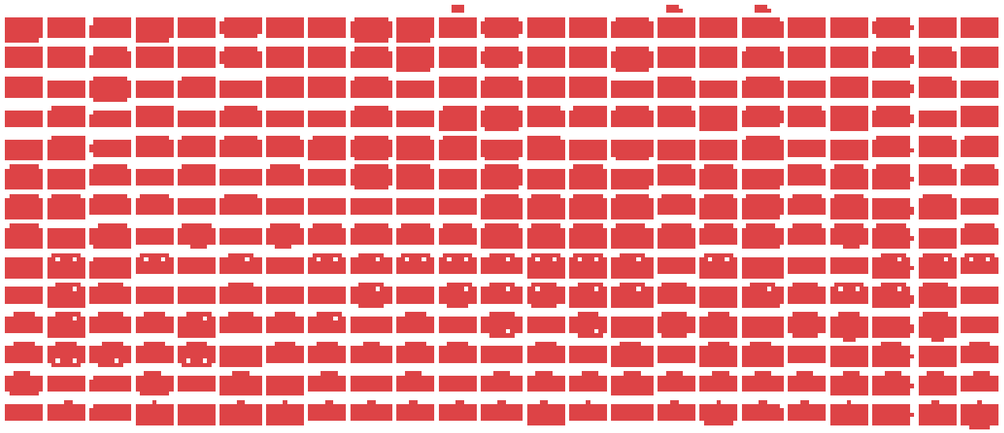
...Permutations

$$p(n,k) = \frac{n!}{(n-k)}$$

A permutation determines the number of possible arrangements in a set when the order of the arrangements matters. Common mathematical problems involve choosing only several items from a set of items with a certain order.

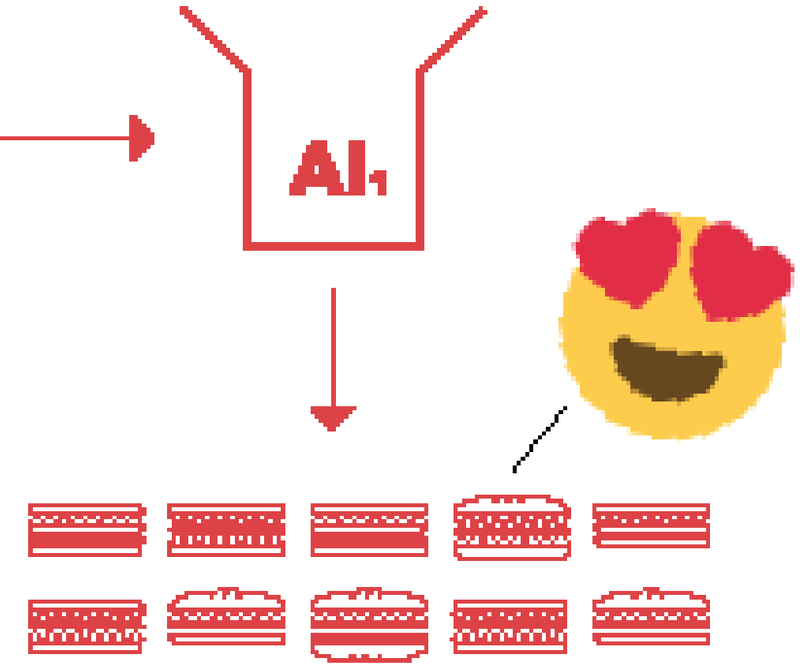
...720 uniques sandwiches

Using computation and parametric modeling, you can generate 720 unique iterations of a possible sandwich with six ingredients. However, this information is useless to you. After all, who wants to read a menu with 720 optional dishes? You could never decide. Using computation, you can create 720 unique sandwiches. However, 720 options are still useless to you. This is “dumb” computation without an intelligence filter. We still need a way to curate this information down to a digestible amount. This is where the use of Artificial Intelligence comes in.



WHAT DO YOU WANT IN A SANDWICH?

1 bread
1-2 meats
1-2 cheeses



Curation:

AI is the curation method. You set parameters for what you like in a sandwich, and it will give you a curated list of sandwiches that best fit your criteria. This is the best of computation and "intelligence."

Now you can select the best sandwich for you from the curated list, or you can decide to input a different set of parameters based on the outcomes you saw.

AI asks for criteria to use when interpreting findings. It runs all outcomes through a set of fitness tests prescribed by the designer and ranks the outcomes based on relative fitness according to the criteria. In this case, you would parameterize your model sandwich for the AI to use when evaluating all 720 sandwich options. It would then present you with ten ranked sandwiches that best meet your criteria. The 720 options have now been curated down to a manageable amount. This method of curation allows us to use computation to its fullest potential.

10 Curated Sandwiches

Barschak, Lainey and Hannah Whitley . "Sandwich Diagram Cont." . Clockwise from top left, Twitter. "Heart Eye emoji" Creative Commons, Wikimedia Commons, 25 Sept. 2020, https://commons.wikimedia.org/wiki/File:Twemoji12_1f60d.svg. Accessed 8 Dec. 2021.

Select The Best Option For You

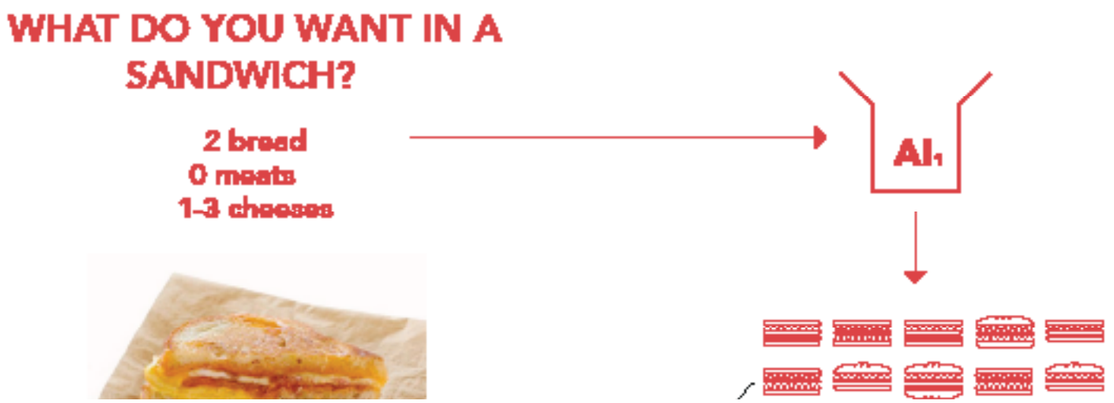
Christoufff. "Bacon Cheese Burger." Open Food Facts, Creative Commons, n.d., https://world.openfoodfacts.org/cgi/product_image.pl?code=2000000116058&id=front_fr. Accessed 8 Dec. 2021.

Select the best option... or change your mind

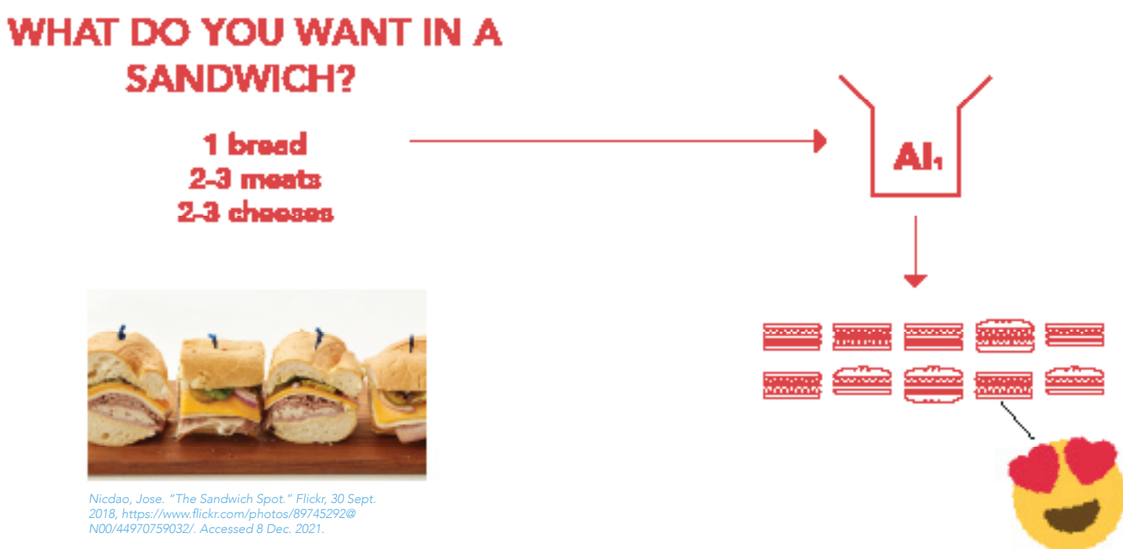
Now that you have been presented with ten optimal sandwiches based on your criteria, you should evaluate each one individually and easily select what you would like to eat. The power of this tool is that it allows you to explore options that you initially may have overlooked. For example, the bacon cheeseburger is something you might not have considered in the original eight combinations because those combinations did not account for double meat. However, through computation and AI curation, it becomes an accessible option.

Perhaps none of the ten sandwiches presented to you sound all that appetizing. If that is the case, go back and refine your parameters for what makes a good sandwich. This process can and should be repeated several times so that you arrive at the best possible option.

What If Your Preferences Change?

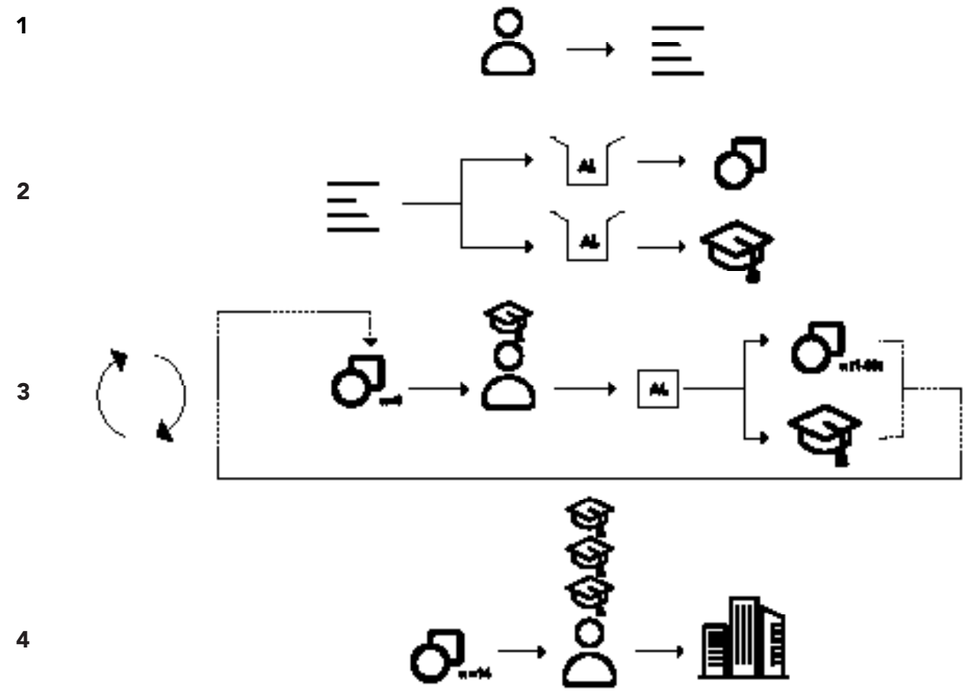


Meador, Granger. "Marbled Rye Grilled Cheese." Flickr, 29 Dec. 2013, https://www.flickr.com/photos/gmeador/11761161626. Accessed 8 Dec. 2021.



Nicdao, Jose. "The Sandwich Spot." Flickr, 30 Sept. 2018, https://www.flickr.com/photos/89745292@N00/44970759032/. Accessed 8 Dec. 2021.

Using Artificial Intelligence



Barschak, Lainey and Hannah Whitley . "Diagram of AI workflow" . Clockwise from top left, Lopez, Elizabeth. " Lopez, Elizabeth. "Person." The Noun Project, n.d., https://thenounproject.com/icon/person-4380616/. Accessed 8 Dec. 2021. ; Zlanabitnig, Tomas. "Graudation Hat." The Noun Project, https://thenounproject.com/icon/hat-3672582/. Accessed 8 Dec. 2021.; Firmansyah, Endang. "Building City ." The Noun Project, https://thenounproject.com/icon/building-and-city-3370315/. Accessed 8 Dec. 2021.

Workflow Experiment:

1. Fitness criteria is determined. This will be used to evaluate the AI outcomes and what the specific design goals are.

Our proposal is optimized for a specific sightline scenario.

2. Input initial criteria/data into AI tool. This step produces possible design outcomes as well as informing the designer about what decisions would result in different outcomes.

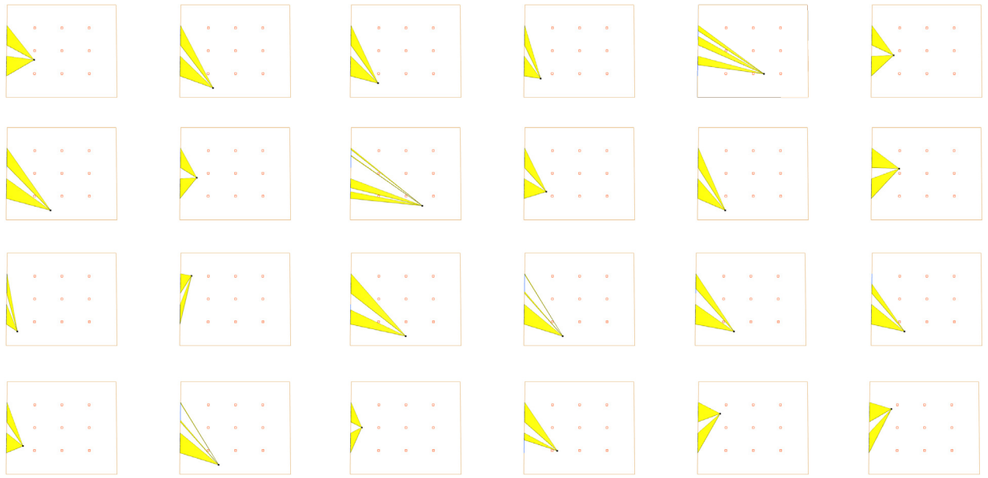
We used the AI tool within Dynamo at this stage to get a general layout for our structural experiment that is optimized for sightlines.

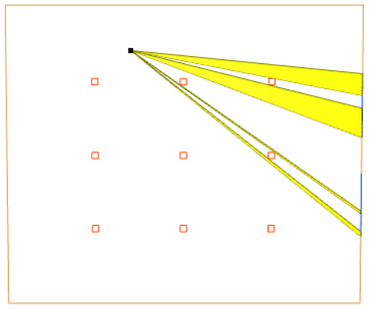
3. Step 1 and Step 2 are then repeated in a feedback loop where the previous steps outputs become the next steps inputs continuously gaining more knowledge to be used for future iterations.

In our experiment this is where we bring in the material optimization AI software within Fusion 360. Using the sightline optimized layout from the previous step we developed a generative design set up to create the structure for our proposal.

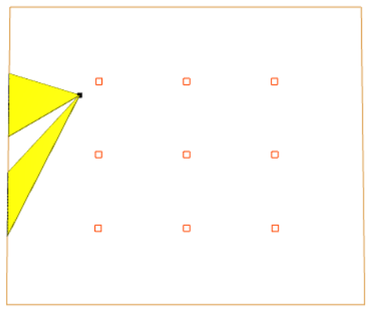
4. Once the desired amount of knowledge has been gained and an outcome has been reached the designer can select a final outcome to develop into a finished architectural proposal.

The next few pages we will go into more detail explaining how each stage of the design was reached and what choice were made by designer compared to what outcomes were AI generated.





EXPERIMENT 1



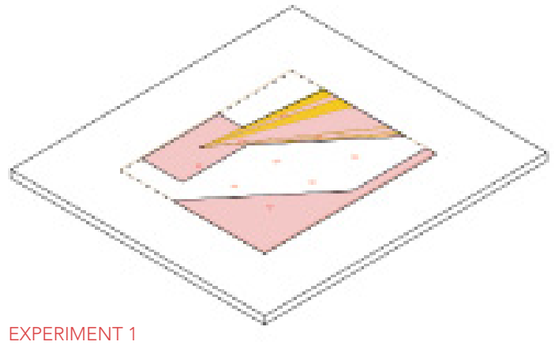
EXPERIMENT 2

Workflow Experiment Start:

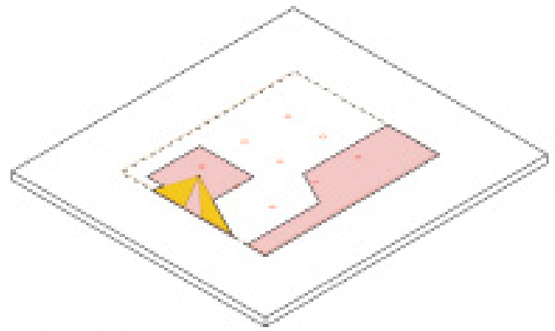
To begin our practical exploration of the AI tools within Dynamo for Revit and Fusion 360, we decided to create a structure optimized for continuous sightlines and material usage. We used Dynamo to create space studies that were optimized for sightlines. We then selected two sightliness strategies to explore further in the matter optimization AI tool within Fusion.

By using more than one AI tool in our experiment, we are attempting to show the full potential of these tools by exploring the possibilities these tools can enable when implemented into a design process together and show how they can be adapted to any project.

Void Areas

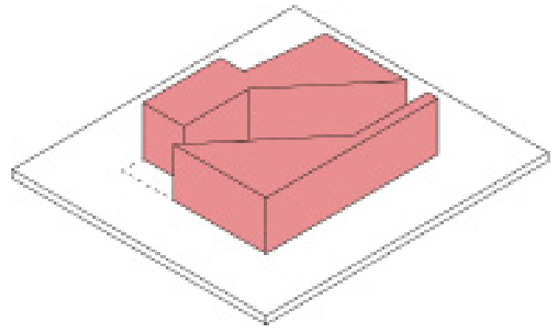


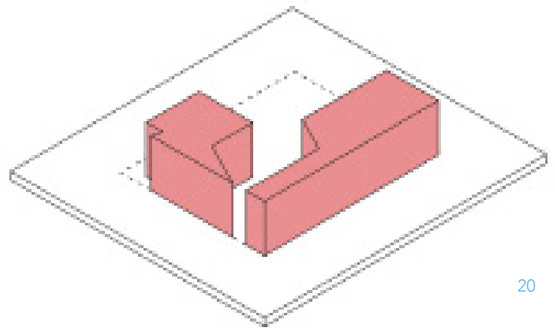
EXPERIMENT 1



EXPERIMENT 2

Void Geometry



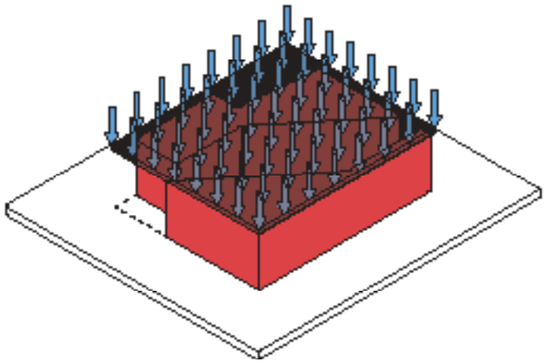


Make Void Geometry:

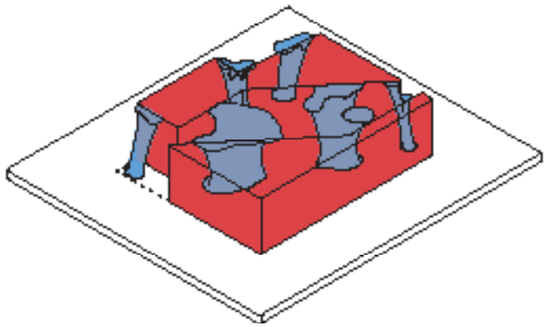
The first step in conducting our collaboration between the AI tools within Revit and Fusion was to create void areas. In the Fusion material optimization tool, void, and preserve areas are defined for the AI to use when generating its proposed structure. Void areas will be left empty, and preserve areas will be what remains unchanged (in this case, preserve areas are the proposed roof and ground plane. Using the sightlines from the selected Dynamo Study, we decided on void areas to ensure the generated structural supports would not interrupt the sightlines and provide other open spaces for interactions.

The void areas were turned into void geometry for the material optimization tool. Each set of void geometries is different because they depend on different sightlines studies. This ensures that the generated outcomes will be significantly different from each other.

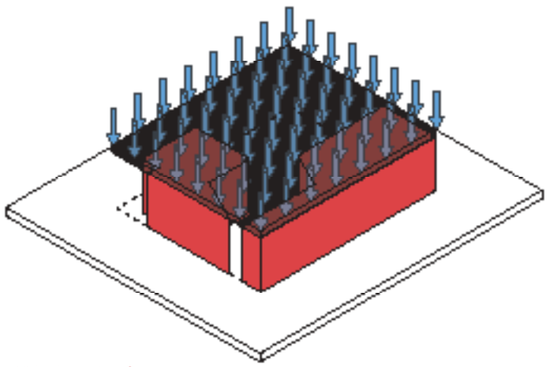
Loads and Forces

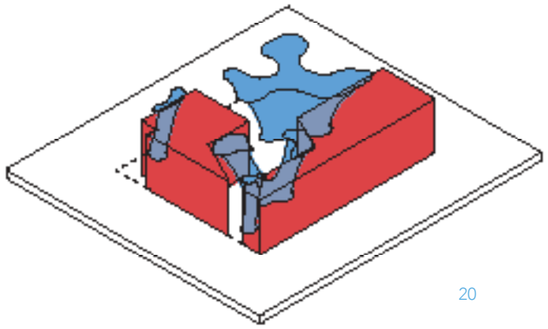


Generated Structure



EXPERIMENT 1





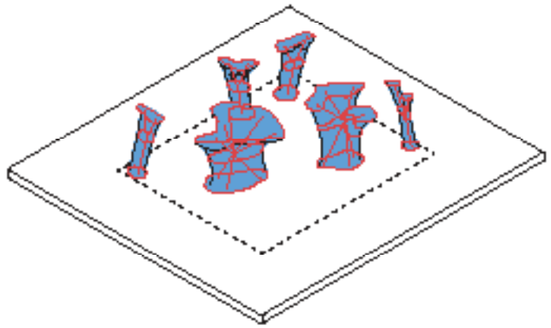
EXPERIMENT 2

Generate Outcomes:

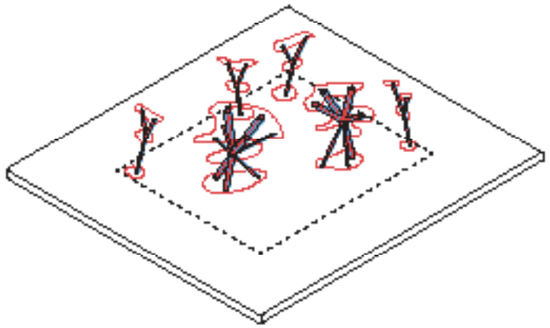
Next, loads and forces were calculated for a typical concrete roof and applied to the material optimization study. The study can now use the accurate structural constraints and forces to calculate where the structure needs to be and how much of it will be needed to support the roof—optimizing the material needed for the structure to support the weight of the hypothetical roof.

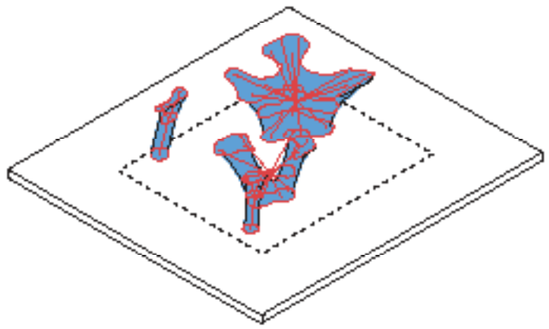
Six unique outcomes were generated after running a generative design for each study. We were able to take the curated options presented to us by the AI and evaluate them individually. Ultimately, we selected the outcomes that showed the most visual transparency, spatial dynamism, and functionality to continue developing.

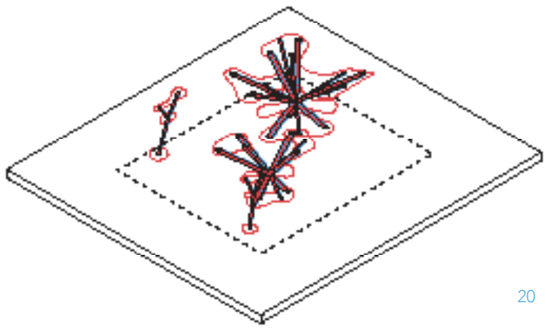
Structural Wireframe



Structural Memebers







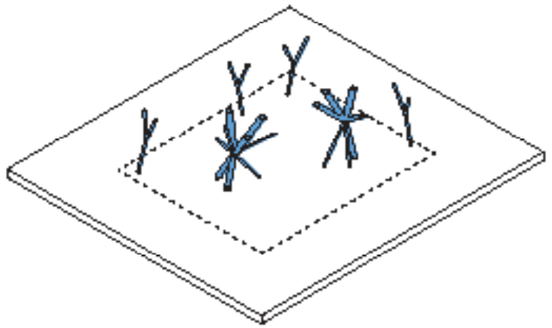
Create Wireframe:

The general shape of the generated structural material was then used to create a structural wireframe composed of straight members. We chose to do this because we wanted to show that using this tool as a force diagram does not require direct formal translation. This workflow can be used to create manually assemblable structures using standard construction methods and modified off-the-shelf components.

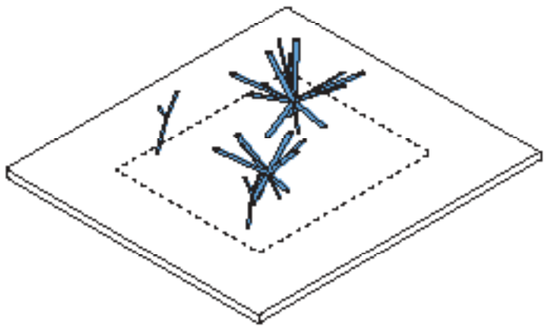
That structural wireframe was then translated into structural members.

Using the simulation AI tool within Fusion 360, the exact thickness needed for the members to support the proposed roof could be calculated. Then, using the parameters feature, the thickness of the individual beams could be quickly changed.

Finished Structural Proposal



EXPERIMENT 1

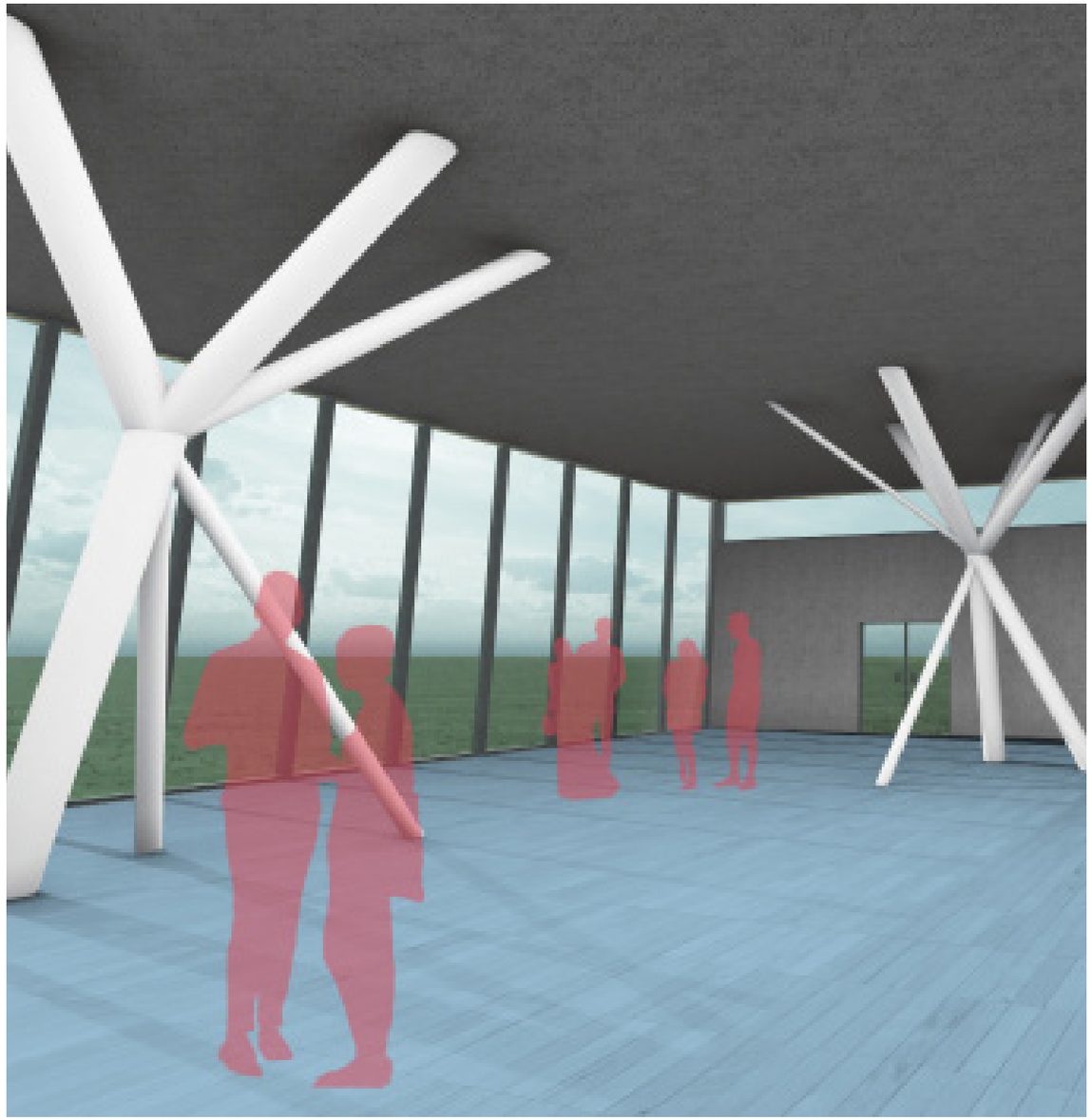


EXPERIMENT 2

Generate Outcomes:

By combining the power of two different AI tools, we created a proposed structure that would not have been so easily achieved through typical design methods. We also have a thorough understanding of the decisions that led to this outcome and the data behind it to back up the proposal's validity.

Our workflow demonstrates how the utilization of AI tools works best in a cycle that involves multiple AI tools, and many designer made decisions. We would not have achieved the same results if we had not used Dynamo and Fusion in our workflow because the dynamo studies greatly influenced Fusion's outcomes. Ideally, this workflow would continue for several more cycles taking what we learned from this completed structural proposal and influencing more Dynamo sightline studies.

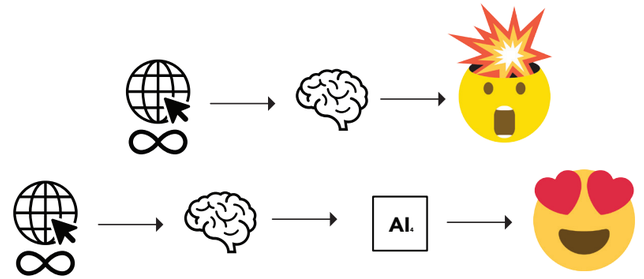


Renders:

We use rendering as a chance to involve or evaluate what is produced by the combination of the two AI's in a more conventional way, over more conventional criteria, as architects always have done. The renderings show that this structural proposal is technologically advanced and functional as well as spatially engaging and beautiful.

Why Use Artificial Intelligence?

Too much Information:



Barschak, Lainey and Hannah Whitley . "Diagram of AI as a Curation tool" . Clockwise from top left, Chintuza, Internet. https://thenounproject.com/icon/internet-3214094/. Accessed 9 Dec. 2021.; Delicti, Corpus. "Infinite." The Noun Project, https://thenounproject.com/icon/infinite-961234/. Accessed 9 Dec. 2021.; Hendricks, Meaghan. "Brain." The Noun Project, https://thenounproject.com/icon/brain-454654/. Accessed 9 Dec. 2021.; Baldwin , Chelsea. "Mind Blown Emoji." Copy Power, 14 Aug. 2017, https://getcopypower.com/mind-blown-emoji/. Accessed 9 Dec. 2021.;

Heuristics in architecture:

A Heuristic technique is a universal strategy derived from previous experience applied to a situation where your objective is to arrive at the most satisfactory solution in a reasonable amount of time, not the perfect solution.[9] Dating back to as early as 3600 BCE, architects relied on heuristic strategies to build buildings.[10] Undoubtedly, those strategies have evolved over time, but the breakthrough of AI design software requires a complete overhaul and re-examination of design workflows.

Many argue that AI will promote heuristic complacency or laziness with the models we have created. We must accept that we are already operating within a heuristic model by necessity.

Currently, the heuristic does not consider all the possible outcomes because it would be impossible even though we have the computational power to do so. We use a series of internal criteria to make our best judgments regarding design decisions. The heuristic will be applying an existing AI tool to a specific design problem in the future. In both scenarios, designers rely on a general workflow or method and tweak it to the problem at hand. In some cases, you must challenge the method entirely. What makes a good designer is a degree of self-awareness of their design method while designing. These design realities remain valid with or without AI.

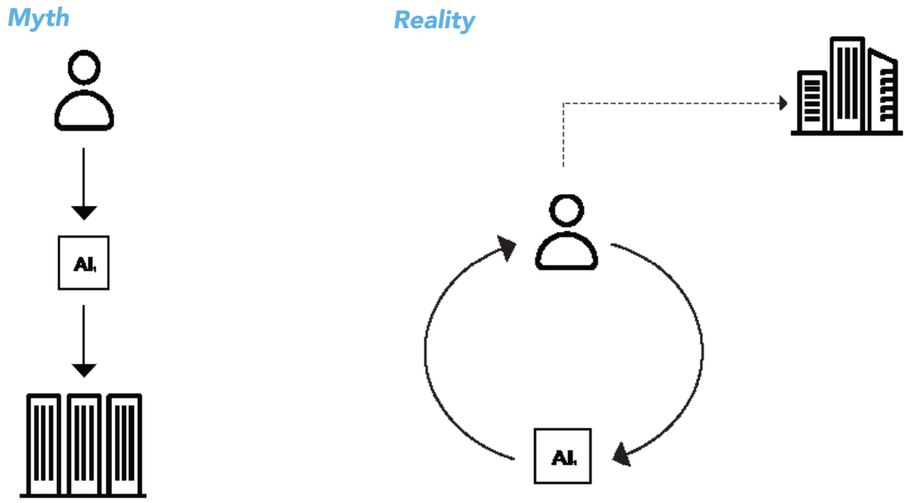
As much as we would like to think otherwise, Heuristics are design reality. The problems designers, especially architects, are charged with are too multifaceted to expect otherwise. We must accept the current status quo as nothing better (heuristically) than what we fear from a future reality that incorporates AI into design.

---

[9] *Myers, David G. (2010). Social psychology (Tenth ed.). New York, NY: McGraw-Hill. p. 94. ISBN 978-0-07337-066-8. OCLC 667213323.*

[10] *"Construction." Encyclopædia Britannica, Encyclopædia Britannica, Inc., https://www.britannica.com/technology/construction.*

Misconceptions of Artificial Intelligence



Barschak, Lainey and Hannah Whitley . "Debunking AI Myth vs. Reality" Diagram of AI workflows . Clockwise from top left, Lopez, Elizabeth. "Person." The Noun Project, n.d., https://thenounproject.com/icon/person-4380616/. Accessed 8 Dec. 2021.; Firmansyah, Endang. "Building City ." The Noun Project, https://thenounproject.com/icon/building-and-city-3370315/. Accessed 8 Dec. 2021.;

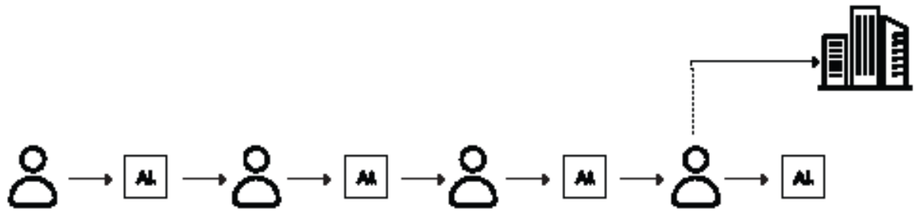
Myth: Using AI Produces Identical Buildings

All the outcomes of a specific force optimization AI tool might have the same formal language, which is a common criticism of Fusion generative design. As these AI tools progress, we can expect future iterations of these tools, and ones like to enable the designer to control a wider variety of variables that influence the expression of the form; and eventually the ability to prescribe those variables. However, ever more critical to emphasis: design need not be a one-to-one translation of that information. Unique combinations of AI tools and workflows will always produce unique outcomes that continue to delight and surprise us with how they can address climate, justice, and accountability. Further, architects and designers understand the human experience in a way that AI could never comprehend. Since AI alone can not and will not ever be able to create a building entirely on its own, we can rest assured that utilizing these tools will not result in bland identical buildings.

Reality: AI is a Tool for Designing

AI is not a linear process that produces standardized buildings. It is a continuous cycle that builds on the previous cycles' knowledge until finally reaching a desired outcome. The best way to use AI tools is in a cycle where each iteration is used to fuel future iterations, and since the designer has their hands in each stage, different outcomes will always be produced. AI allows designers to explore possibilities faster than using typical "brute force" design methods. It is a systematic way to explore hundreds of thousands of iterations, not a systematic approach to design.

More Than One Artificial Intelligence



Barschak , Lainey and Hannah Whitley . "Diagram of AI workflow-:Multiple AI tools are used in prodcution of Buildings " . Clockwise from top left, Lopez, Elizabeth. "Person." The Noun Project, n.d., https://thenounproject.com/icon/person-4380616/. Accessed 8 Dec. 2021.; Firmansyah, Endang. "Building City ." The Noun Project, https://thenounproject.com/icon/building-and-city-3370315/. Accessed 8 Dec. 2021.

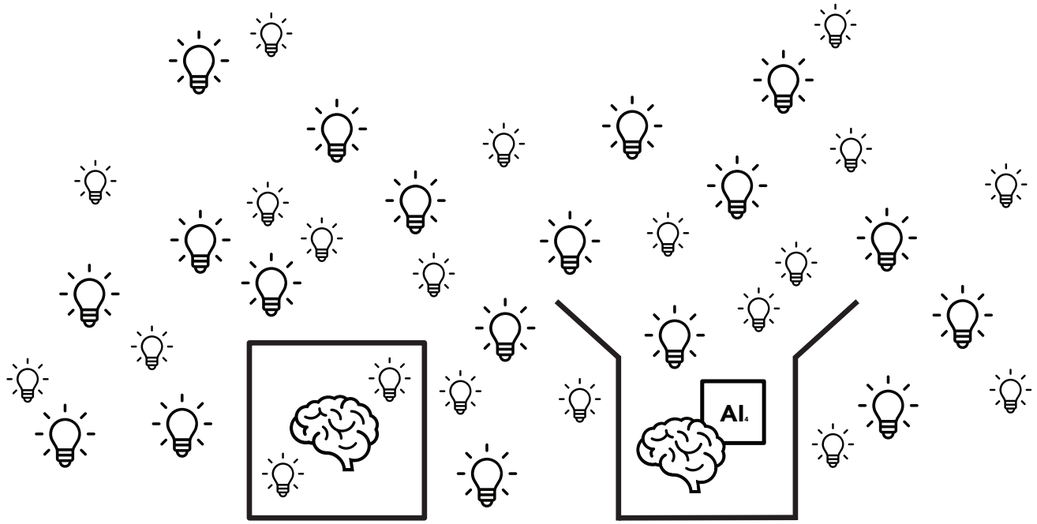
It Takes a Village

A building is not the product of a single AI widget. As seen in our workflow example, we used three different AI tools to decide on a finished structural proposal. If it requires three tools to design the structure of a building, it will require many more to design a complete building. One tool could help make decisions for a specific aspect of a building. However, to design a completed one, designers need to design a unique workflow using many tools to approach various design-process problems.

Currently, Revit has a fixed number of tools determined by Autodesk. Dynamo is a way of making tools "open source." This increases accountability because instead of Autodesk doing a cost assessment of which tools are most profitable to develop, designers can develop their own tools and offer them up for peer review.

This openness enables any designer to develop their own tool, and the ability to do so will become more accessible with time.

Accountability and Artificial Intelligence



Barschak , Lainey and Hannah Whitley . "Diagram of AI opening up perceptions of the status que" . Clockwise from top left, Coquet, Adrien. "Idea." The Noun Project, https://thenounproject.com/icon/idea-1175577/. Accessed 9 Dec. 2021; Hendricks, Meaghan. "Brain." The Noun Project, https://thenounproject.com/icon/brain-454654/. Accessed 9 Dec. 2021;

AI Can Make Us More Accountable:

By Overcoming Bias

Using typical design methods, architects discount ideas immediately, often without knowing it. Designers are an elite few that make decisions that impact many different people. Since designers are such a select few, they can fail to consider the opinions of groups different from their own. AI has no biases; being a computer, it will evaluate all outcomes equally based solely on the criteria given to it by the designer. AI can inform us of potential solutions that we might have overlooked, leading to more equitably designed spaces. AI is a tool for circumventing our own deep-rooted biases and allows designers to consider a wider variety of possible design solutions more efficiently.

By Keeping Data at the forefront of our design

While design is a qualitative process, using AI keeps data at the forefront of our investigations. Ensuring that architects remain aware of the data behind their decisions to continue to be the best-educated designers possible.

In Terms of our Material Use

Building construction and operation are responsible for 40% of annual global CO_2 emissions.[11] AI helps us use material more efficiently and be more aware of how much material we are using in a given construction project.

[11] **Climate change increased Hurricane Harvey precipitation over land by 37.7%** *"2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION Towards a Zero-Emissions, Efiifficient and Resiliient Buiilldiings and Construction Sector, https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf. Accessed 6 Dec. 2021.*

AI can make us better.

In their most basic purpose, buildings are shelters; they take care of people. For the buildings we are designing today to have the capacity to take care of the people of tomorrow, we must take a step back from the designer's perspective and view the world as a human. Being an architect is not about creating grandiose monuments to our egos; our purpose is to think generously about the people in charge.

Throughout history, many watershed moments affected what people demanded from their spaces and their architects [12]. The same holds true today.

To list a few:

- Sever political division [13]
- Racial violence [14]
- Pervasive mental health issues [15]
- Devastation due to Climate Change [11]

These events have affected the world in very specific ways. We live in a time where people crave accountability, and building form is not exempt from that. The architecture of spectacle, expense, social elitism, material waste, formal interest does not represent people.

Buildings that look sustainable, equitable, and inclusive and actually function as such.

One way to view these tools is that they are a method of quantization that crushes the spirit of design and devalues the autonomy the designer has over how a building looks. You can also take the perspective that by using these tools to explore design situations through parametric models, architects can be more self-aware of their decisions and why they make them and keep designers accountable to whom they are designing for.

---

12. *"Howell-Ardila, Deborah. "Berlin's Search for a 'Democratic' Architecture: Post-World War II and Post-Unification." German Politics & Society, vol. 16, no. 3 (48), Berghahn Books, 1998, pp. 62–85, http://www.jstor.org/stable/23737374.*

13. ***"When asked about the possibility of violence related to the 2020 presidential election, 44% are very concerned Nteta, Tatishe."*** *"University of Massachusetts Amherst Poll Finds Widespread Disillusionment and Fear among Likely Voters as Election Day Nears." UMass Amherst, https://www.umass.edu/news/article/university-massachusetts-amherst-poll-0.*

14. *"FBI Reports Hate Crimes at Highest Level in 12 Years." Equal Justice Initiative, 9 Sept. 2021, https://eji.org/news/fbi-reports-hate-crimes-at-highest-level-in-12-years/.*

15. ***35.2% increase in suicide rate between 1999 and 2019*** *"Suicide." National Institute of Mental Health, U.S. Department of Health and Human Services, https://www.nimh.nih.gov/health/statistics/suicide.*

11. ***Climate change increased Hurricane Harvey precipitation over land by 37.7%*** *"2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION Towards a Zero-Emissions, Effifficient and Resiliient Buiilldiings and Construction Sector, https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf. Accessed 6 Dec. 2021.*

Citations:

[1] *O'Donnell, Kathleen M. "Embracing Artificial Intelligence in Architecture." The American Institute of Architects, https://www.aia.org/articles/178511-embracing-artificial-intelligence-in-archit:46.*

[2] *Fairs, Marcus. "Rise of Artificial Intelligence Means Architects Are 'Doomed' Says Sebastian Errazuriz." Dezeen, Dezeen, 22 Oct. 2019, https://www.dezeen.com/2019/10/22/artificial-intelligence-ai-architects-jobs-sebastian-errazuriz/. Accessed 6 Dec. 2021.*

[3] *Hintze, Arend. "Understanding the Four Types of Artificial Intelligence." GovTech, GovTech, 23 Apr. 2021, https://www.govtech.com/computing/understanding-the-four-types-of-artificial-intelligence.html.*

[4] *"Dodo - Scientific Tools and AI for Grasshopper." Raphos, 2 Jan. 2021, http://raphos.com/geometry/dodo-scientific-tools-and-ai-for-grasshopper/.*

[5] *"Quelea - Agent-Based Design for Grasshopper." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/quelea-agent-based-design-grasshopper.*

[6] *"Zebra." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/zebra.*

[7] *Rutten, David. "Galapagos." Grasshopper, https://www.grasshopper3d.com/group/galapagos.*

[8] *Vierlinger, Robert. "Octopus." Food4Rhino, 23 Nov. 2021, https://www.food4rhino.com/en/app/octopus.*

[9] *Myers, David G. (2010). Social psychology (Tenth ed.). New York, NY: McGraw-Hill. p. 94. ISBN 978-0-07337-066-8. OCLC 667213323.*

[10] *"Construction." Encyclopædia Britannica, Encyclopædia Britannica, Inc., https://www.britannica.com/technology/construction.*

[11] *2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION Towards a Zero-Emissions, Effifficient and Resiliient Buiilldiings and Construction Sector, https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf. Accessed 6 Dec. 2021.*

[12] *Howell-Ardila, Deborah. "Berlin's Search for a 'Democratic' Architecture: Post-World War II and Post-Unification." German Politics & Society, vol. 16, no. 3 (48), Berghahn Books, 1998, pp. 62–85, http://www.jstor.org/stable/23737374.*

[13] *Nteta, Tatishe. "University of Massachusetts Amherst Poll Finds Widespread Disillusionment and Fear among Likely Voters as Election Day Nears." UMass Amherst, https://www.umass.edu/news/article/university-massachusetts-amherst-poll-0. 11McCoy, Neal H. (1968), 14.* [14] *Introduction To Modern Algebra, Revised Edition, Boston: Allyn and Bacon, LCCN 68015225*

[15] *"FBI Reports Hate Crimes at Highest Level in 12 Years." Equal Justice Initiative, 9 Sept. 2021, https://eji.org/news/fbi-reports-hate-crimes-at-highest-level-in-12-years/.*

[16] *"Suicide." National Institute of Mental Health, U.S. Department of Health and Human Services, https://www.nimh.nih.gov/health/statistics/suicide.*