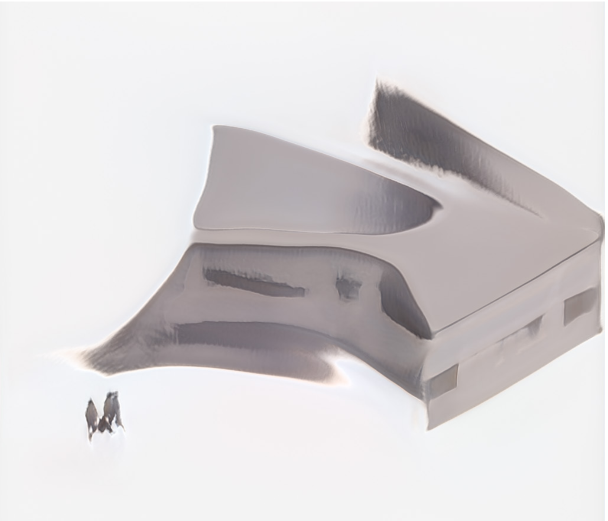
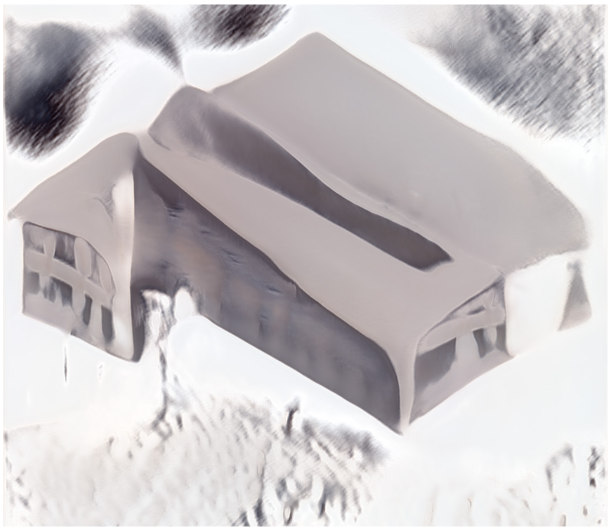
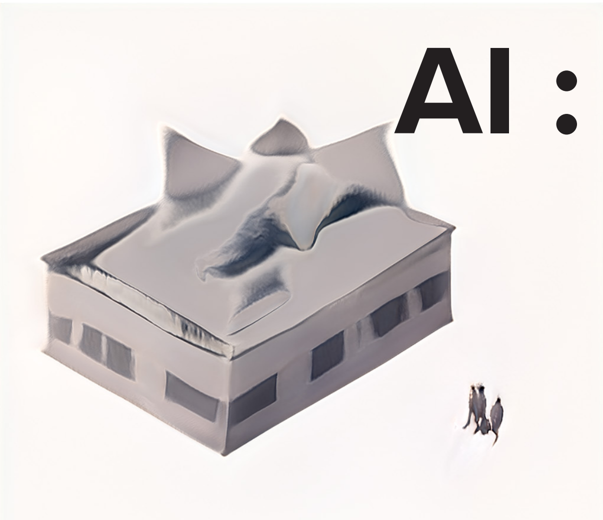


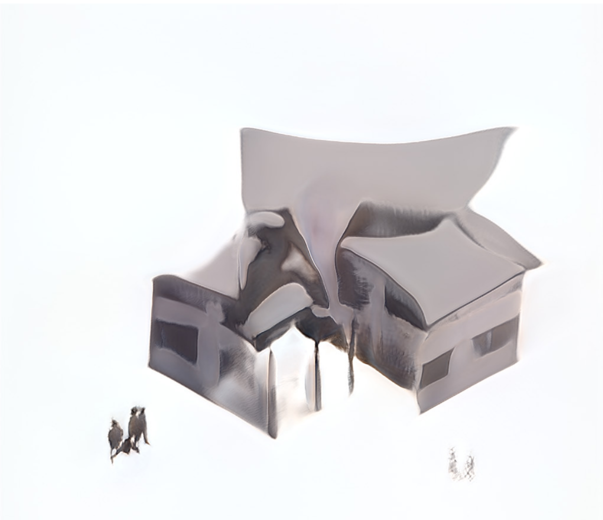


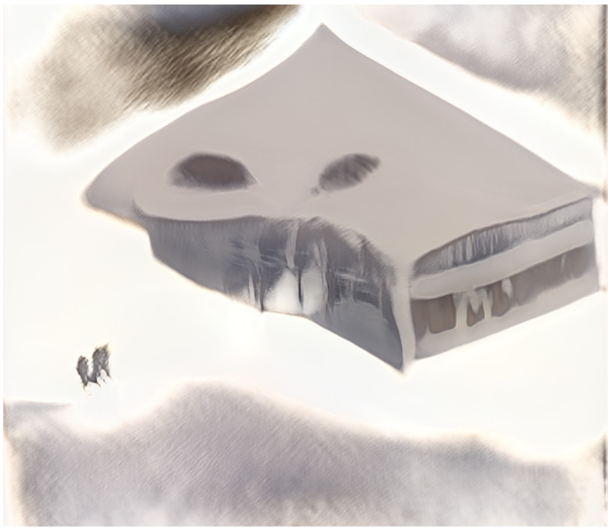


AI : Architects' Inferiority?

An exploration of the creative potential of machine learning algorithms

Aloys Heitz - Lund University





I would like to acknowledge and to thank the following people, without whom this thesis would not have been brought to completion :

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AI : Architects' Inferiority?
AAHM10 : Degree Project in Architecture - Spatial Experiments

Author : Aloys Victor Heitz
Examiner : Per-Johan Dahl
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Lund University
LTH, Faculty of Engineering

June 2022

AI : Architects' Inferiority?

Content

AI : Architects Inferiority?

AI : Architects Inferiority?

Glossary

For this thesis I taught myself how to code, and outside of my field of expertise and into the world of computer science and more precisely machine learning. Here is a non-exhaustive list of some of the terms I encountered on this journey which could be helpful to someone not familiar with this field.

AI - Artificial Intelligence : In this thesis we will accept Max Tegmark's definition of narrow AI, which is the ability of non-biological agents to accomplish a narrow set of complex goals[0001]

ML - Machine Learning : AI algorithms which can improve their own performance through experience.[0001]

ANN - Artificial Neural Network : A computer architecture in which a number of processors are interconnected in a manner suggestive of synapses in a human brain and which is able to learn by a process of trial and error.[0002]

GAN - Generative Adversarial Network : ANN capable of automatically discovering and learning the regularities or patterns in input data in such a way that the model can be used to generate new examples that plausibly could have been drawn from the original dataset.[0003]

HIT - Human Intelligence Task : Task that requires human intelligence to complete. CAPTCHA are HITs.

Parametric Design : Design method where features are shaped according to algorithmic processes, in contrast to being designed directly. The term parametric refers to input parameters fed into the algorithms.[0004]

Genetic Optimisation : Parametric design sub-field, where the input parameters are optimised by the computer rather than being decided by the user.

Overfitting and Underfitting : Overfitting happens when a ML model models the input data too well, so it merely replicates it. Underfitting on the other hand happens if a ML model fails to model the training data, resulting in random noise.

Seed : Used to label one specific iteration of an ANN.

Abstract

In this thesis, I am testing the potential of a machine learning algorithm as a creative collaborator.

Context

AI* is already widely used in architecture, mainly in the form of parametric genetic optimisation*.

However fast and complex these programs are, they cannot compute non-numerical values.

Nevertheless, with the ongoing rise of Machine Learning (ML)*, it is possible to train artificial neural networks* on existing datasets. This process “teaches” the computer how to deal with any type of data, including abstract ones. One of these technologies, Generative Adversarial Network (GAN)*, is in that sense particularly interesting.

GANs are efficient ML algorithms able to generate new data based on training sets. They were invented in 2014 by Ian Goodfellow. This method has been largely implemented to different uses and has achieved impressive results in generating 2D images.

Intent

In this thesis, I aim to train a GAN to generate a summer house.

Such a tool will allow me to shift my role as an architect from designer to curator. I will curate the input dataset, let the model generate novel geometries and assess the outputs. I suppose this framework to allow more iterations, more testing and tryouts and ultimately to enhance my creativity.

What is more, I suppose the post-human qualities of the generated images have the potential to break away from architectural preconceptions.

* The terms specific to machine learning are specified on the glossary on page 6.

AI : Architects Inferiority?

Method

I will create a database of 3D-models of summer houses. Such database will probably get heavy and pose evident problems in terms of computational power so I will limit its size to 200 houses.

I will extract a set of axonometric views from this database and train the GAN on these 2D files.

I will assess the outputs from the GAN based on ther spatial qualities, to the best of my architectural knowledge. I suppose that this will confirm or dismiss the potential of GANs as a creative collaborator for architects.

Hypothesis

This thesis investigates the potential of GANs as creative architectural collaborators.

This will be tested through the implementation of a new framework for the design of a summer home.

I aim to diversify morphogenesis processes to fuel the discourse on the architect’s role in the future. Additionally, I sought to reflect upon the definition of creativity and the implications of post-human design.

Other problematics linked to my thesis

Can a machine be creative? Where does randomness stop and creativity begin? Are machine learning algorithms a sort of mimicry and if so at which point do they break away from imitating?

How can a rule-based algorithm learn abstract qualities of space? Can an AI develop an architectural sense? How is AI the next discourse in architecture? Will a shift take place in the profession and how will architects respond?

AI : Architects Inferiority?

Chapter I

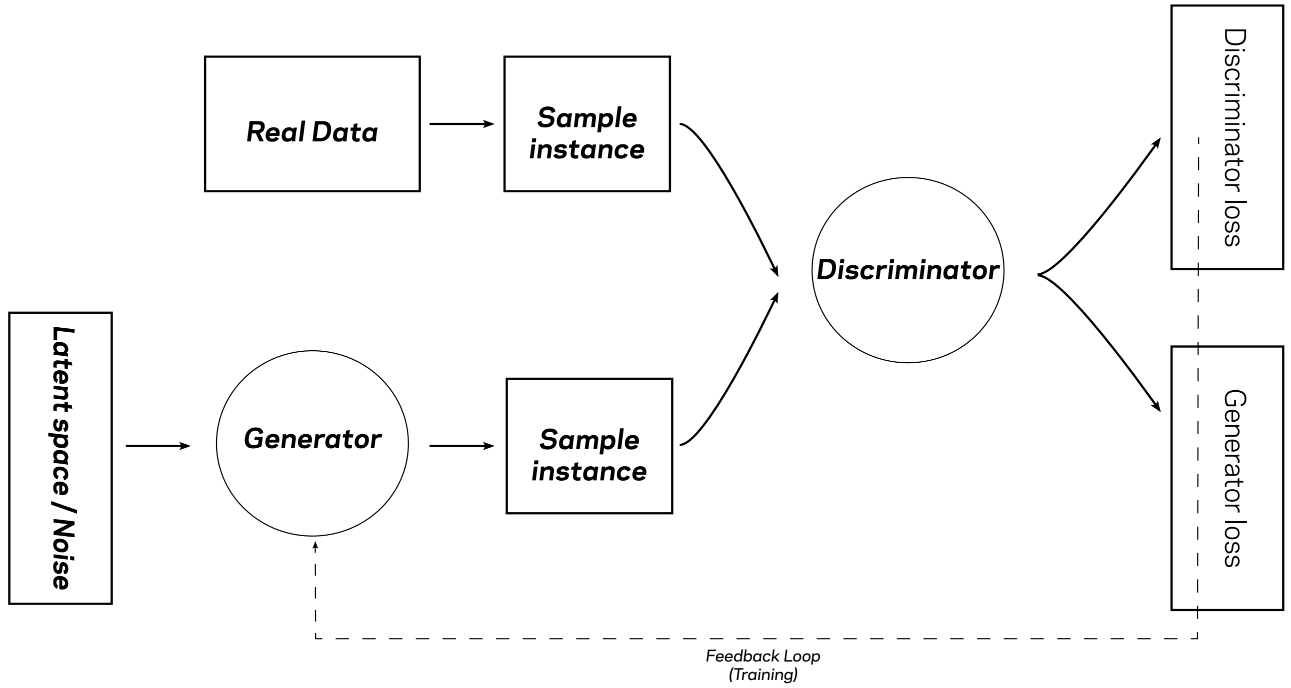
Theoretical Background

‘On Air’ by Studio Tomás Saraceno. Source : Alina Grubnyak[001]

Foreword

Project premises

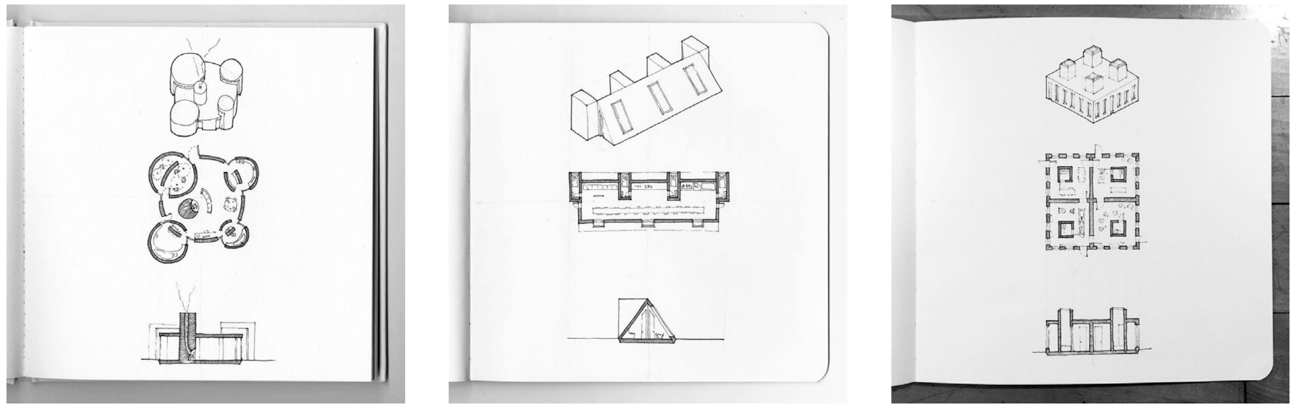
In the Spring of 2020, the world was put to a hold because of the COVID pandemic and many events were happening online rather than physically. This allowed me to digitally attend several conferences and symposiums on AI and architecture. As I was starting to think about my thesis, I got inspired by this new discourse for the architecture world and decided to focus my thesis work on learning more about it.
I am not a computer scientist, and had back then no experience in coding. To simplify my learning processes, I decided to feed existing data into existing algorithms. This seemed like an easier way to enter the world of artificial intelligence.
While reading on how AI can be applied to the disciplines of art and architecture, I found that Generative Adversarial Networks (GANs) were amongst the most named technologies.
GANs are efficient ML algorithms able to generate new data based on training sets. They were invented in 2014 by Ian Goodfellow. They are a combination of two artificial neural networks, a generator and a discriminator, which compete against one another. The generator's goal is to fool the discriminator by trying to imitate the training data, and the discriminator's goal is to distinguish between real and fakes. There is a feedback loop (independent backpropagation) so that over time the generator produces better samples, while the discriminator becomes more skilled at flagging synthetic samples.[0005]
Based on the very reduced amount of literature that was available at the time (or at least the literature I could understand), I decided to go with the most documented GAN architecture for image generation; StyleGAN, developed by NVIDIA.[0006]
This algorithm is openly available on the development platform GitHub[0007], as well as some pre-trained networks it generated. These networks are AIs able to generate images of people, bedrooms, cats...
These images fascinated me because they are *almost* perfect. The longer one looks at them, the more unsettling they become.



Architecture of a Generative Adversarial Network (GAN). Source:author

Portraits generated with StyleGAN. Source:NVIDIA

In order to use the algorithm to train my own network, I needed to first come up with a dataset. I read that to maximise chances of success, the training dataset should be as big as possible (the ones that NVIDIA used for their original paper were close to a hundred thousands images), or as consistent as possible.



Source:Andrew Bruno for @one_house_per_day[1002]

I thought about an instagram account called @one_house_per_day[0008]); In January 2020, Andrew Bruno started drawing one house per day in plan, section and axe and posting these images on this Instagram page.

The style was very consistent and the topic obviously interesting for me as an architect, so I decided to scrape the entirety of his account (it was around 300 at the time) and made a dataset out of it. Around that same time I attended a lecture on AI and the future of architecture by Stanislas Chaillou[0009]. Chaillou is an architecture graduate who used GANs to generate floorplans for his master thesis. (Figure 1) I wanted to try to do a similar exercise as a training, so I resized the One House Per Day (OHPD) dataset to only keep the floor plan parts. I obviously ran into many complications, because I am again not a computer scientist. But this process was a chance for me to start learning new skills. I did not fully understand the math behind it (and in all honesty I still don't), but after countless days and nights of trial and error, googling countless cryptic error messages, I managed to make these novel, AI-generated images (Figure 2).

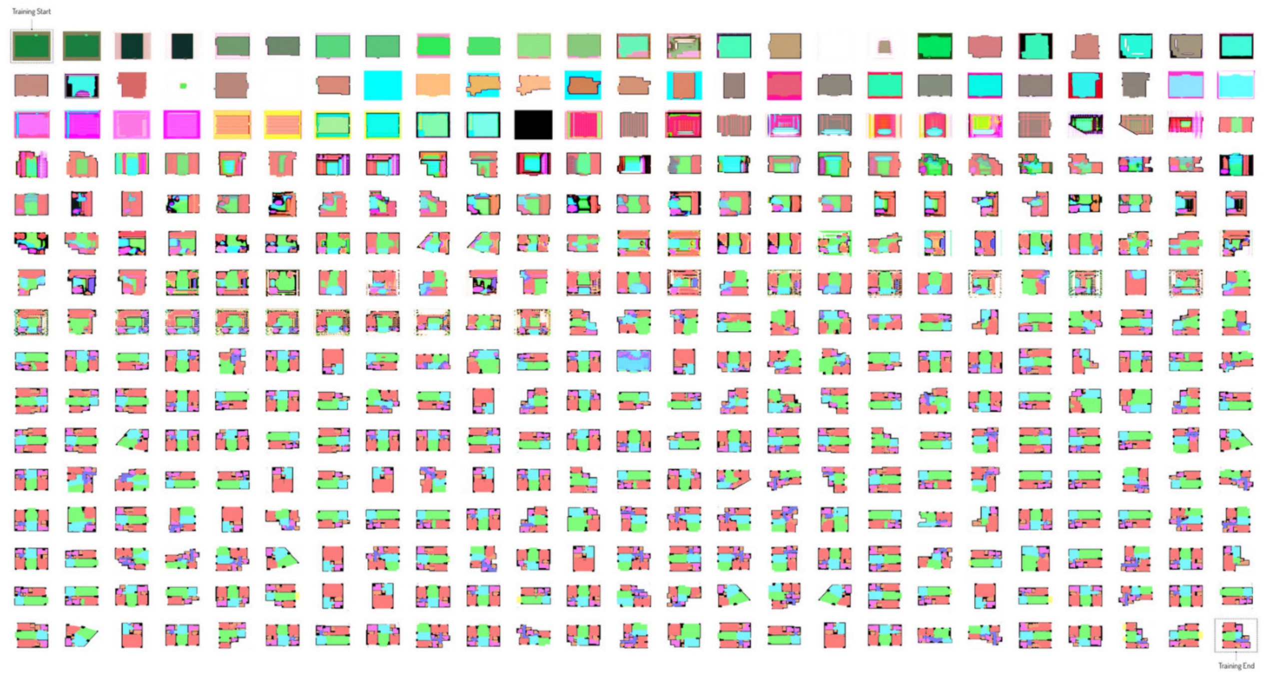


Fig. 1
Training Sequence. Source:Stanislas Chaillou[1003]

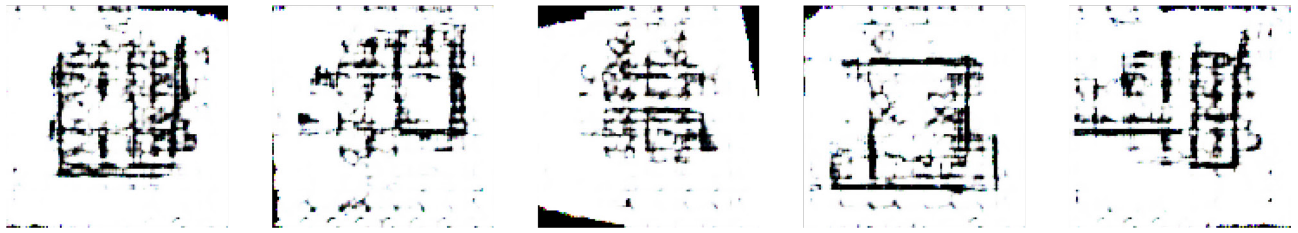


Fig. 2
First attempt at generating images using GANs. Source:author

I recall being overwhelmed with excitement looking at what most people saw as a pixelated Rorschach test, because I could feel the start of some architectural sense. There were walls which were getting thinner in some parts, suggesting windows and doors, there were rooms and corridors...

The following year I started my thesis semester, the global interest for GANs grew, and therefore more material on the matter became available online. My coding skills increased accordingly, and I learned for example that repurposing a pre-trained network to generate a different kind of output was more efficient than training a new one from scratch. For example using an algorithm that generates humans faces and teaching it to generate buildings works faster and better than just telling it to generate buildings from the start[0010]. Which is exactly what I did, and these were the images I generated (Figure 3).

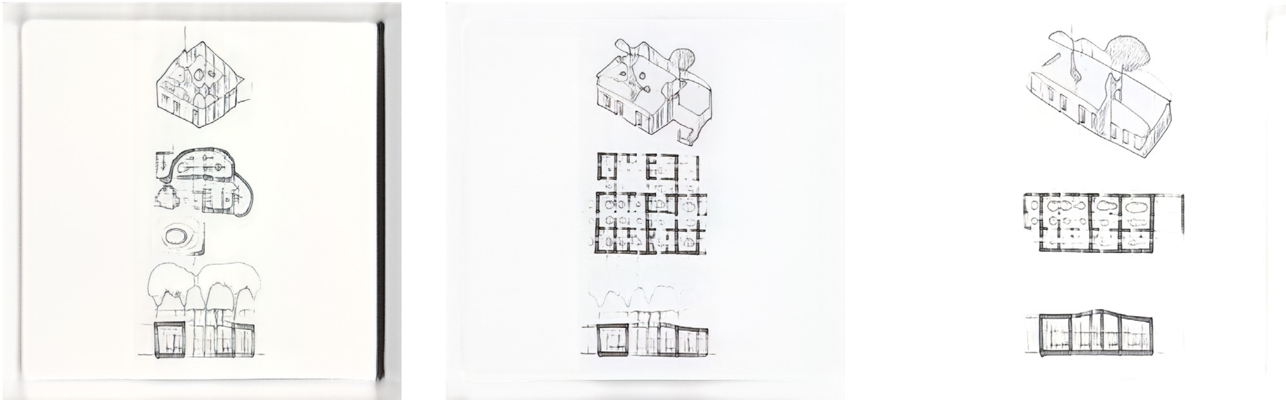


Fig. 3
Second attempt at generating images using GANs. Source:author

This time I did not limit the training to just plans but extended it to the combo plan/section/axos.
I wanted to see if the computer could understand the relationship between a plan and a section. Studying the results I believe it recognised the patterns to some extent. Because these results look very promising, I wanted to try something on a bigger dataset. That's when I scraped the instagram account @axo_madness of its 800 axonometric views and fed them to my algorithm. I liked the aesthetics of the resulting images (Figure 4) so much that I decided to start my thesis work on these premises.

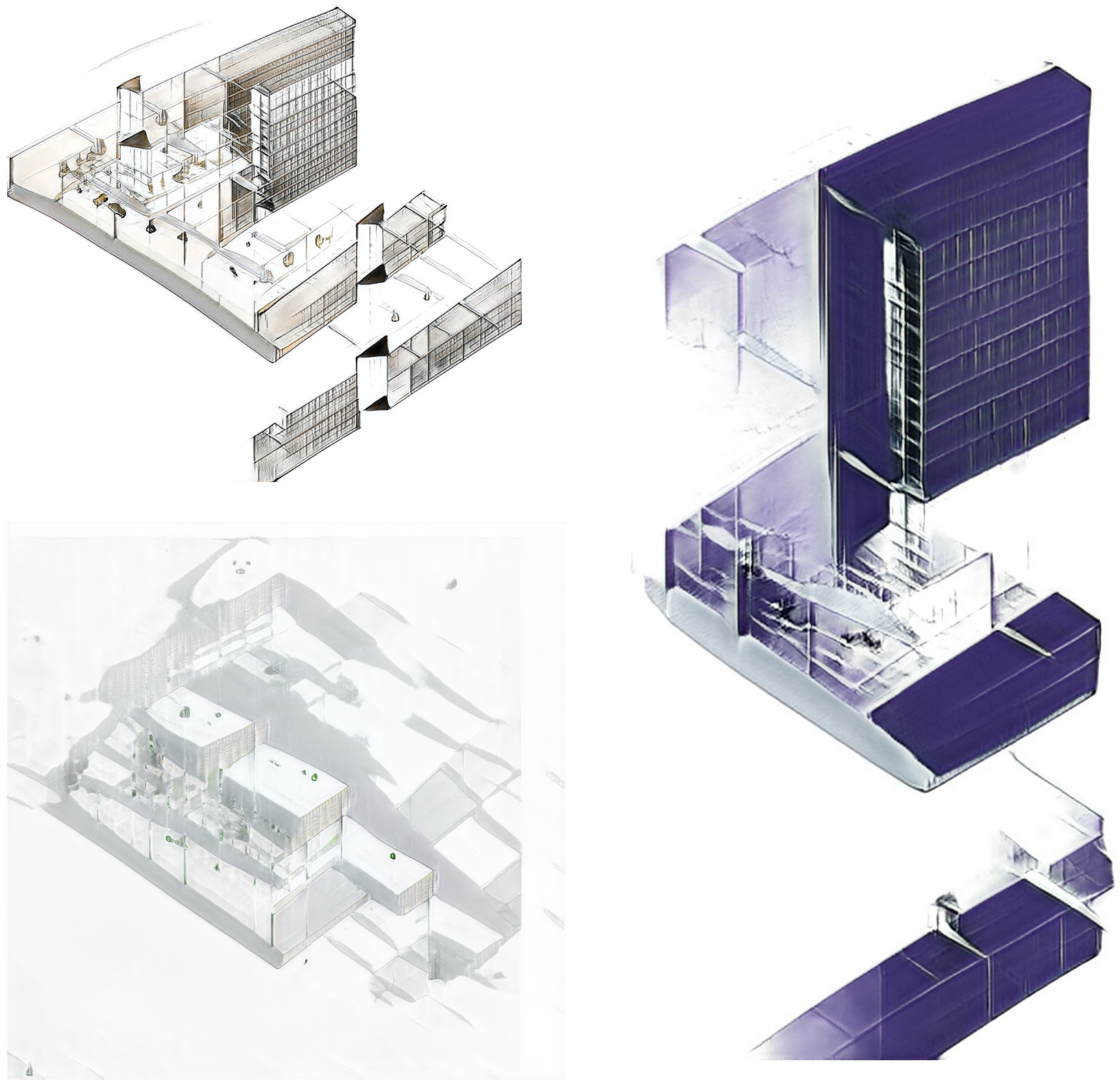


Fig. 4
Images generated on a GAN trained on 800+ axo views. Source:author

What is creativity?

If you are reading this, chances are you are human.

You experience the space around you through sight and hearing. You can feel walls by touching them. You can smell the distinctive scents of coffee, of spring flowers, of pizza which gives you clues on where you find yourself.

If you are reading this, chances are you are creative.

Maybe your work is even qualified of creative and involve designing spaces. Even if it doesn't, you are creative; everyday you use language to speak sentences that have never been spoken before. Creativity is to some extent what makes us human and has allowed our species to evolve into complex civilisations.

Why Are We Creative?. Source:Celluloid Dreams[1004]

AI : Architects Inferiority?

The documentary Why are we creative (Vaske, 2018)[0011] condenses 30 years of interviews. The director Hermann Vaske asks artists, political leaders, scientists the same question : Why are you creative?. The answers he got are as diverse as they are interesting. It seems that creativity is a widely debated topic. In other words, everyone is creative, but differently.

To help me approach the topic, I had a short discussion with Eva Hoff, an Associate Professor at the Department of Psychology at Lund University and a researcher *inter alia* on the measurement of creativity, the development of creativity and imagination.

A discussion with a creativity expert
Eva Hoff (Lund University)[0012]

Aloys Heitz (author) : It seems that the definition of creativity is a rather debated one. How would you define it?

Eva Hoff : There is not much of a debate regarding the definition of creativity, at least within the field of Psychology; most researchers agree than in its most basic form, creativity is the ability to form unusual or original ideas, given that these are also useful. This is the ground definition that Terese Amabile or Robert Sternberg give in their work, just to name two.
So it is important for an idea to be useful in order to be qualified of creative. You can do something very original but if it serves no purpose, it is not creative. Usefulness can however be problematised in many different ways. In the field of the Arts for example, the concept can be extended to meaningfulness. This is where there might be a debate to define what is creative and what's not.
What about AI and architecture? Would you say AI is useful in this context?

My hypothesis is that we can enhance human creativity by using these algorithms, to help us think outside of the box and getting inspired in ways we have not thought about before. Maybe this brings me to my next question, do you think creativity inherently human, or could other agents (ie. a machine) be creative too?

I suppose people who work with artificial intelligence seem to already say that it can be creative.
I doubt it (laughs) but I know AI is getting better at it. There are some animals that are creative (crows for

example will fly very high up and drop some food they can't open up with their beak). There is experiments that determined that some birds and cats can find creative solutions to problem, with a bit of trial and error, but they can find new ways.
But to be creative, there is a need for a huge database, that's what humans have. If you have a lot of knowledge in an area, then you can possibly also invent new things, build upon the bases you have but without knowledge you can't be creative. If you haven't been taught an instrument, well you can't play it.
People often say that children are very creative, that is a little bit mistaken. Because children don't have a lot of knowledge and experience, what they do is more play or fantasy. What they do isn't necessarily novel nor useful. Of course it can happen, but it is more likely to be accidental. Adults are in a greater capacity to be creative than children. But on the other hand some adults listen too much to their inner knowledge and are afraid of stepping away from what they know. In that sense knowledge and experience can also be a hinder to creativity.

In AI, the equivalent would be overfitting (trying to replicate exactly the training data) on one end and generating random noise (chaotic result) on the other. Creativity would then be an equilibrium between copying what you know and have experienced, and doing something completely random and useless.

Exactly, and one of the major resources humans have in that sense is the ability to take inspiration from a completely different area. This is still within your experience and the realm of what you know, but this ability to associate thoughts that seemingly have nothing in common to handle complex problems is a human characteristic. Humans also have the ability to make analogies in a way no other species can. I can think about and solve a complex problem I have even though I am doing something completely different or standing in a very different place, because I can connect these things.
There is a lot of famous inventions that have been using this analogy thought framework.
In that sense, maybe machines lack this "out of the box" vision, and the ability to venture far off their area of expertise. Human creativity depends on coincidences, not all humans can invent the same things because the way they think about things and the way they solve problems depends on their knowledge and experience.

GANs are great at understanding patterns and becoming expert in a specific area (ie. Generating a specific kind of images) but they can't really get inspiration from other areas. Their creativity if they have any seems rather limited compared to humans'. But if we project ourselves in the future, do you see AI posing a threat to human creativity?

Creativity is a human characteristic. Everyone uses creativity in their everyday life, maybe in ways that are not novel or useful for the world, but at an individual scale they are.
This is a difference between what is called big 'C' Creativity, or when an idea changes an entire domain on a global scale, like the way Picasso would produce art, and small 'c' creativity. No one had done what Picasso did before, so he changed the way artistic representation worked.

AI : Architects Inferiority?

If AI could create these shifts on a global sense, maybe it could threaten humans. But I don't see it threatening small 'c' creativity, which refers to the everyday life creativity, like experimenting a new recipe, trying a new outfit, etc. I don't think I would rather go to my phone and ask it for a way to solve my problem, I don't think that would ever happen because it would mean I stop thinking myself. It would be so much quicker for me to use my own brain.
AI would not threaten creativity as a human characteristic.
To go back to the arts, would we program an AI to do new kinds of drawing? I wouldn't be surprised at all if some artists were already doing this. But then would the programmer be the artist? Or the program itself? And would these artworks even be sellable?

There is actually a young market for AI art. And I think your question on authorship is very relevant, it is a very complex problem.

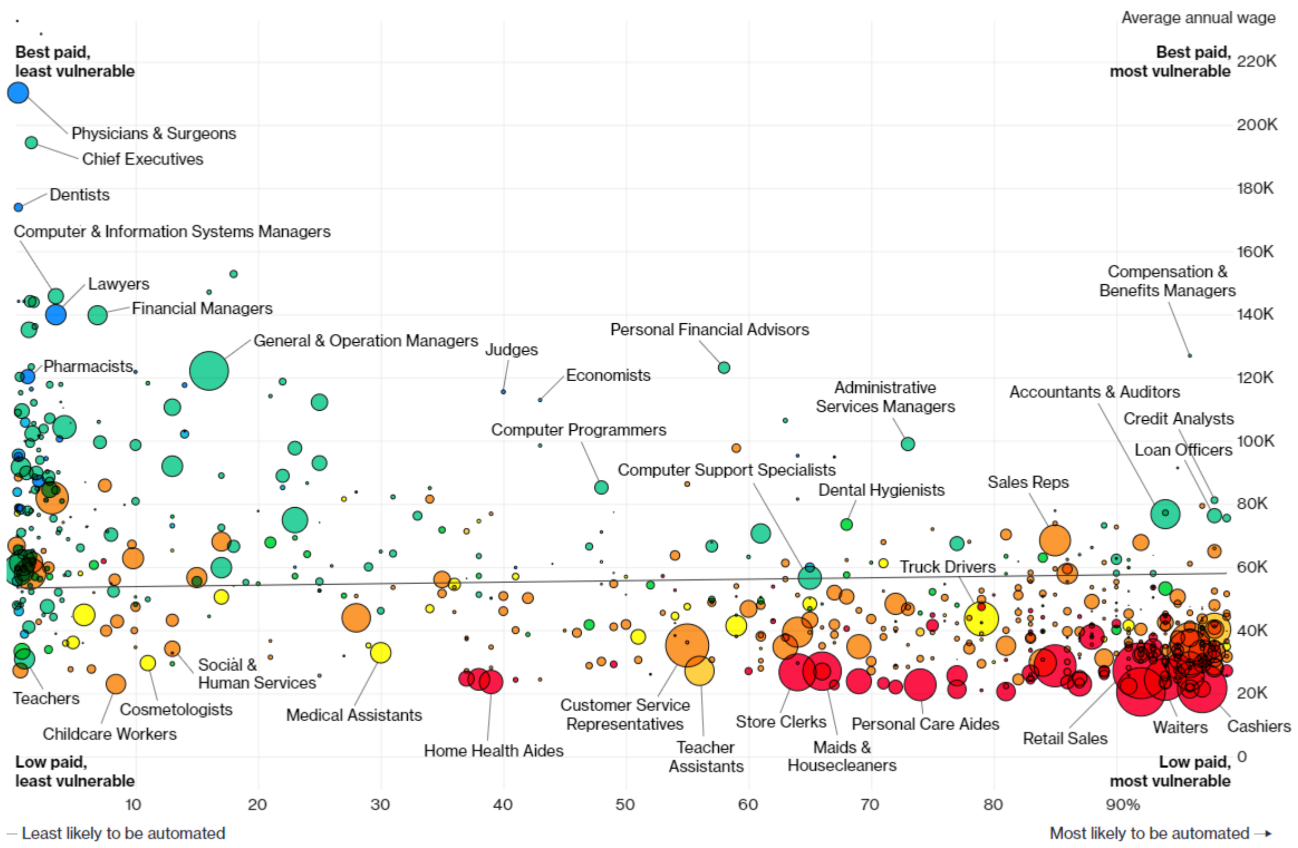
But certainly there is also pleasure in creating, when a painter paints, or a musician compose, there is a certain joy in that. Even though a machine could do it quicker, the artists would probably still want to do it themselves. Or what do you think, as a member of a creative domain?

There is definitely a thrive for creativity in architecture, but I can see how these algorithms could potentially be used to accelerate production and decrease costs. The issue is that these algorithms are managed by people who were not trained to design spaces and their influence on humans. There is a need for reflection on how we as architects can take ownership of this discourse.

I suppose you are right, it is better that you learn how to use it rather than letting it in the hands of people who don't have the kind of experience and knowledge a trained architect would. But then there is the question of how much it actually adds to a project. As I see it, I guess it could be another tool to get inspired, a way to invent precedents that don't exist, but I don't think it could take over the whole process, because construction projects are so incredibly complex.

Automatic architecture

In 2013, Frey and Osborne[0013] examined 702 jobs and ranked them based on the risk of them being automated. Jobs that require empathy, creativity or a high level of social intelligence were the least at risk. Thanks to these factors, architects were ranked 81 least likely to be automated, with a risk of 1,8%. At the bottom of the list (less than 1% risk) are occupations like nurse, psychologist or speech therapist, which all require human interaction, care for others and empathy. At the very top of this list (more that 95% risk) are bank, post office or library clerks. While these jobs also involve human interaction, they do not require a



Data:Frey & Osborne/Bureau of Labor Statistics. Source:Bloomberg[1005]

Max Tegmark's illustration of Hans Moravec's "Landscape of human competences", where elevation represents difficulty for computers, and the rising sea level represents what computers are able to do.

Hans Moravec's Landscape of human competences. Source:Max Tegmark[1006]

high degree of social intelligence, which put them at risk.

This particular study has not been updated since then, but it can be argued that these percentages might increase unexpectedly thanks to advancements in computational power and artificial intelligence. In The Second Digital Turn (2016), Mario Carpo argues that architects and designers embraced the digital turn of the 1990s sooner than other fields because we could see the enormous potentiality of mass-customisation. Bespoke and custom-made designs have always rhymed with high costs. The advent of Computer Aided Design (CAD) softwares, along with digital fabrication, meant that we could use technology not to mass produce, but to mass customise. Going against the trend of standardisation and mass-production, digital design promised a future where everyone could enjoy bespoke products and environments, without investing significantly more money and energy. After the burst of the internet bubble and in the rise of the participatory "Web 2.0", the 2000s saw major developments like Facebook or Wikipedia. The design world shifted accordingly from mass customisation to mass collaboration. The most notable example is the quasi systematic use of Building Information Modelling (BIM) in architecture companies today.[0014]

However, architects have mostly just been transposing the manual work they used to do with pen and paper on to the computer. This is argued by Neil Leach in his essay There is No Such Thing as Digital Design (2018)[0015]. Therefore, despite most designers being digitally intelligent, these tools are mainly used as a way to automate or accelerate manual processes.

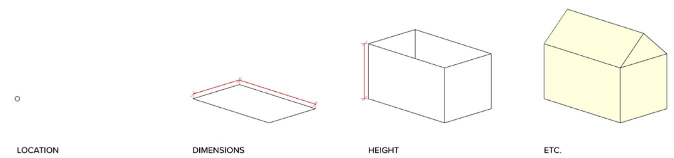
The democratisation of parametric design in architecture, both in academia and in practice, might give the impression that architectural design has gone truly digital. But I would argue that even though parametric design permit shapes that could not have been done by hand, designers still follow a manual logic, detailing how scripts works, one command at a time.

I acknowledge that evolutionary algorithms (like the Grasshopper's component Galapagos, released in the late 2000s by McNeel) could challenge this theory, but the fitness parameters required need human

decisions and this still leave too little room for true machine creativity.
There is here a need of precision of the difference between Parametric Design and ML.
While working on this thesis, several people asked me if I was using visual coding software Grasshopper. I understand the confusion as a generalisation of digital processes that use some sort of coding skills. But there is a major difference between parametric design and machine learning; In Grasshopper definitions and other coding languages, the rules are set. They follow a human logic because a human or a group of humans had to think about them. In machine learning, the rules are not explicit, they are found by the algorithm. ML algorithms learn to replicate characteristic, and humans don't have any kind of agency in the learning process. The program builds up its own intuition based on the data it is fed.

Parametric design

Framework



Variations

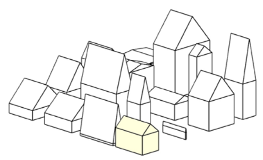
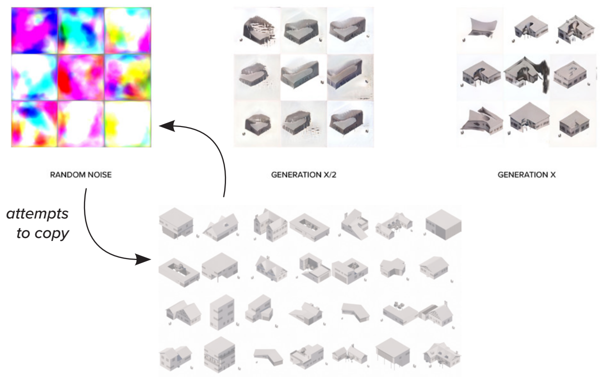


Diagram explaining the framework of parametric design. Source:author

Machine Learning

Framework



Variations

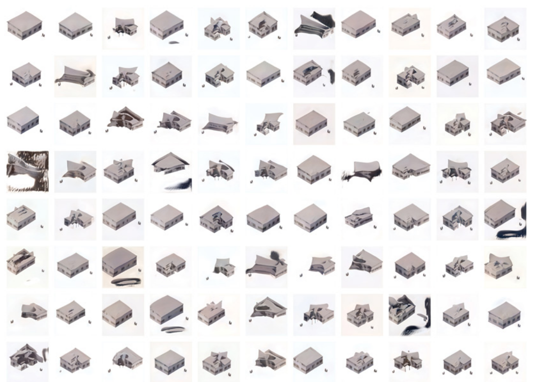


Diagram explaining the framework of machine learning. Source:author

The idea and the craft

-- The idea will always be more important than the craft --
Daniel Wenzel, 2019

Computers are tremendously better at craft than we are. But what happens if they become better at formulating ideas?

DeepBlue and AlphaGo are two programs that can play chess and Go, respectively. Both programs have entered history as the firsts to beat grand masters in tournament condition. In 1996, DeepBlue beat Garry Kasparov (back then world chess champion) by playing an "incredibly subtle move".[0016] In 2016, AlphaGo beat Lee Se-dol (a Go master) with a " killer move, a move no human player would have made"[0017]
In both these cases, the machine beat the humans by "thinking" outside of the box and finding new ways of playing that were more efficient than the humans'. These examples prove that anthropocentrism is not relevant in machine creativity : computers have their own way of thinking and it is very different from humans'.

There are some sounds we cannot hear, some light we cannot see, some scents we cannot smell... What if there were also some thoughts we could not think of ? Some ways of thinking our brains are effectively unable to produce ?
This is where I see the true potential of GANs as creative collaborators. Human bias means there is a limitation to creativity, and these non-human collaborators could help us find new ways of designing.

In the foreword of Robotic Building (2019), Mario Carpo explains that "in the 90s computers were seen as tools for making [...], today computers are again being

hailed as tools for thinking”.[0018]
Today we need computers for mathematical operations our brains can not deal with, but they remain tools; we give them some input and they give us a mathematically correct answer we were looking for.
AI Art already exists today, and there are numerous artists who use ML to create, but wether it is Mario Klingemann referring to the ANNs he works with as his paintbrushes[0019] or Refik Anadol using data as pigment[0020], computers are still mostly used as tools and therefore encaged by human limitations.
I want to challenge this notion by exploring the potentiality of seeing computers as *collaborators* instead of tools.

As Slavoj Žižek agues in the documentary Why are we creative (Vaske, 2018), “True creativity is order. Any idiot can have an outburst of creativity, but it is putting ideas into form that truly define creativity.”[0011]. Computers deal well with order, with their memory depending on location and precision. On the opposite, human memory is auto-associative; it works with association rather than location or precision. We saw earlier that this is one of the characteristics that enables us humans to be so creative, formulating abstract thoughts and drawing inspiration from seemingly unrelated areas. In that sense, I wonder if using ML algorithms as collaborators in creative industries could enhance our creativity, bridging the gap Žižek mentions : we deal with the creativity outbursts because they come naturally, whereas the computer puts it into form because they are inherently order.
I said earlier that computers are better at craft than we are. On this matter, we have to reflect on what craft means for us as humans, and how we celebrate imperfections. Mass-produced objects are cheaper, because of the economy of scale, than hand-crafted ones. We also attribute more value to handcrafted objects because we know someone spent time fabricating them.
Portrait d’Edmond de Belamy (2018), is a print on canvas realised by the French art collective Obvious.[0021] The artwork was generated by a GAN, trained on a set of 15 000 portraits taken from online art encyclopaedia WikiArt, and spanning from the 14th to the 19th century.[0022] It went down in history as the first piece of art created using artificial intelligence to be featured in a Christie’s auction, selling for $432 500.

This introduces the question of tool and authorship.

Edmond de Belamy (Obvious (collective), 2018). Source:Obvious[1007]

In the case of a 14th century portrait, the author is the painter, the tool is the paint brush and the support is the canvas. Edmond de Belamy was allegedly created by Obvious. But should credit be also given to the thousands of painters who painted the different portraits in the training dataset? To Robbie Barrat, who wrote the specific code Obvious used to generate the portrait publicly available on his GitHub page?[0023] To Ian Goodfellow, who invented the principle of GANs altogether? Or even to the Artificial Neural Network (ANN) in itself? Despite being non human, it did craft the image.
Whereas these notions were very clear and straightforward with a traditional painter, they become blurry and interconnected in the world of AI Art.

-- All tools modify the gestures of their users, and in the design professions this feedback often leaves a trace--

Mario Carpo, 2016[0024]

This sentence from Mario Carpo in The Second Digital Turn (2016) brings us to extrapolate that the use of computational collaborative agents in architectural design will lead to new styles. Styles that would originate in human design but would be inherently alien, because not created by human beings *per se*.
The widely recognised 3D-printed architectural project Digital Grotesque imagined by Michael Hansmeyer and Benjamin Dillenburger, and exhibited in two exhibitions in France in 2013 and 2017, sets a first milestone in what post-human aesthetics would look like.[0025]
Of course, looking back at history, it seems like anticipating the evolution of aesthetics on the long term is an extremely hard endeavour. What we deem technologically advanced and the aesthetics we associate to it varies greatly over ever shorter period of times (Figures 5 & 6).

AI : Architects Inferiority?

Fig. 5
The evolution of what we see as technologically advanced is very fast paced. Sources : see references 1008, 1009, 1010, 1011 & 1012. (p.100)

Fig. 6
Digital Grotesque II (Dillenburger & Hansmeyer, 2018). Source:Fabrice Dall'Anese[1013]

Chapter II

Design Report

Seed 4197. Exterior view. Source:author

AI : Architects Inferiority?

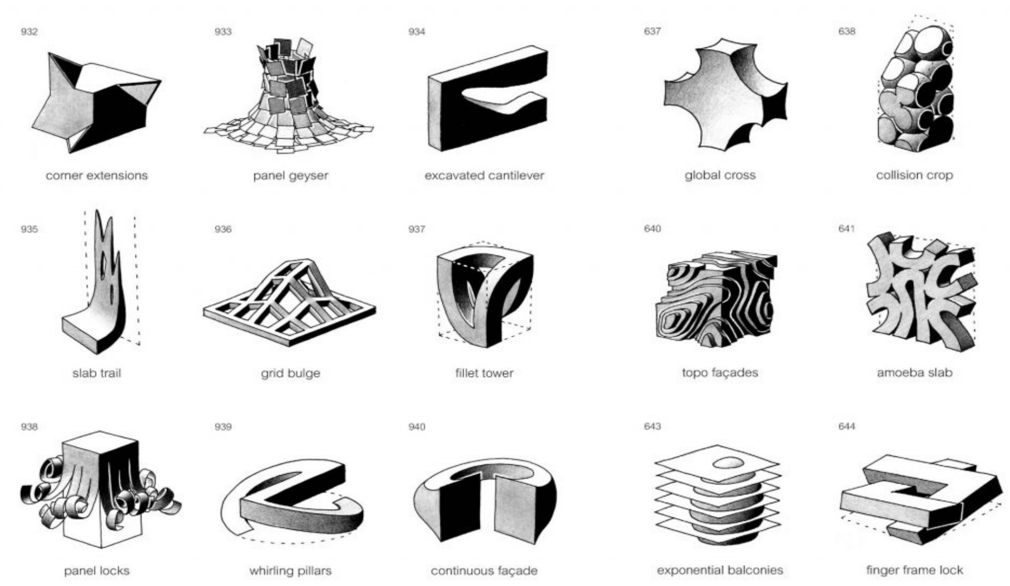
Siteless architecture

The ultimate goal of this potential design framework was never intended to solve all form finding and to put architects out of job. I rather intend to explore the potential of machine learning as an extension of the tools that are used today in concept design phases.

To illustrate and test this feature the best, I decided to design a building.

This building is meant to be a summer house for a family of four, as this is the most rudimentary architecture program I could come up with. This fictional family would have a substantial budget which would allow me to gain a certain freedom in terms of material choices.

Since this thesis investigates a concept design generation framework based mainly on form finding, the building site is not so relevant. In this regard, throughout the project I always considered a rectangular flat site, in Southern Sweden, without any specific condition.



Siteless building forms. Source:François Blanciak[1014]

A new architectural design framework

Presentation of the design process

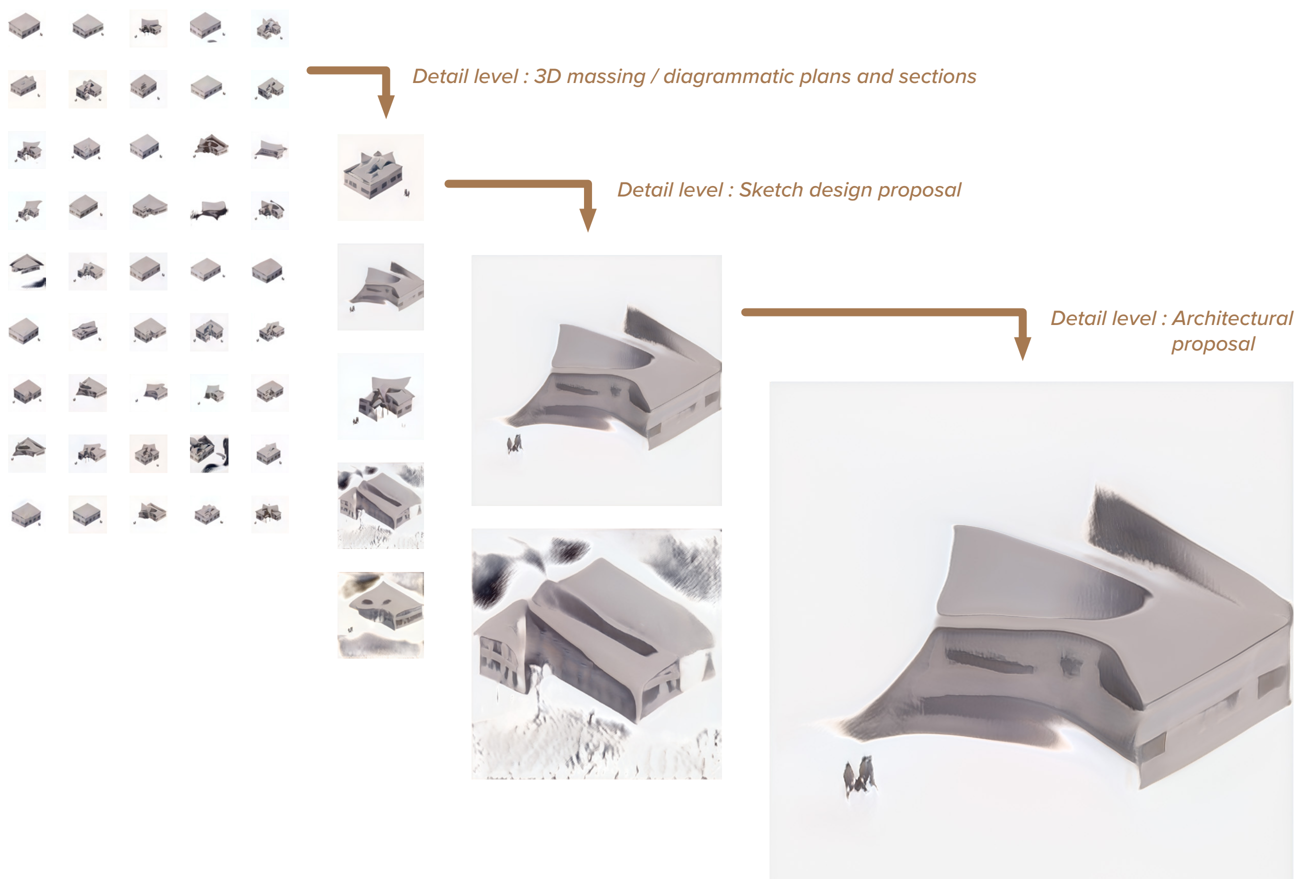
Along with coming up with an architectural proposal for a summer house, I explored several roles that architects might take in the future. In this regard, I distributed the design process into four different roles. The different roles informed each other greatly and by consequent, the structure of the thesis adopted a temporal linearity rather than following the four parts one after the other. In the following pages, and as I explain the design process, the different roles I took will be highlighted by the colour scheme specified below.

CONCEPTUAL ARTIST

In this role I will produce a dataset of precedents to train the algorithm on. This conceptual process means that I will have control over what the algorithm will understand as a summer house. In other words, the algorithm will be an extension of my architectural style.

TECHNICIAN

If you were to go on any job search portal right now and type “architect” in the search bar to look for open positions, most results would advertise roles in IT services, IT consulting or IT engineering. The world of data science already chose the nomenclature of our field to name theirs. In this role I will design digital structures, rather than physical ones, by writing and fixing a Generative Adversarial Network (GAN).



Curation process. Source:author

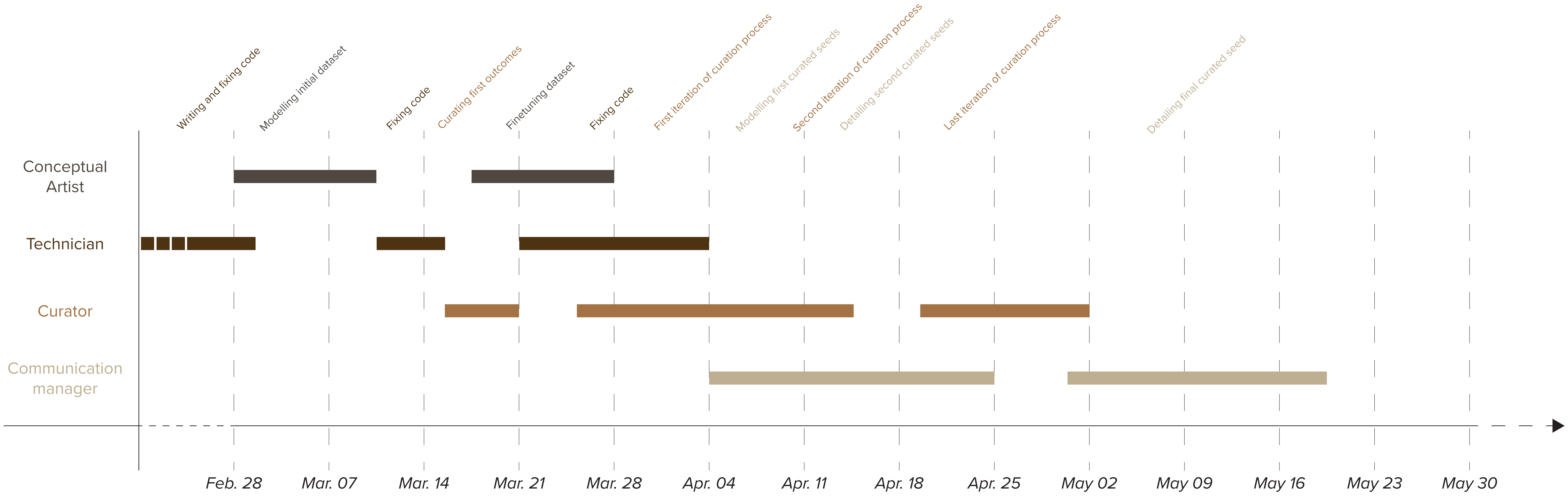
CURATOR

Once the GAN has been trained and starts producing novel houses, I will assess these outputs using my own evaluation method. I aim to evaluate a very large amount of machine-generated typologies and curate them to a decreasingly smaller amount of options. I will proceed iteratively, refining the level of details with each selection round.
This selection process is illustrated above.

COMMUNICATION MANAGER

I will design a summer home based on the reduced amount of options I would have had selected before. This role might be the one that is closer to the one of a current architect, only I will not work under the supervision of a senior architect or a design lead but follow the ideas of the algorithm and serve as a bridge or translator between the artificial network and the imaginary client.

AI : Architects Inferiority?



Timeline of the design process. Source:author

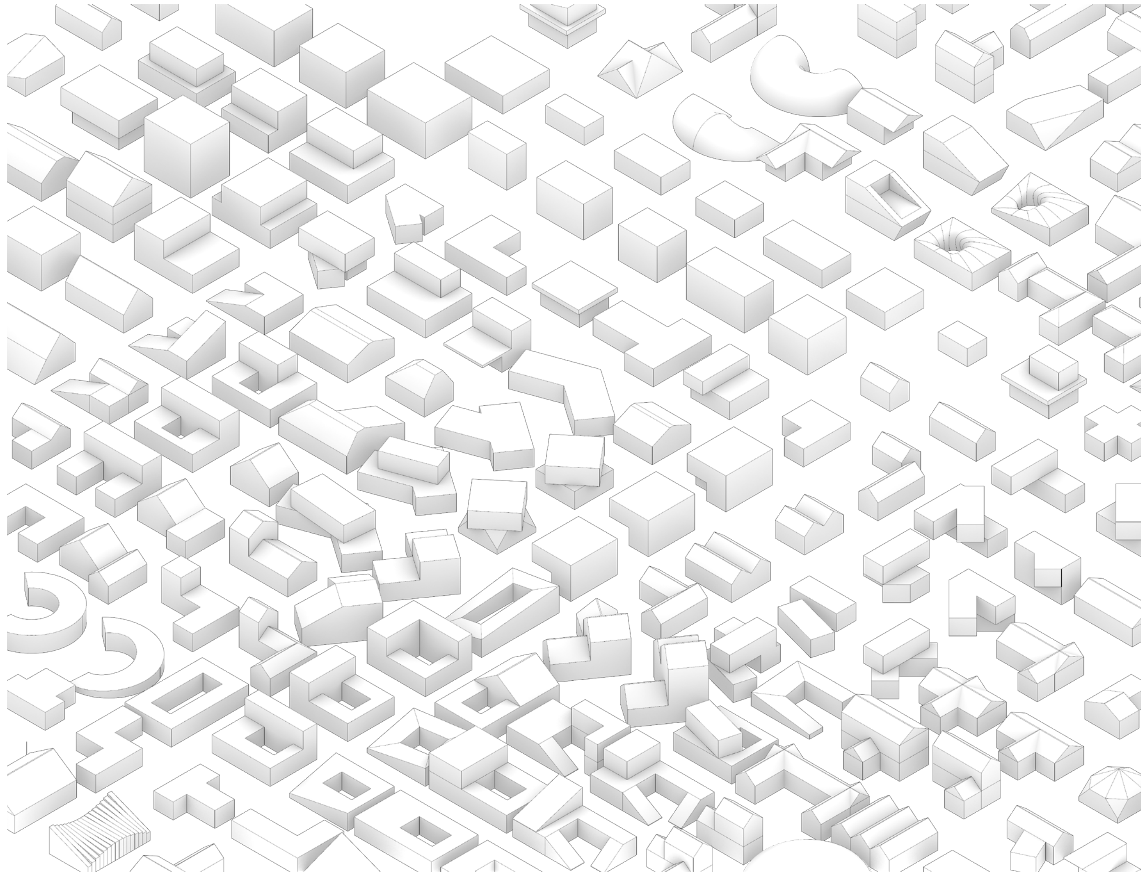
Step 01 : creating the initial dataset

To start this project, I needed data.

In order to start training my GAN, and based on my previous experience with existing datasets, I evaluated that in order to have acceptable results, the minimum size of the training dataset is 200.

I thus imagined 200 family homes typologies inspired by houses found in the Scanian countryside.

Creating that amount of houses required an effective framework in order to cut down modelling times. I started by creating just massings.

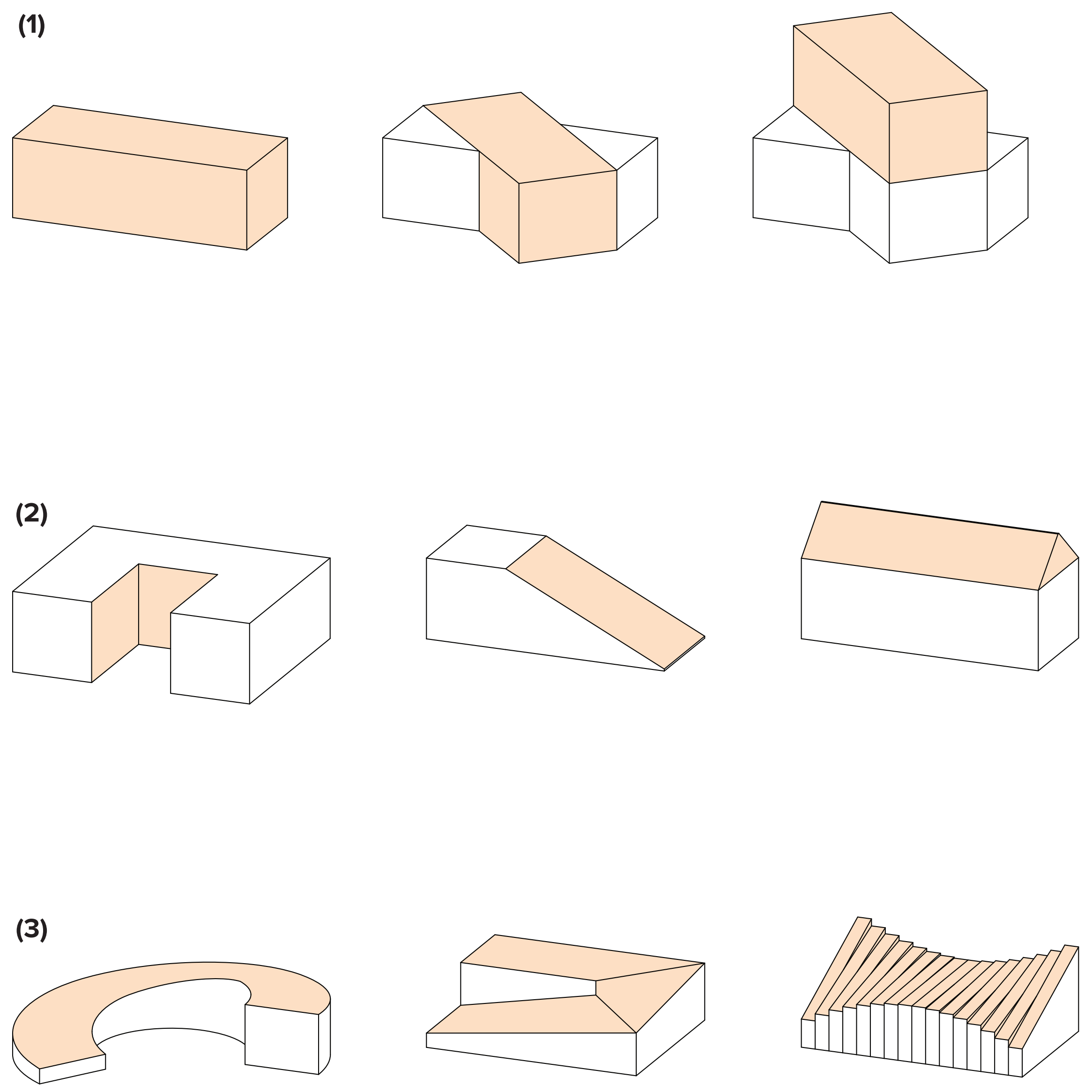


Massing dataset. Source:author

These massing were at first responding to basic geometric rules : basic blocks being rotated, superposed, mirrored, etc. (1) As these basic configurations were being exhausted, I moved to adding pitched roofs, slopes, inner courtyards, etc. (2)

Towards the end of the series, and as inspiration was drying out, I added some rather experimental or unusual structures. (3) I deemed this form diversification crucial to get a greater range of results, to teach the algorithm that a house can come in many shapes.

AI : Architects Inferiority?
Conceptual artist

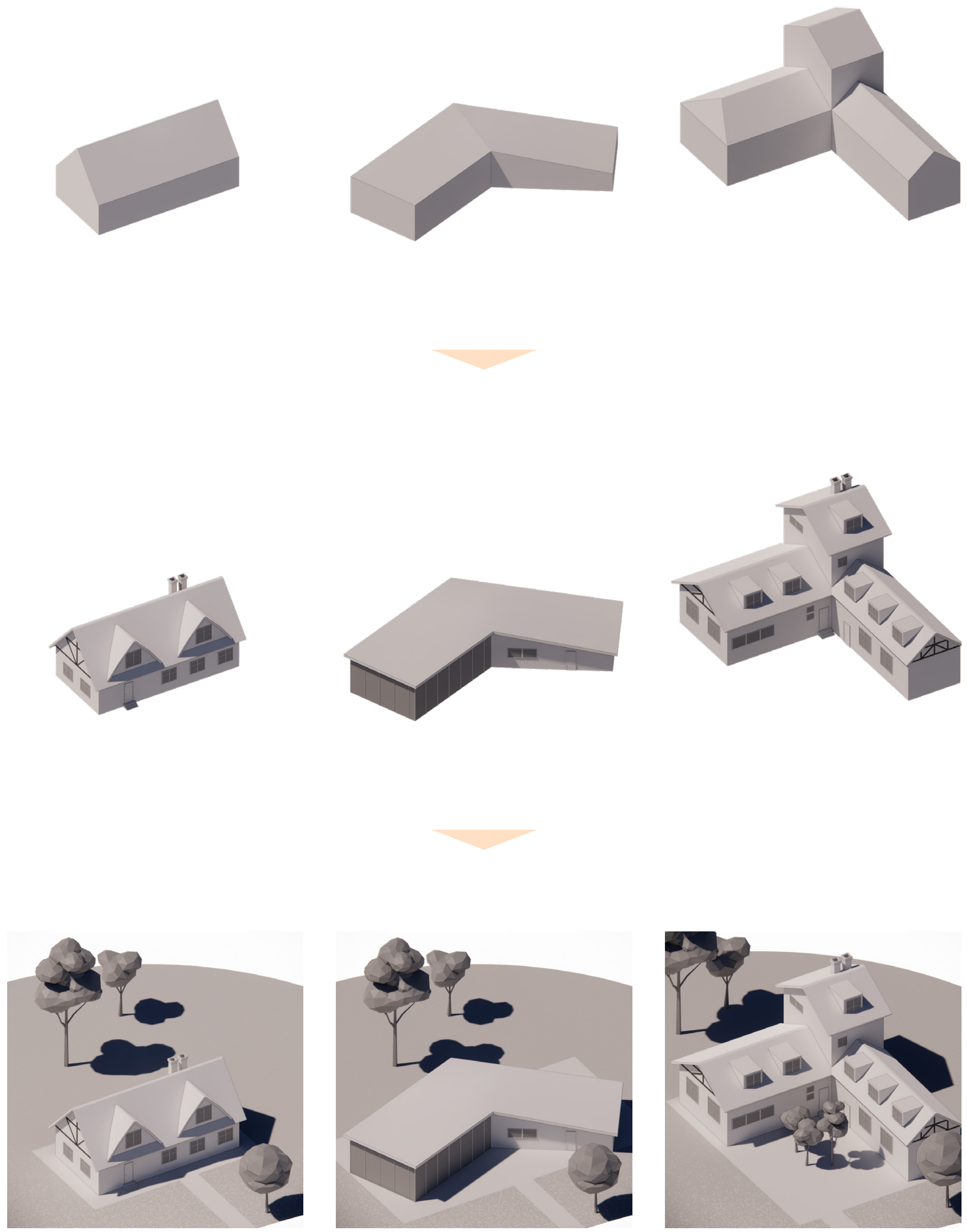


Massing buildup methods. Source:author

Having this database of solid objects, evoking to some extend the work of François Blanciak[1014], I created a small library of processes to add details (grasshopper definitions to generate stairs, balustrades and glass curtain walls/families of blocks for windows and doors/groups of poly surfaces for dormers and chimneys...).

These images show the first attempt at making the detailed houses. The level of details is still rather rough because I wanted to first test the algorithm's ability to understand the general shapes before adding more complex notions. In order to give these houses a sense of scale, I placed them on a little context disk with very basic landscaping.

All 200 of these houses are laid out on the next double-page.



Detailing process. Source:author

AI : Architects Inferiority?
Conceptual artist

Initial dataset. Source:author

Technician

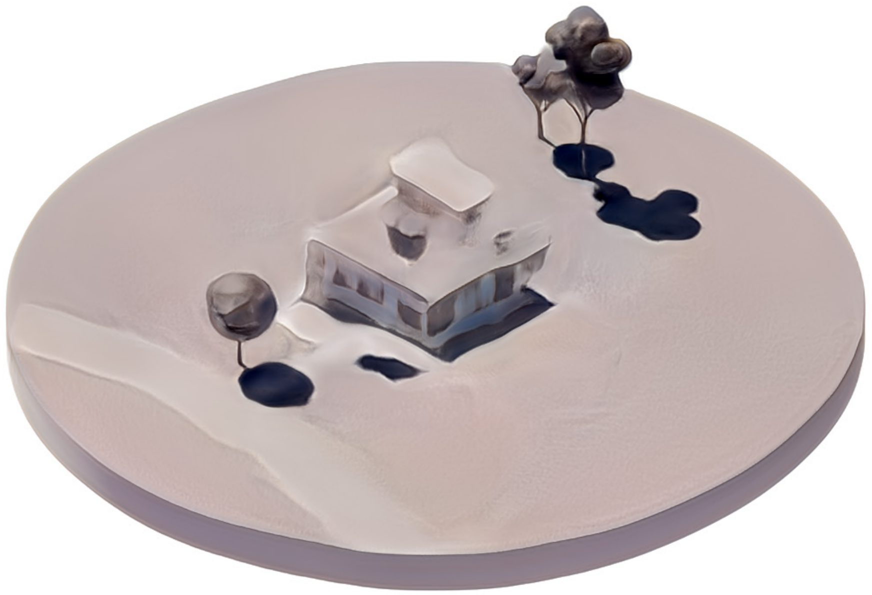
Step 02 : training the networks on the initial dataset

By the time I started the design phase of my thesis project, I had already had some experience using the algorithm and successfully generated at least two sets of novel images. The code was working well and when I started training my first dataset, I was not expecting to run into any problem. However, I noticed the time frames of one training cycle were much longer than when I was training networks on the axomadness dataset or the OHPD one : In March 2021, the speed of one epoch training was 482 s/kimg (second per 1000 images). In March 2022 it is 1879.27 s/kimg.

I could not really explained such a huge disparity in training time, because the images were the same size and I was using the same algorithm... Since the start of my interest in ML, I have been using the platform Google Colab, which allows to run code using Google's GPUs in the cloud. This service is free and accessible from any computer because it is online. When I first used it, I was allocated Tesla V100 GPUs. This is amongst the world's most advanced GPUs, it is used in the most cutting-edge AI centres worldwide and is worth several thousands of dollars. This is one of the reason Colab became extremely popular; anyone with an internet connection could get access to state of the art processors, for free. Since then, Google has downgraded the GPUs available and according to several reddit posts, no one, not even the paying subscribers, get the coveted V100s anymore[0026]. So I have to train my dataset on K80s and T4s GPUs, which have respectively 3 and 1,5 times less transistors (hence 3 to 1,5 times slower) than V100s, on which I trained the axomadness and OHPD datasets.

AI : Architects Inferiority?

Technician



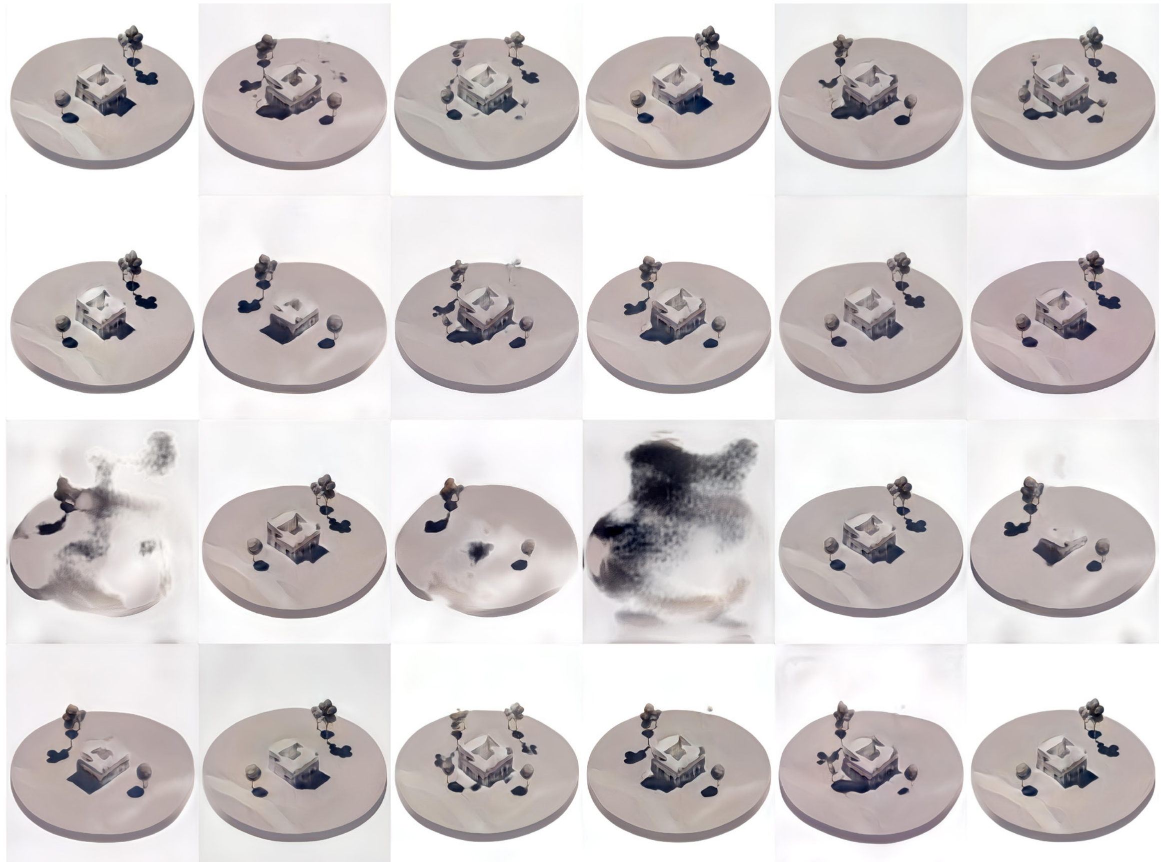
First acceptable output from the GAN. Source:author

AI : Architects Inferiority?

First outputs from GANs trained on the initial dataset. Details. Source:author

Using the first database, I quickly started to realise that the little landscape disk, here to add a sense of context and scale was in fact adding to much disturbance for the GAN. It was not really focusing on the building but rather on the trees around. In these examples one can see the buildings look very similar while the changes are focused on the surroundings.

I thus had to go back to my conceptual artist role and to edit out this context disk.

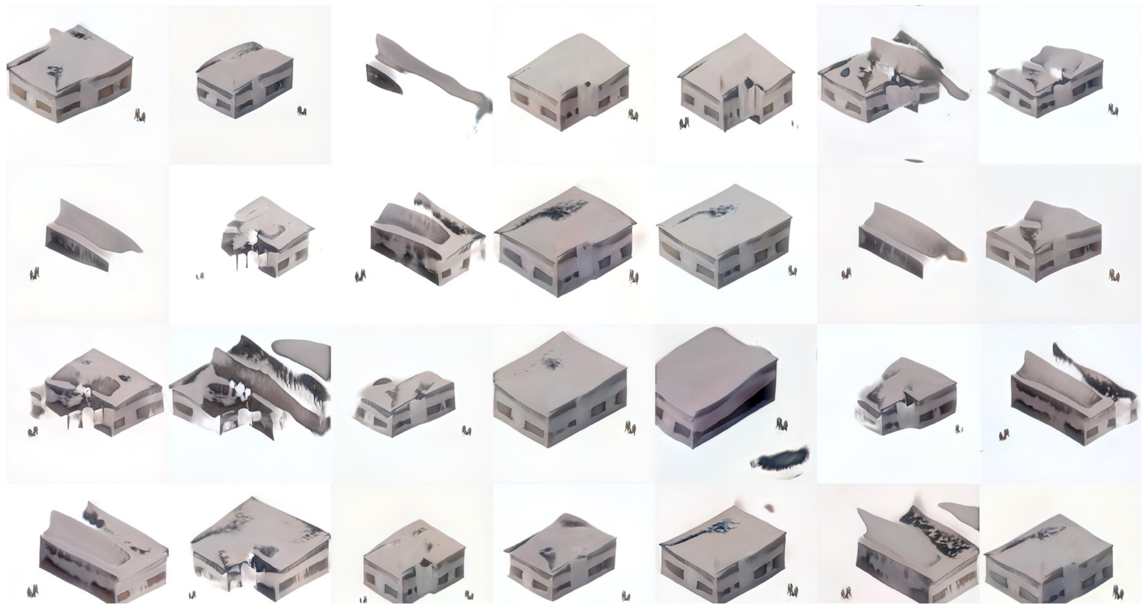


First outputs from GANs trained on the initial dataset. Source:author

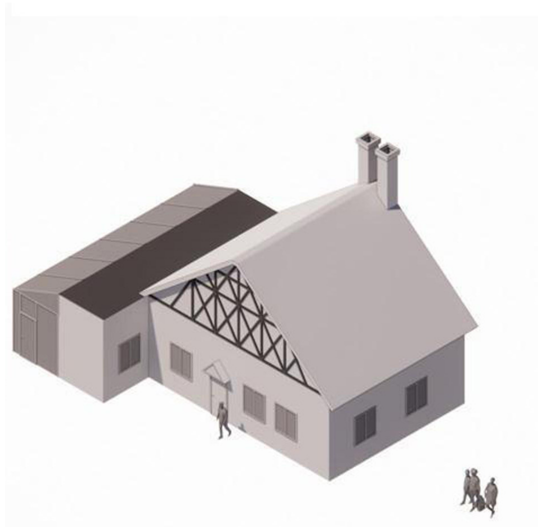
Curator

Step 03 : fine tuning the training dataset

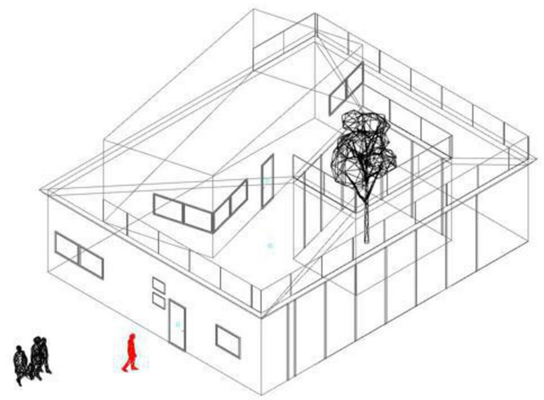
I went back to the dataset to edit the landscape disks out. In order to keep a general sense of scale in the images, I added some scale figures to the models. The level of detail is still quite rough but it worked fairly well. As seen on these examples, an architectural sense started to develop and most of these images would be understood as buildings by anyone looking at them. Since the overall massing remained a bit blurry and it was hard to understand the inner room layout, I decided to add the same houses seen in wireframe mode, to see if the algorithm could perceive the depth of the houses and develop a more three dimensional understanding.



Outputs from GANs trained on the first edited dataset. Source:author

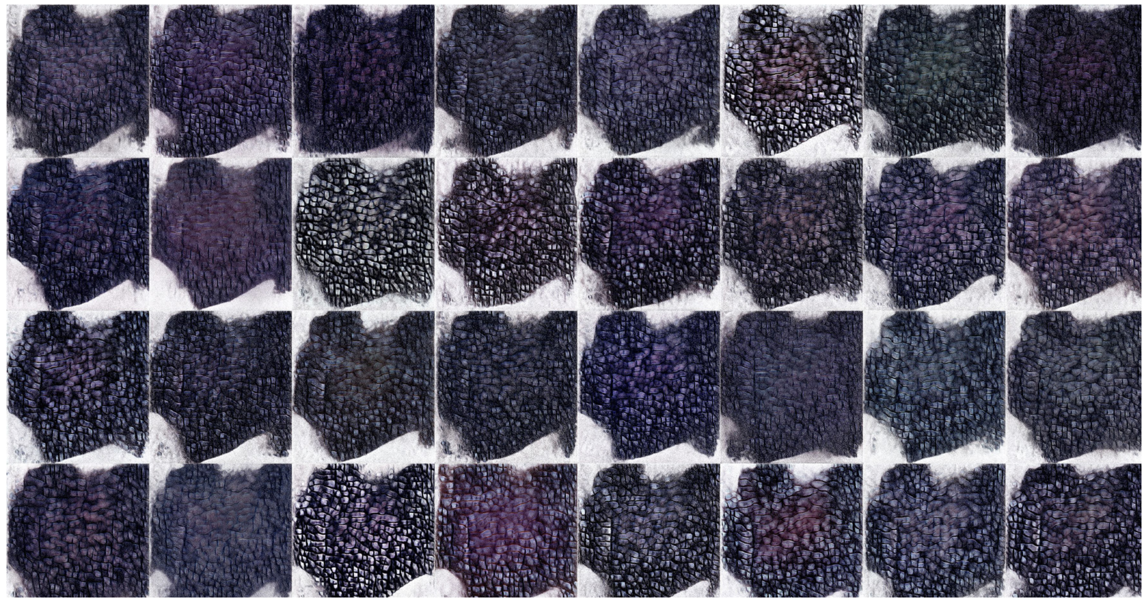


Example taken from the second edited dataset. Source:author



Example taken from the third edited dataset. Source:author

The third database was a failure as all attempts were leading into this kind of overall blur. I expect that to be caused by an enormous amount of lines, causing a graphical confusion. If all these wireframe line drawings were to be superposed, the resulting image would be a very confusing blur.



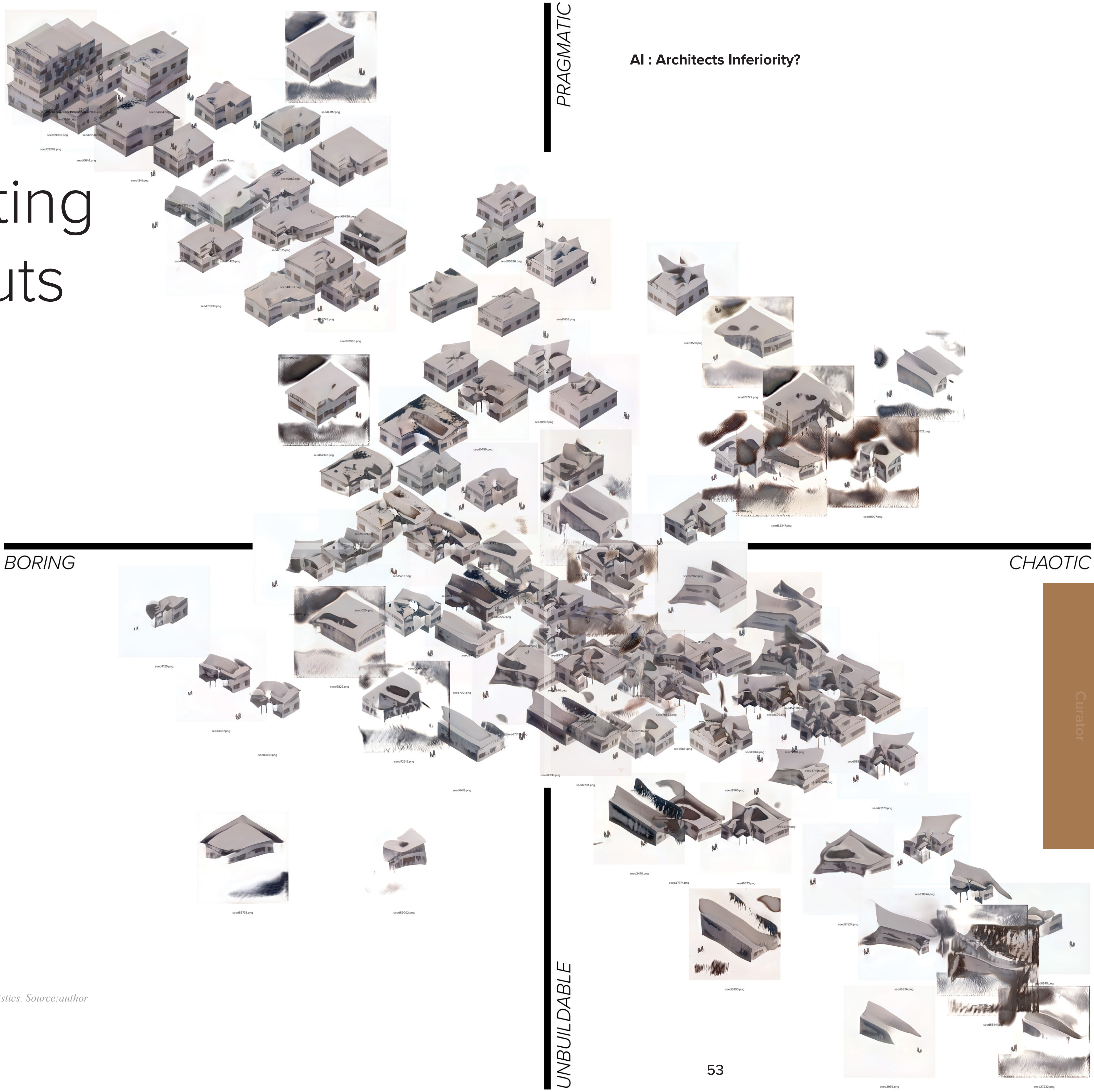
Outputs from GANs trained on the second edited dataset. Source:author

Step 04 : curating the raw outputs

I thus went back to the neural networks trained on the second database and used them to generate over 1600 images that I sifted by eliminating the seeds (1) that looked too similar. This curation pass, allowed me to reduce their number to 150.

I then started to evaluate these remaining seeds based on two criteria: their pragmatism and their boringness.

I evaluated them one by one and placed them on this two axis diagram, which is an actual depiction of how I proceeded. I did not have a clear method, but rather pinned them on a wall based on my own taste and in comparison to one another.



Outputs from GANs sorted according to their pragmatic and chaotic characteristics. Source:author

Step 05 : diagrammatic proposals

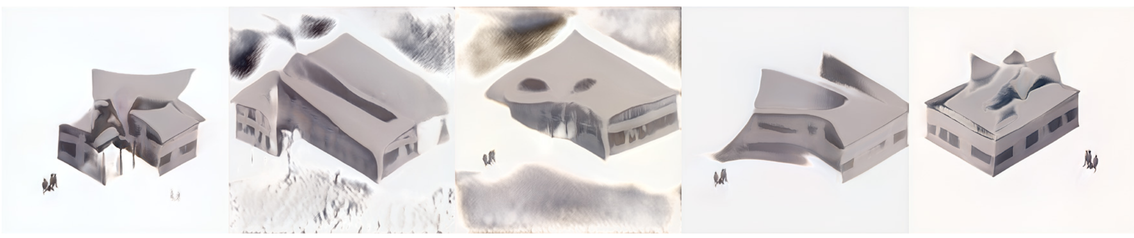
The next curation pass was to assess which of these seeds could be developed into interesting architectural concepts.

Here, my role shifted towards a communication manager's one, because I had to start translating what the algorithm has given me into an understandable architectural concept.

I selected five that I could model into diagrammatic proposals. The detailing level here is minimal and rather abstract, to keep this step as an early conceptual design stage.

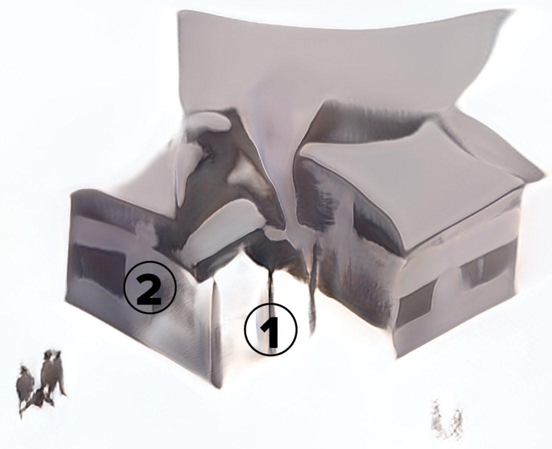
Since the dataset was made from axonometric views of only one angle of the building, I had to use some imagination to model the other two facades. Sometimes, like with seed 17054 with its extended roof suggesting a glazed facade, some visible elements were implying the existence and nature of hidden ones. In most cases, the other two facades were for this phase just plane and blank.

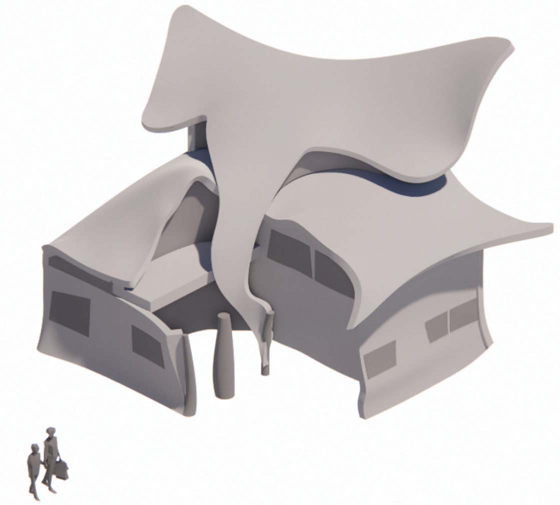
In terms of scale, I did keep in mind the scale figures from the GAN outputs. However, in some cases I adjusted the dimensions slightly into an overall that was more fitting. For example, seed 0168 got slightly bigger during the translation to 3D, while seed 4197 decreased slightly in size.



The five seeds selected to move to the next detailing phase. Source:author

AI : Architects Inferiority?



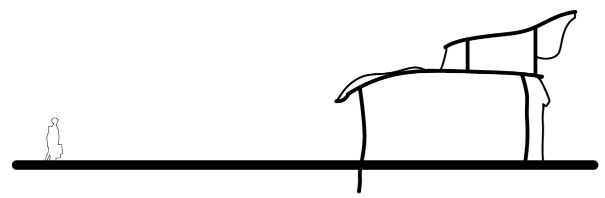


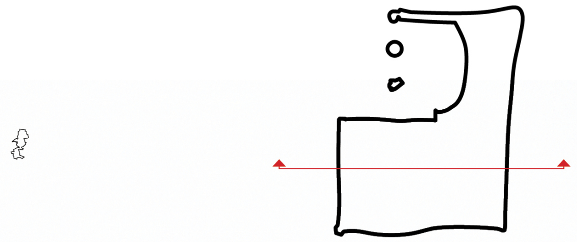
Seed 23170

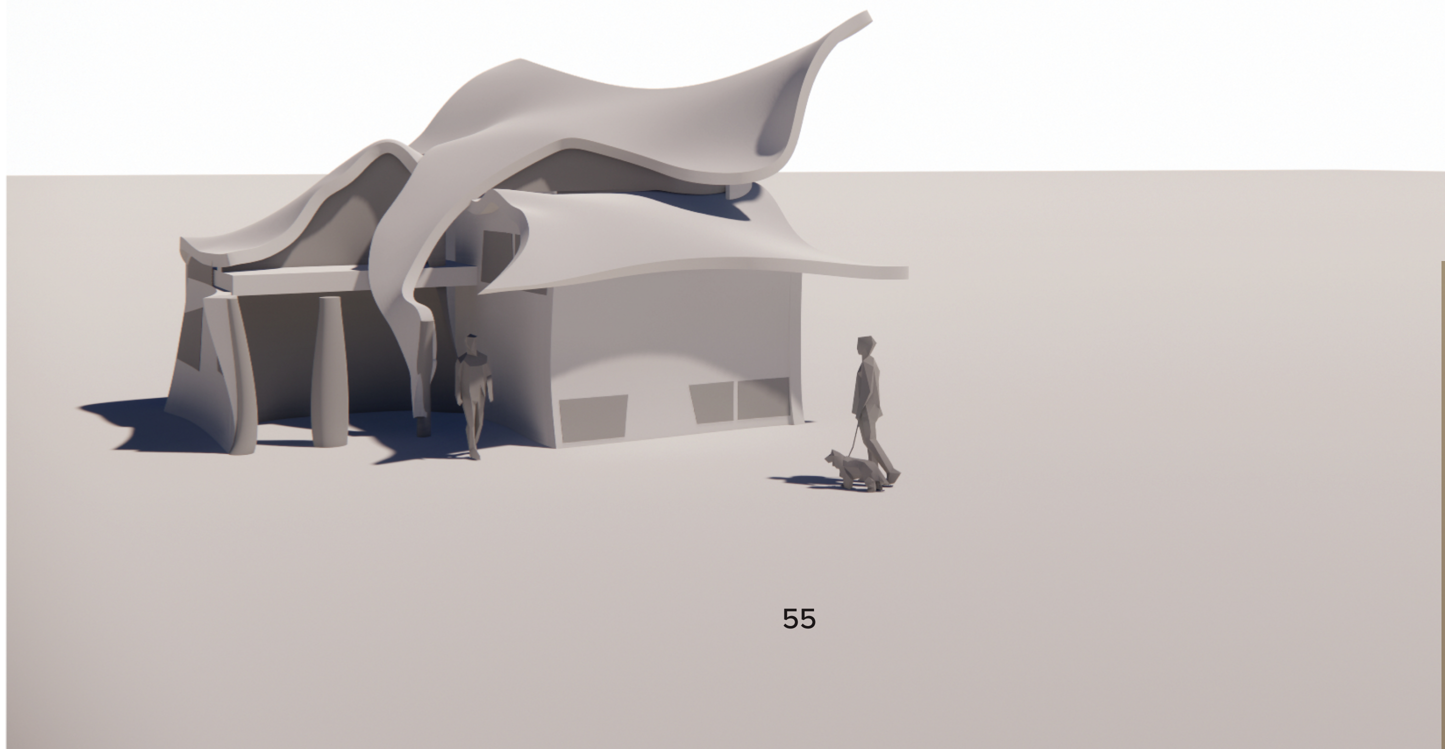
While slightly small in scale, this seed features a very intricate roof, with several accessible terraces possibilities. There is a small courtyard with three columns (1), which interestingly do not seem to support anything.

I was also very intrigued by the wall directly attached to the columns (2). Indeed this wall seems to disappear, which could be translated into an unusual material later in the design process.

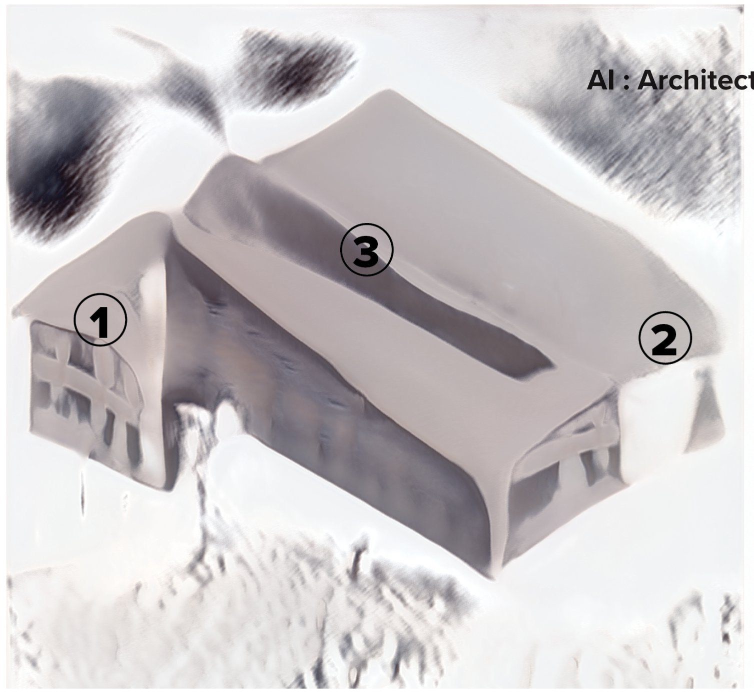
This seed also features windows that are flushed with the ground, like seed 4197. This could suggest an underground level.

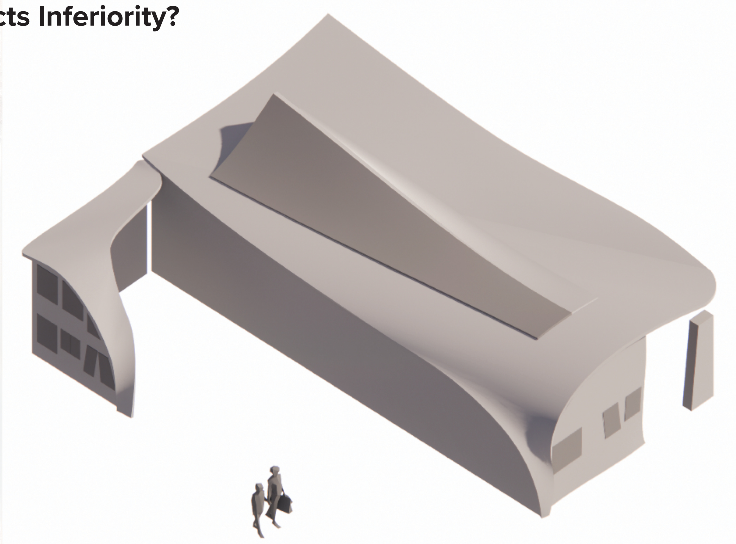






Communication Manager

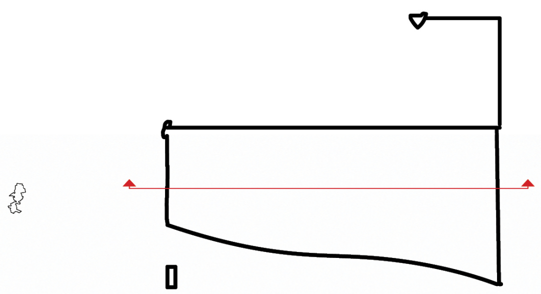


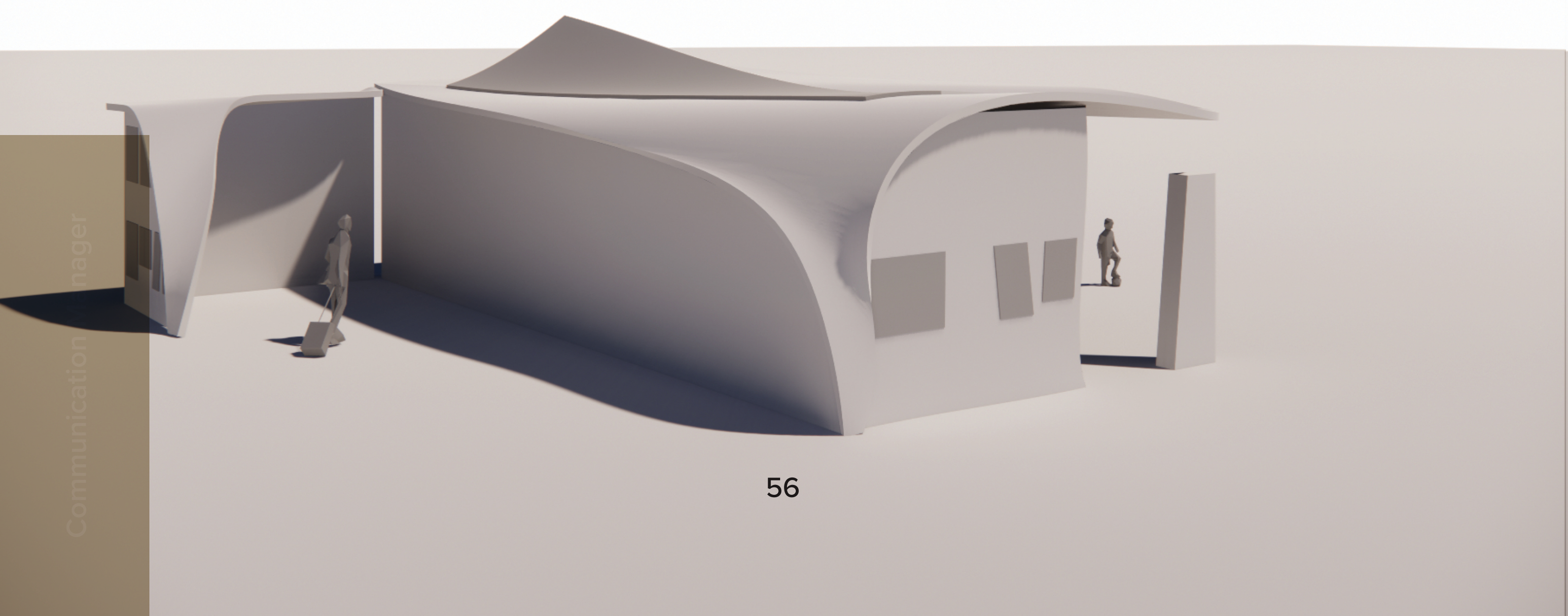


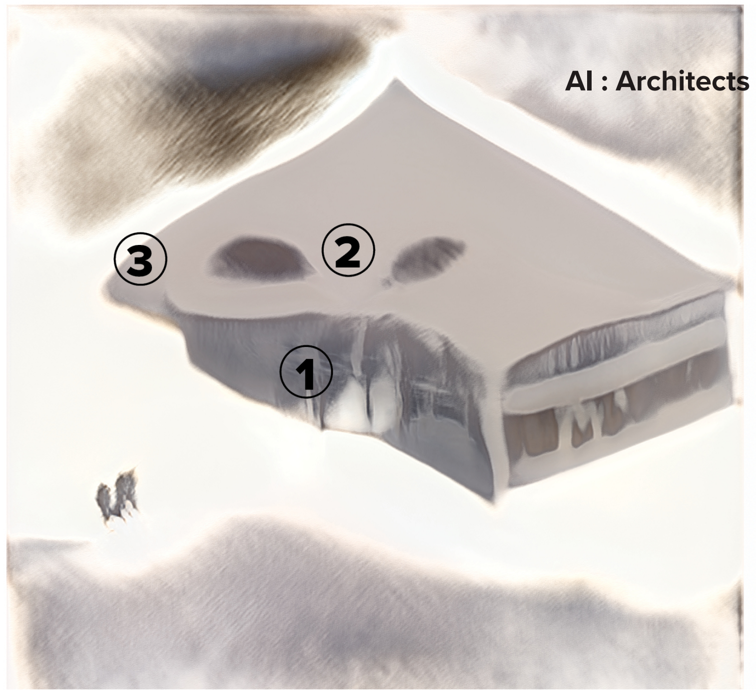
Seed 17054

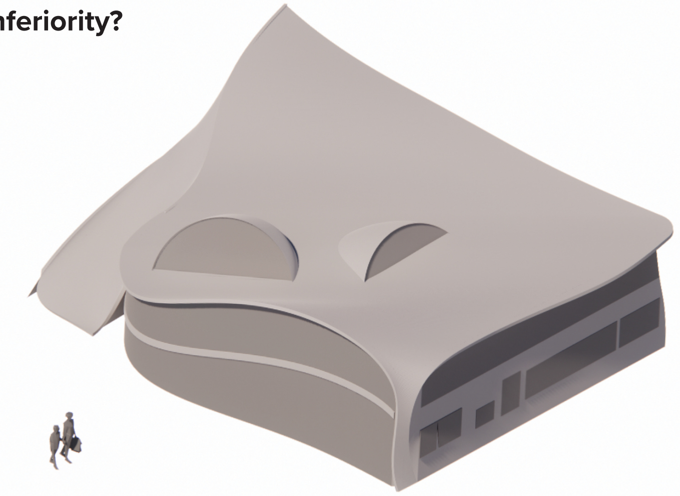
This seed is rather conservative in shape but features two elements that I deemed interesting; A sort of semi-covered outdoor element (1) and a roof that extends past the facade line (2) indicating a shaded facade and maybe suggesting a glazed one.

There is also a dark elongated spot on the roof (3). Since darker colour meant glass in the training dataset, I read this as skylights, which would increase the light qualities of the interior.

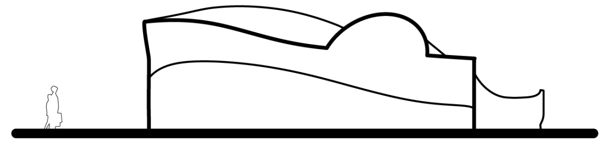






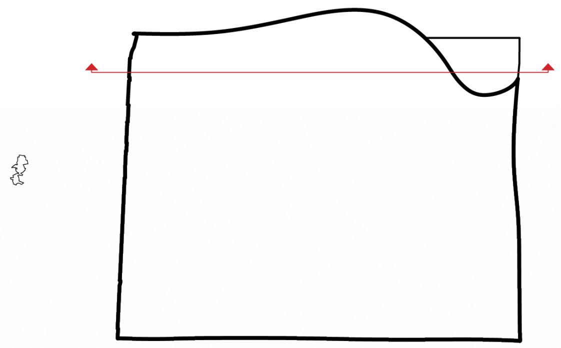


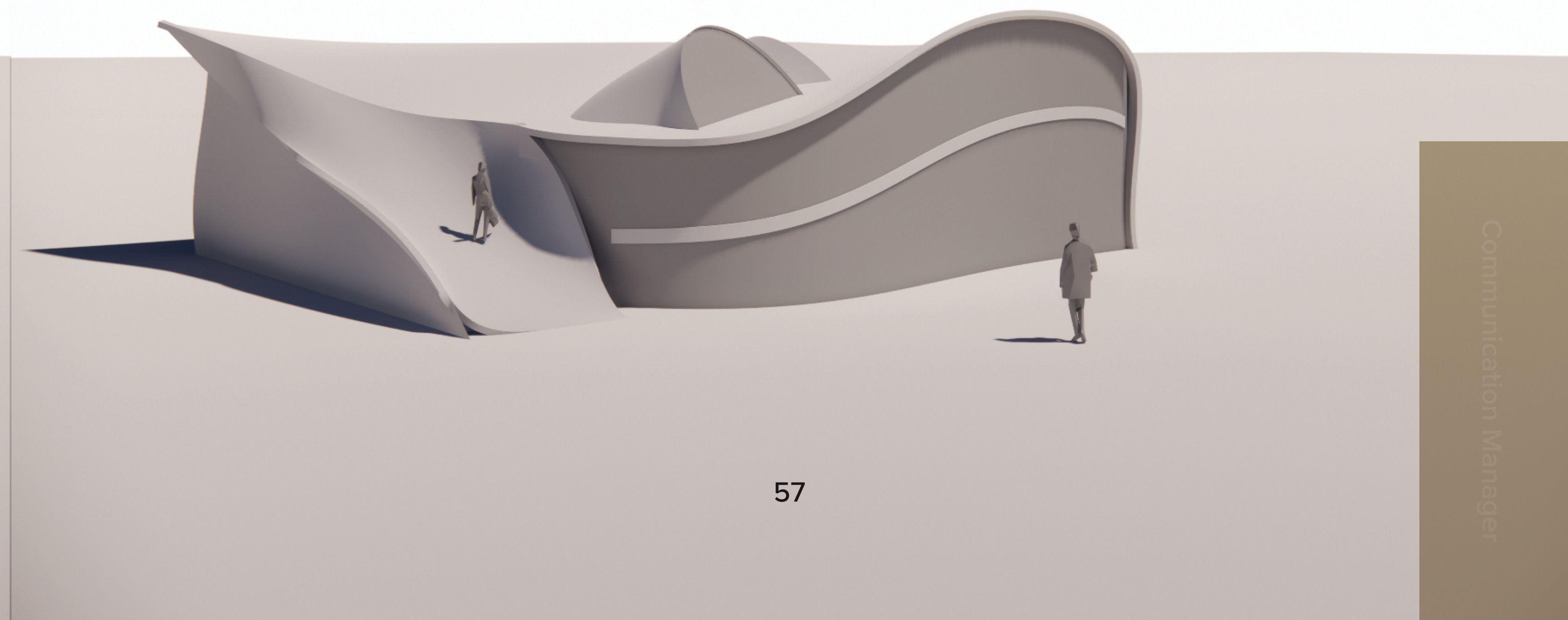
Seed 79722

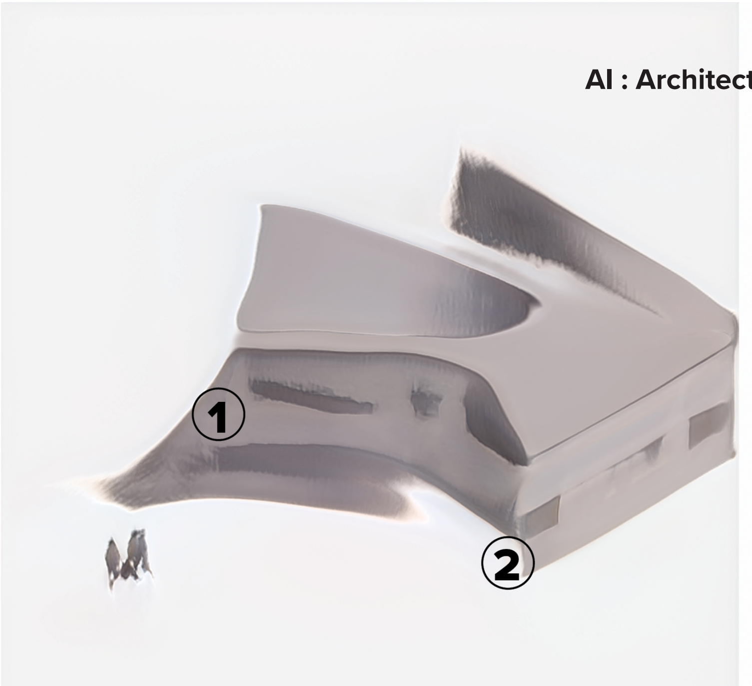


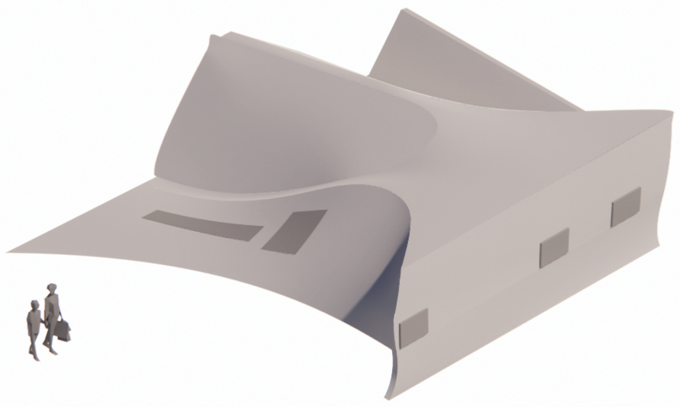
This seed is quite clearly readable as a large house with two levels and a double level floor to ceiling glass walls (1).

There is two dark shapes on the roof which suggest two skylights (2). It also seems that this seed's roof lowers to the ground (3) which just like with seed 4197 could indicate an accessible roof.







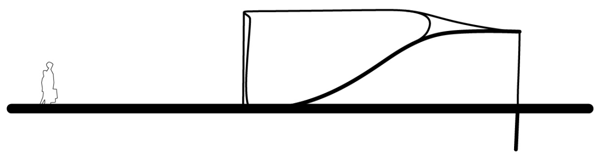


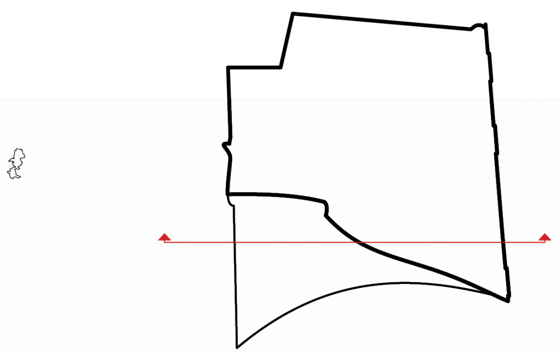
Seed
4197

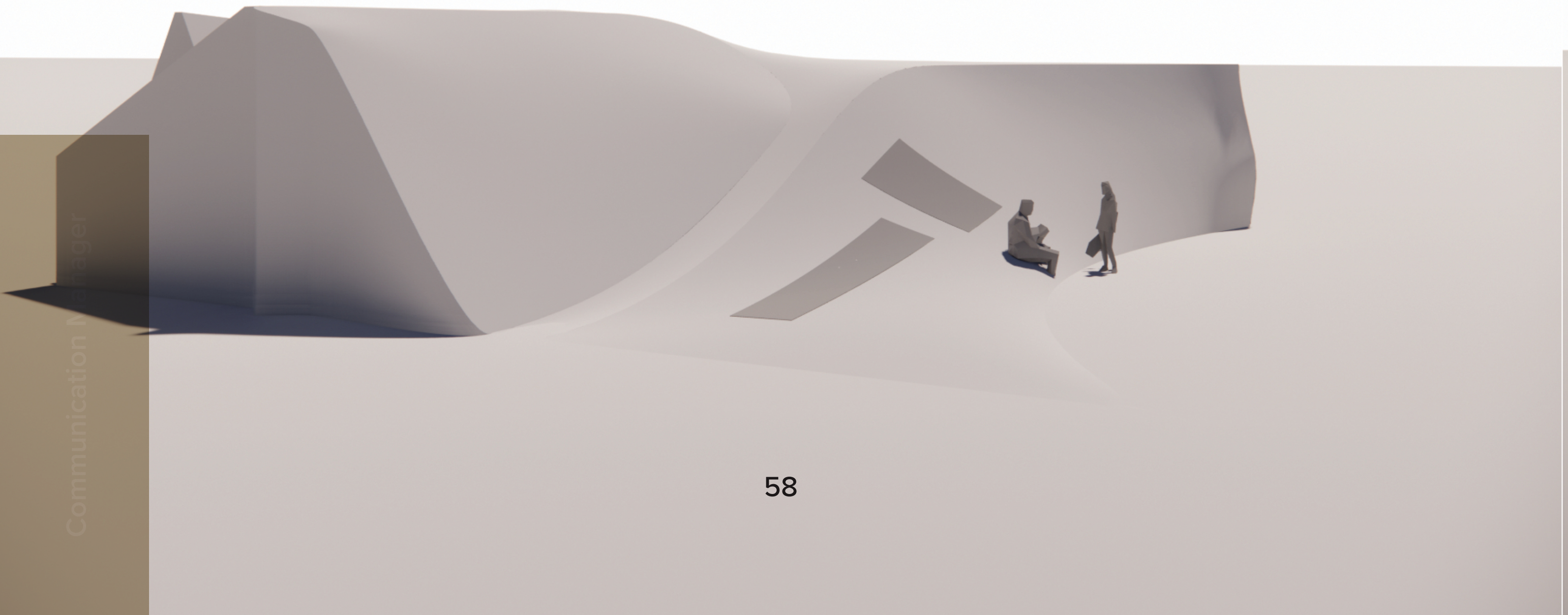
This seed presents a roof that seems to be parted in three, with one part lowering to the ground. This could be understood as an accessible roof (1) just like in seed 79722.

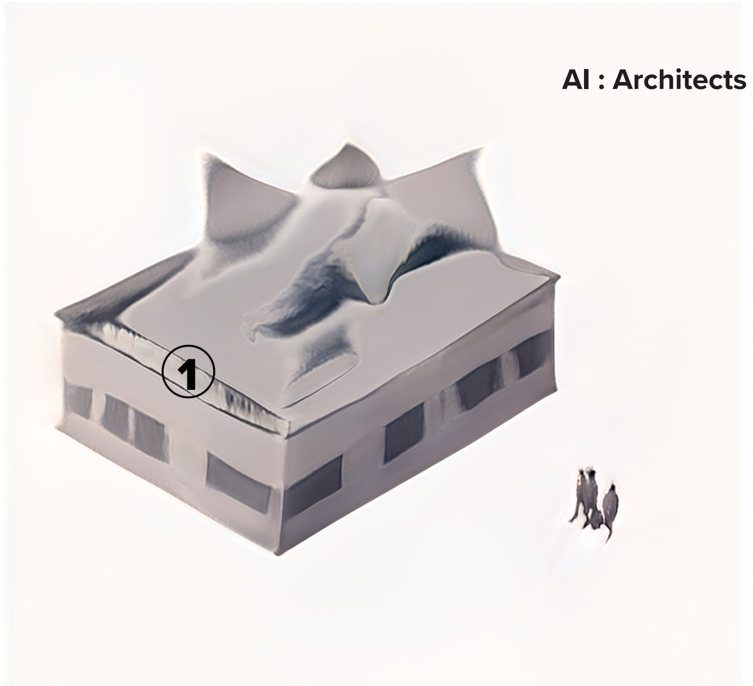
It also showcases a wall that seems to go lower than ground level (2), just like seed 23170, with three windows flushed with the ground. My understanding of this is an underground level, with these windows as skylights.

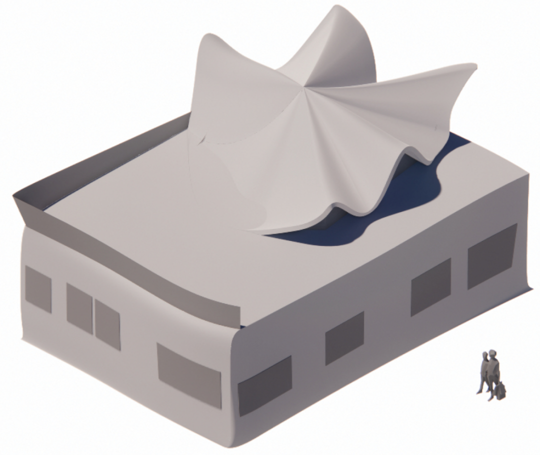
What is more the human figures gave an acceptable scale to the overall house, that fits the program.









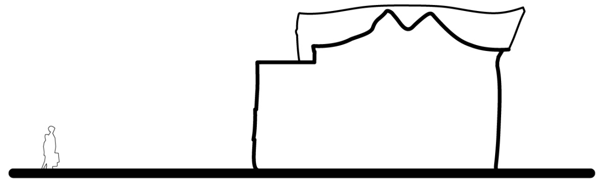


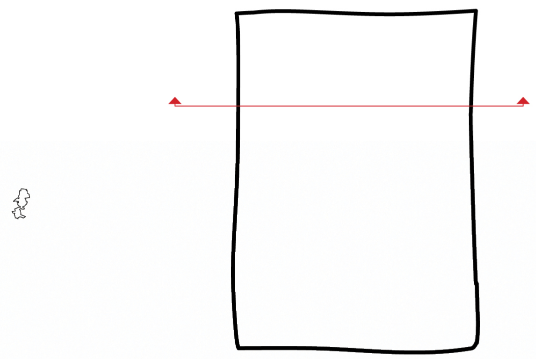
Seed
0168

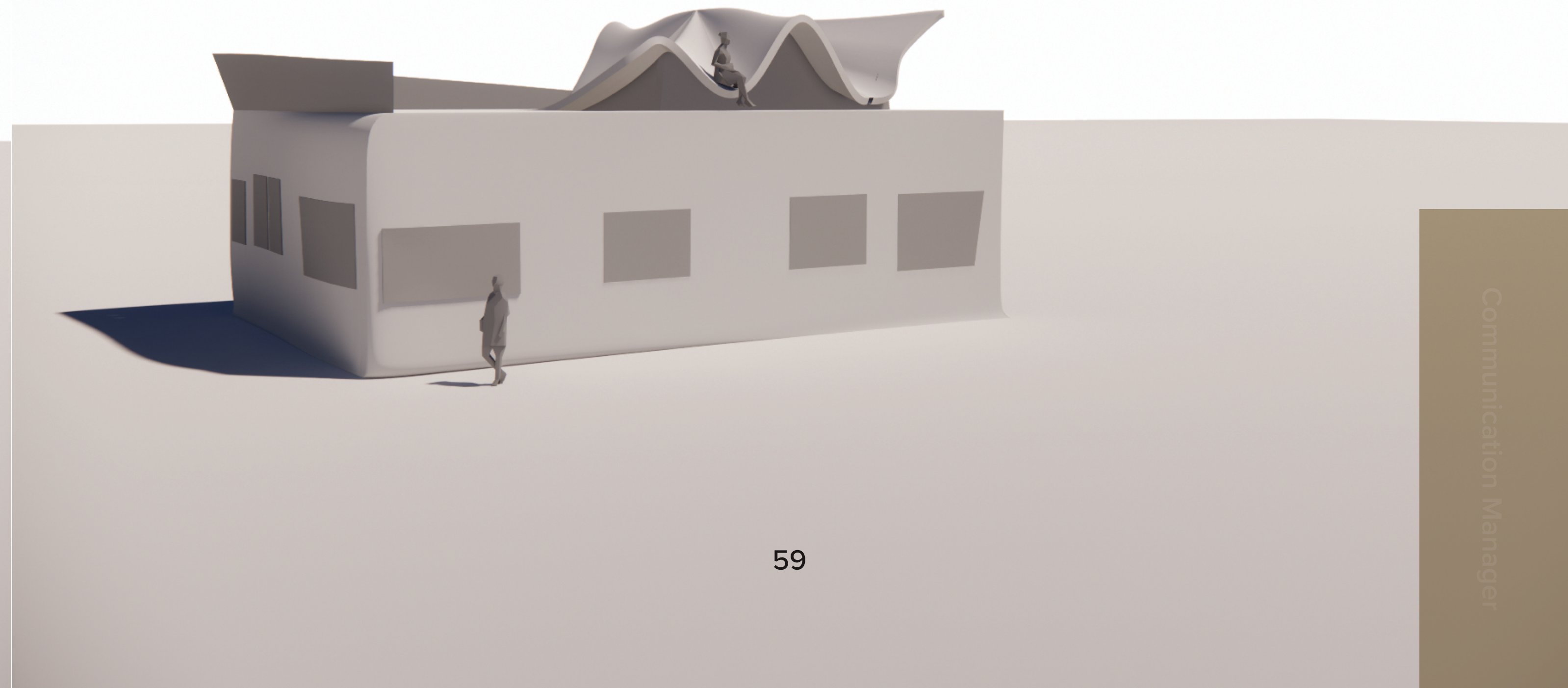
This seed has quite a boring plan, a simple rectangle, but it features an unusual roof piece, and what seems to be a balustrade (1), indicating an accessible terrace.

In comparison to the scale figures, the dimensions of this house could be however a little bit small for a family of four. The roof piece could however be developed into an audacious bunk bed situation.

Along with the extensive rooftop terrace, this potential made me select this seed despite its high boring index.







Step 06 : selecting two seeds for further detailing

With these five seeds selected and modelled, I did some additional analysis to determine two I could develop further, and imagine their interior spaces and atmospheres. Since I selected all five of them for specific properties I deemed interesting, I decided to proceed by elimination.

First, I decided to cull seed 0168 because while the rooftop could be developed into something novel, the overall shape of the building was quite boring and not really showing the full potential of AI aided design, or at least in a rather timid way.

On the other hand, I chose to remove seed 23170 because the overall shape was quite chaotic, and while it suggested interesting spaces, its interior would have almost certainly been very crooked in some places. Lastly the scale was very small for a family of four and would have needed a lot of extra thinking when it comes to interior planning.

Seed 0168 Source:author

Seed 23170 Source:author

Since seeds 4197 and 29722 both showcased similitudes in their accessible roofs and double level floorplan, I decided to select only one between the two. This was not an easy decision to make but I had a slight preference for 4197, since a traditional typology of the pitch roofed farmhouse was still visible, only with a twist : a part of the roof lowered to blend with the ground. I thus eliminated seed 79722 and was left with seeds 4197 and 17054 to move on to the next curation phase.

Seed 79722 Source:author

Seed 4197 Source:author

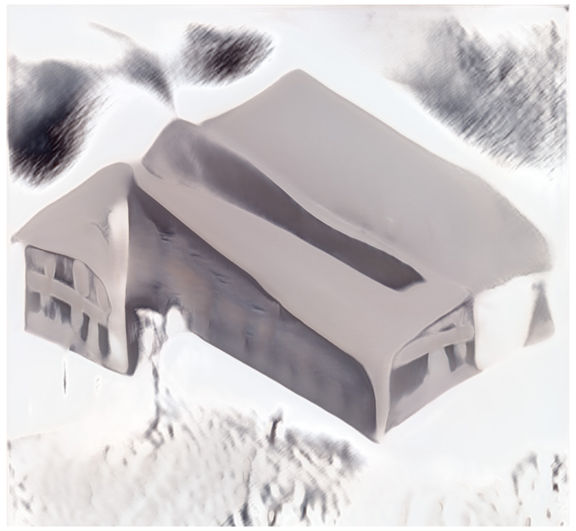
Seed 17054 Source:author

Step 07 : detailling two seeds

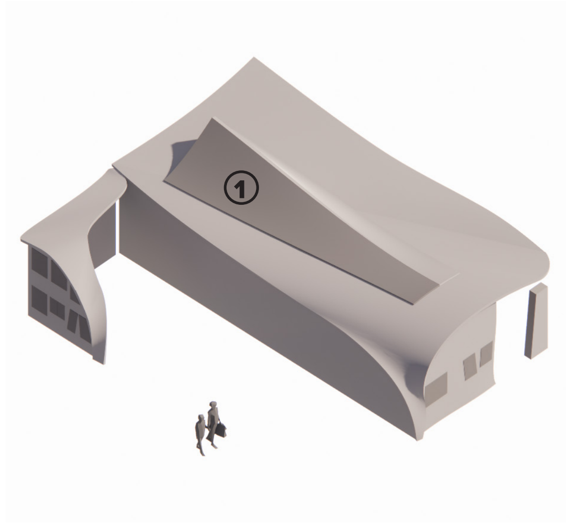
Seed 17054

In this phase I took an outside-in approach, which is the opposite of what architects usually do.

I started oriented the seeds the same way I imagined the training dataset, which means looking at them from South West. I started by placing the windows on the plan diagrams to understand where the openings would be and to give me clue regarding the internal layout. For seed 17054, this meant placing a glazed wall on the north facade, as well as modelling this pitch roof with skylights (1).



Seed 17054. GAN-generated axo view. Source:author



Seed 17054. Axo view. Source:author

Communication Manager

1.1 Entrance hall

1.2 Bathroom

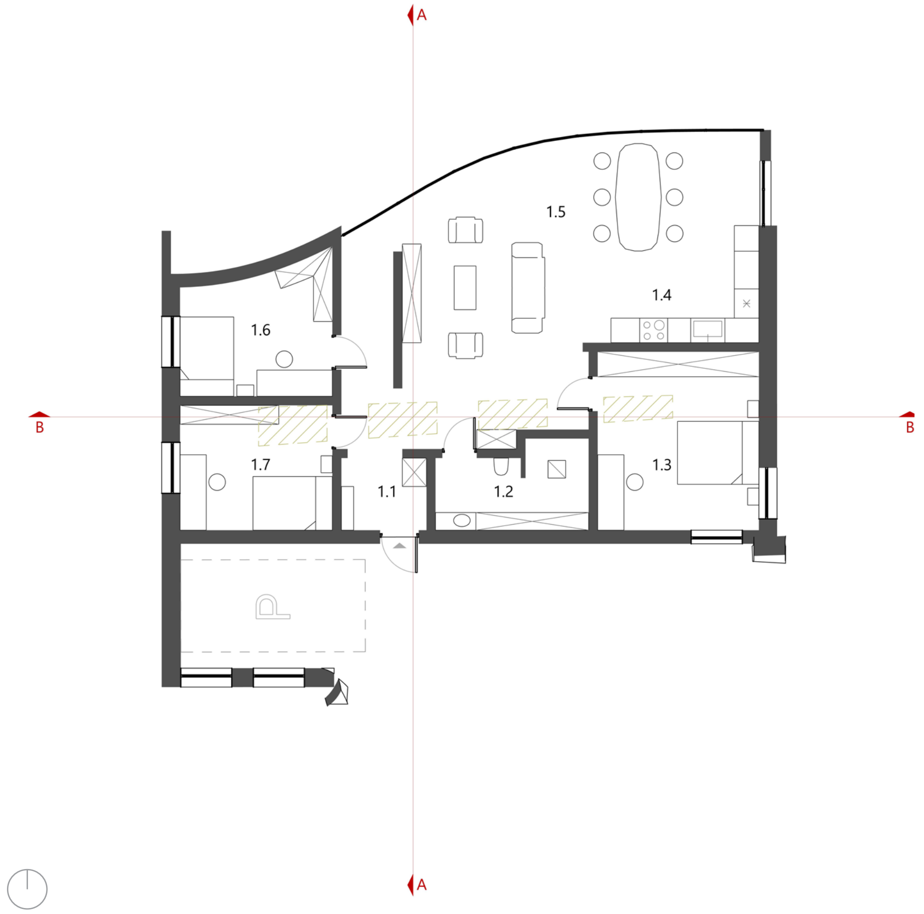
1.3 Master Bedroom

1.4 Kitchen

1.5 Living/Dining room

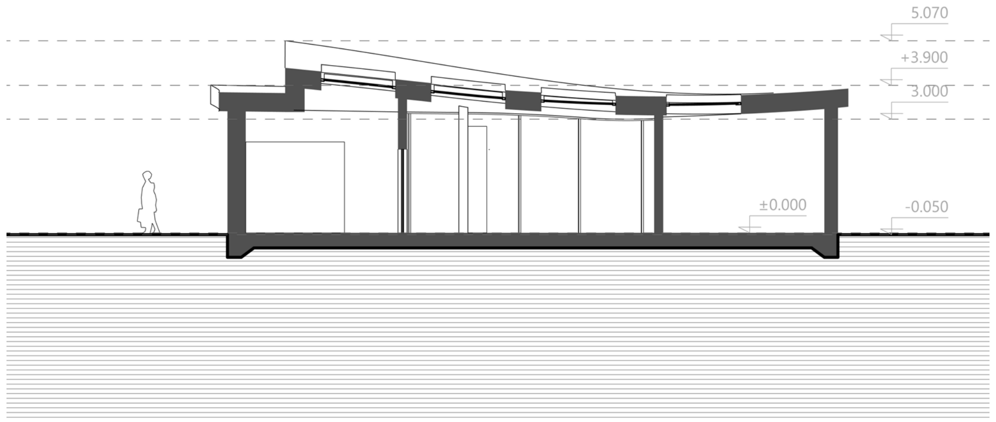
1.6 Bedroom 1

1.7 Bedroom 2



Seed 17054. Ground Floor Plan. 1:200 Source:author

Communication Manager



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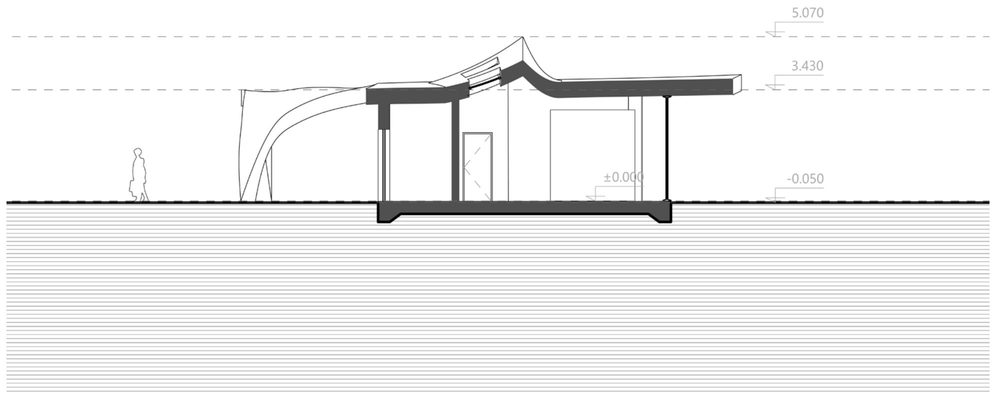

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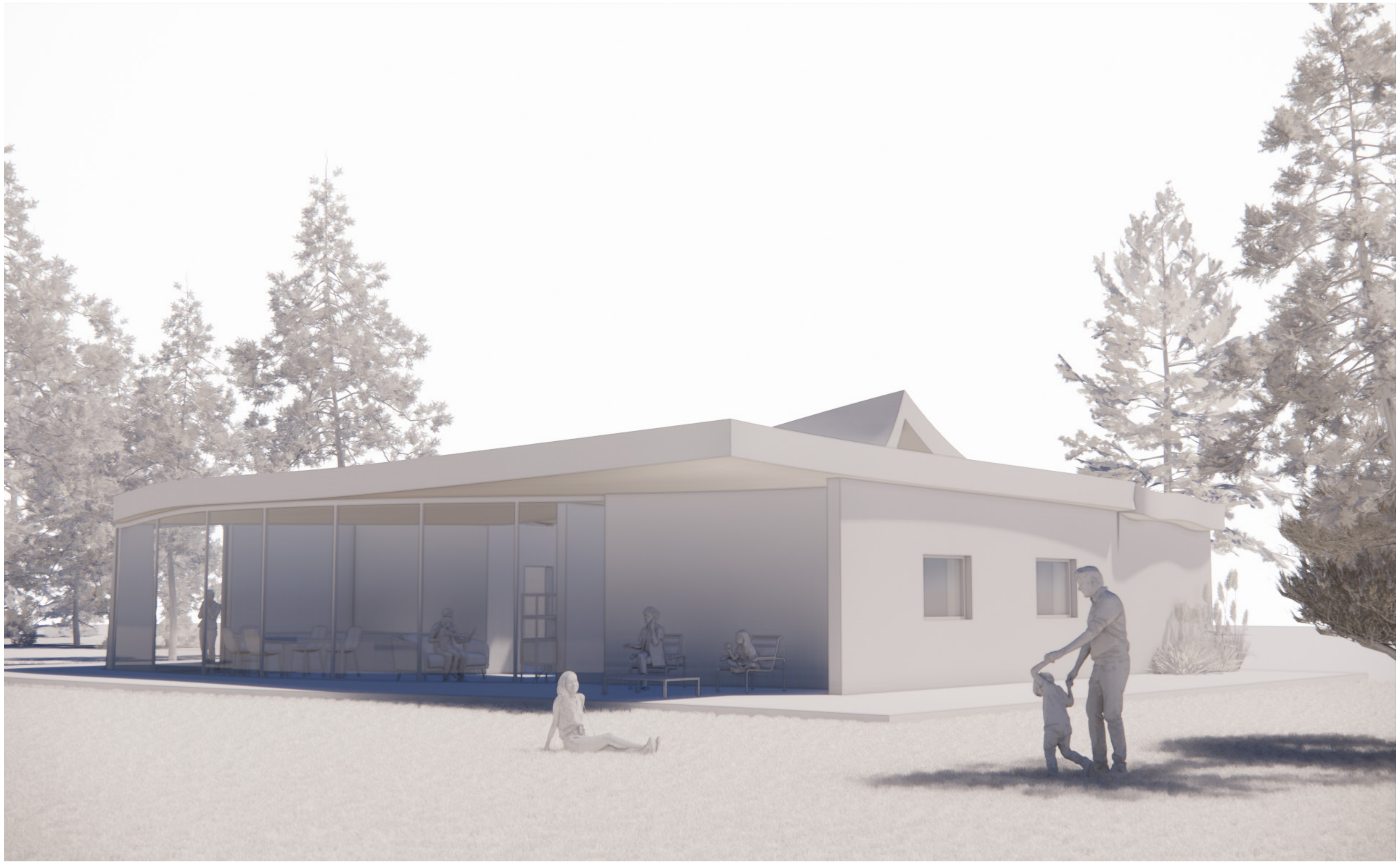


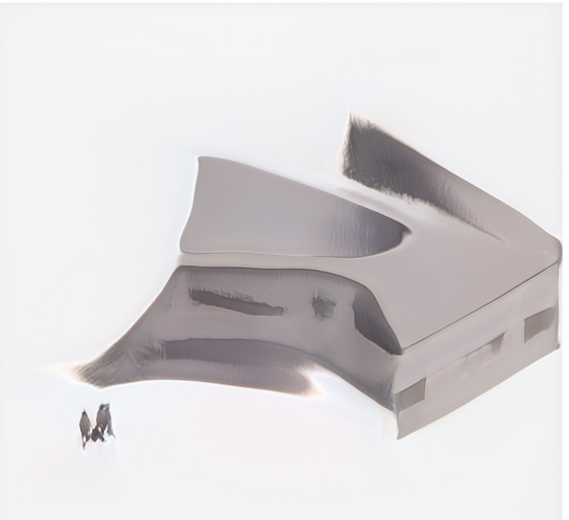
Seed 17054. Exterior view. Source:author

Seed 17054. Interior view. Source:author

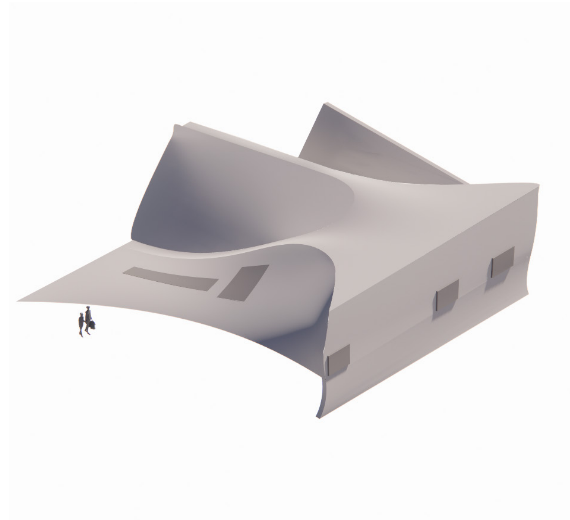
Seed 4197

For seed 4197, I modelled an underground level and decided to dress the part of the roof that blends with the ground with some windows, which become skylights.

From then on, the process was quite organic and I imagined the interior space to the best of my architectural abilities, while trying to keep as close as possible to the machine’s vision. With this seed I had more square meters and thus was able to add a guest room (2.8), a pantry (2.5) and a laundry room (2.7), but the program remains a house for a family of four, like with seed 17054.



Seed 4197. GAN-generated axo view. Source:author



Seed 4197. Axo view. Source:author

1.1 Entrance hall
1.2 Bedroom 1
1.3 Bathroom 1
1.4 Bedroom 2
1.5 Terrace
2.1 Master Bedroom
2.2 Living room
2.3 Dining room
2.4 Kitchen
2.5 Pantry
2.6 Bathroom 2
2.7 Laundry room
2.8 Office/Guest room
2.9 Lounge

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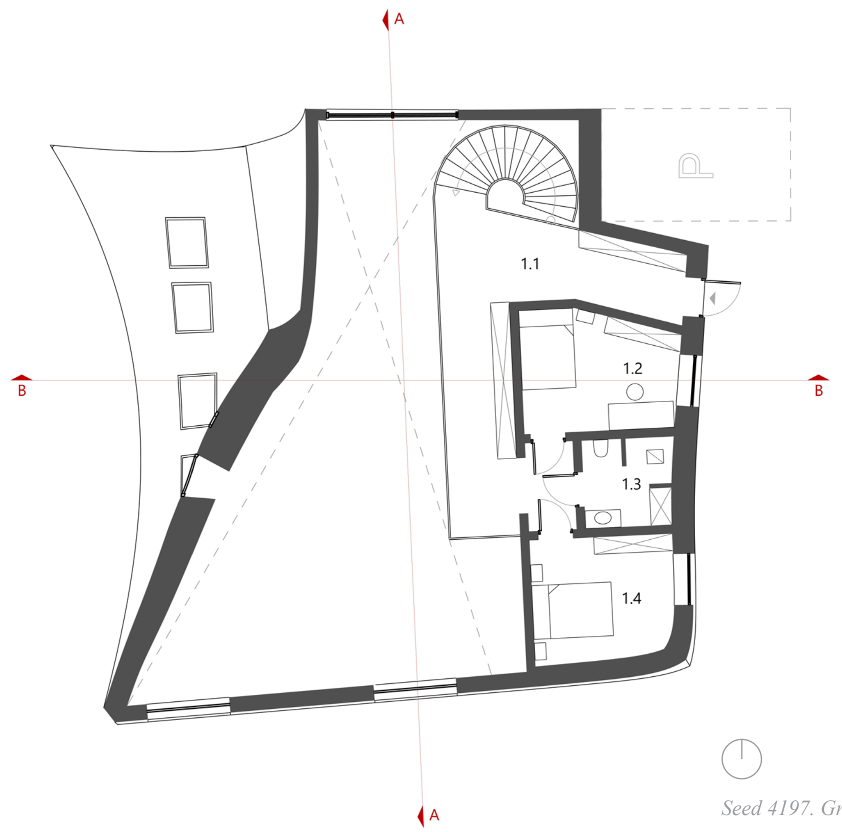
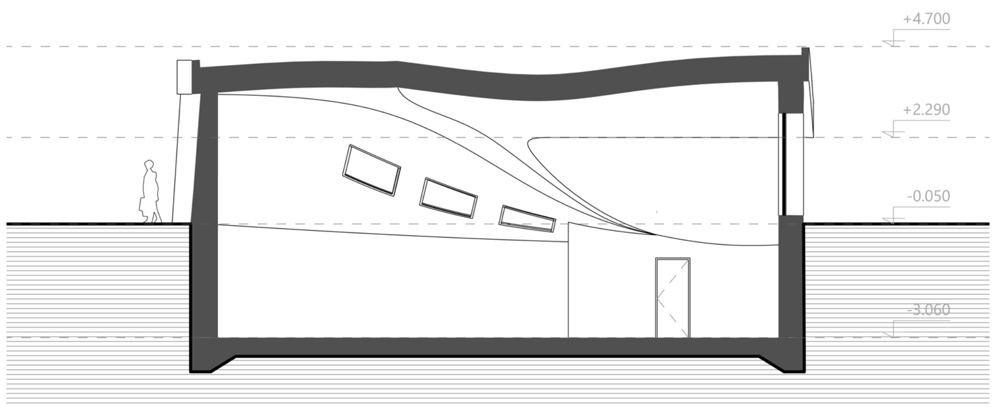


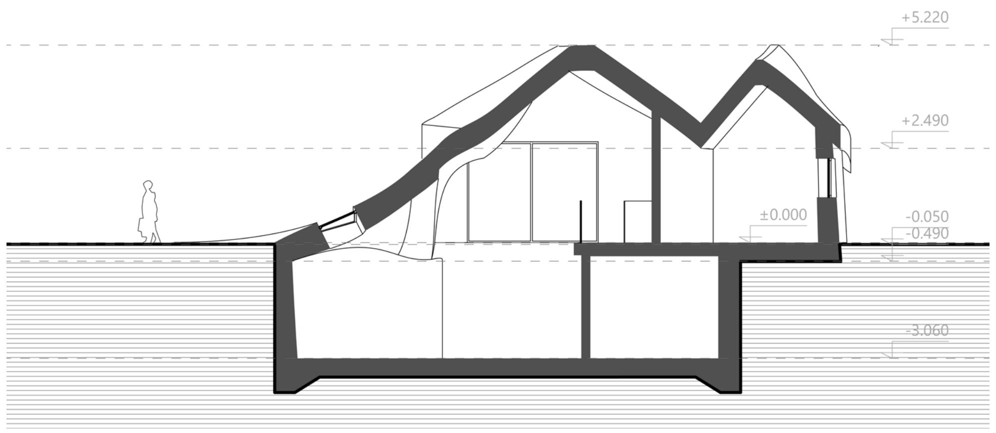
Seed 4197. Ground Floor Plan. 1:200 Source:author

Seed 4197. Basement Plan. 1:200 Source:author

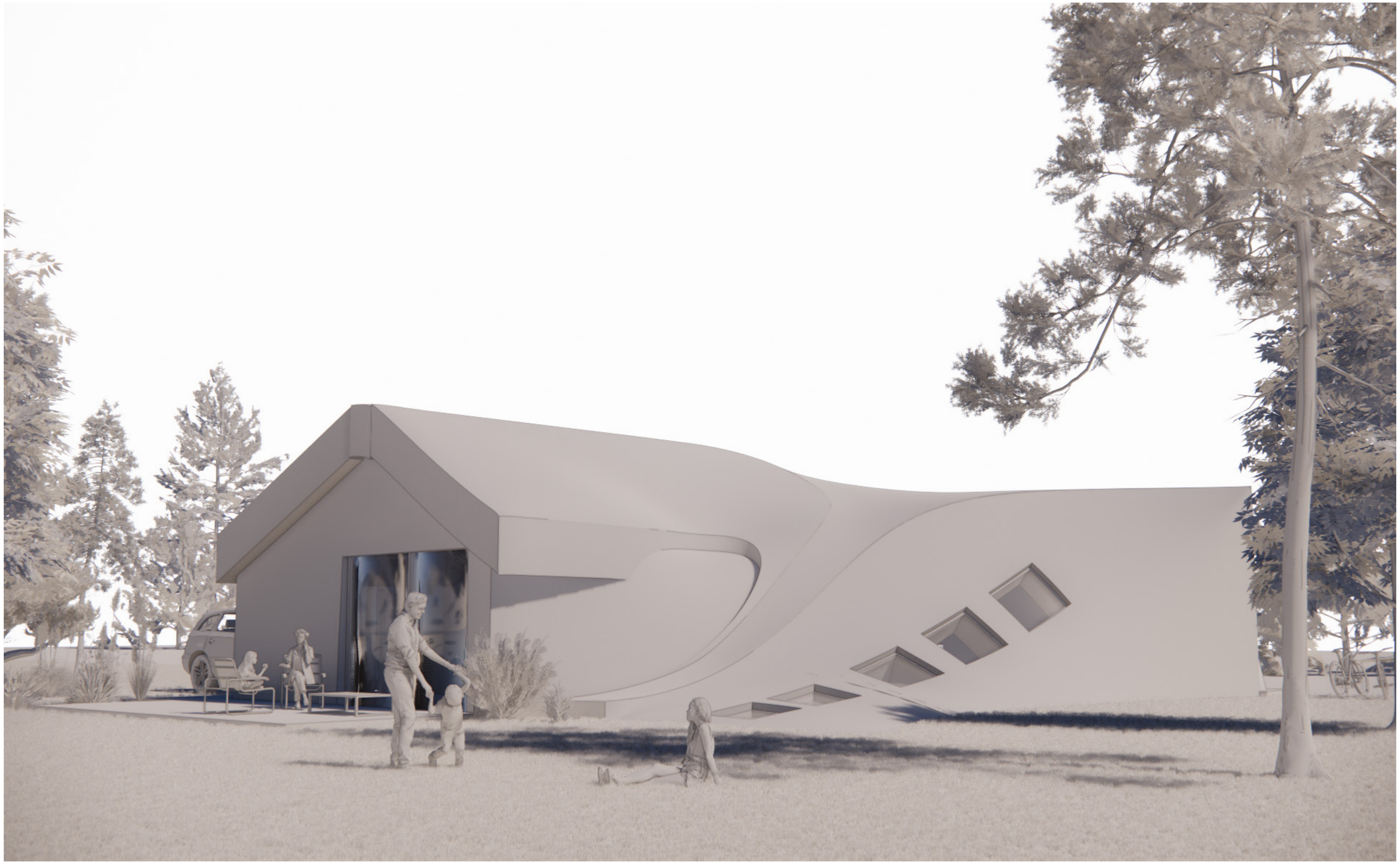
Communication Manager



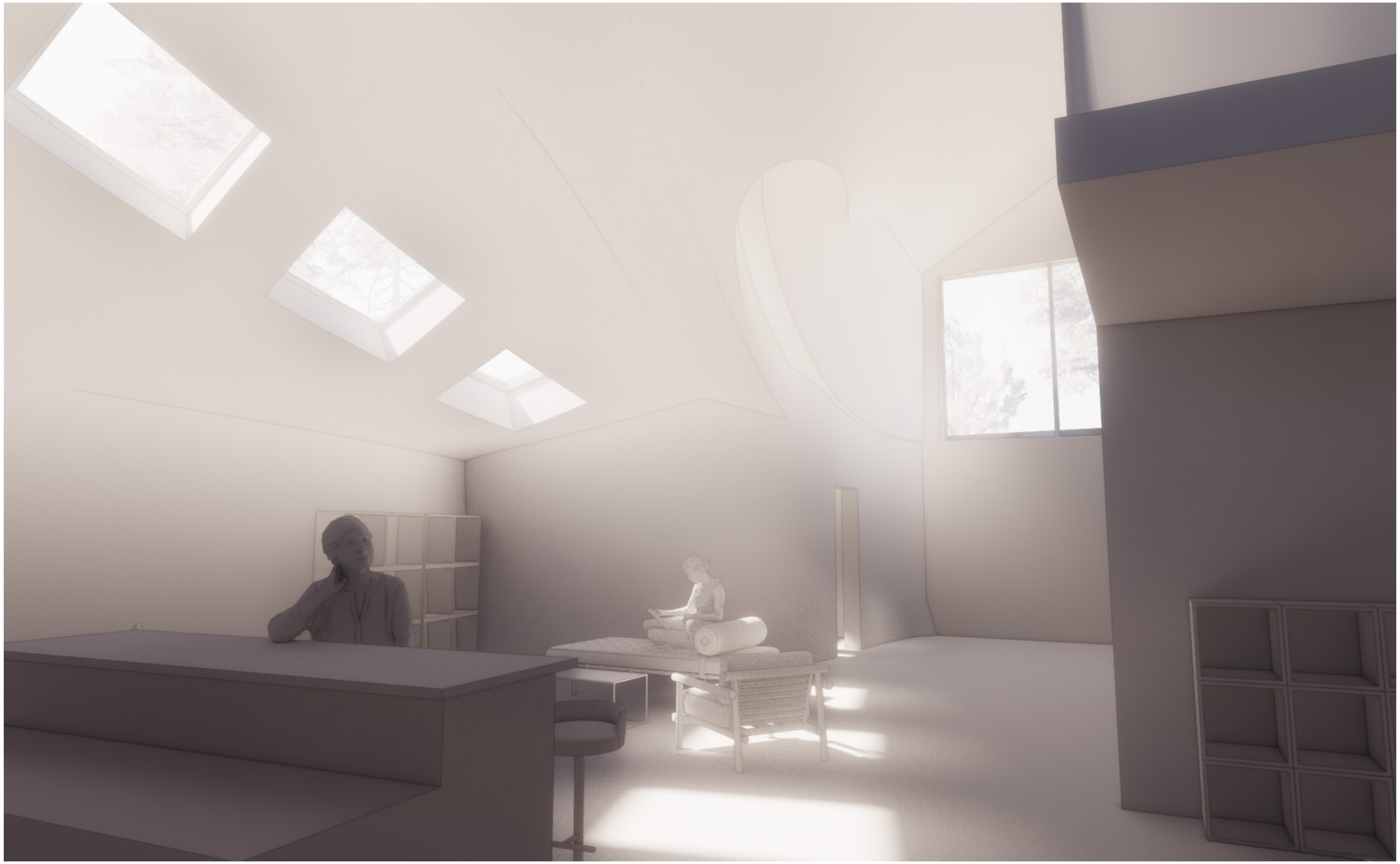
Seed 4197. A Section. 1:200 Source:author



Seed 4197. B Section. 1:200 Source:author



Seed 4197. Exterior view. Source:author



Seed 4197. Interior view. Source:author

Step 08 : selecting the final seed


Seed 4197. Exterior view. Source:author

The last curation step is to chose one of the seeds and develop it into a full architectural proposal. I did this by analysing plans, sections and views I had, and decided which one would be the most interesting. I followed my architectural sense to chose seed 4197, because I deemed the overall shape more intriguing and the interior atmosphere more inviting.

Furthermore, I felt like seed 4197 better transposed the fact that I used an artificial intelligence in the design process, whereas as much as I liked seed 17054, it remains more conventional.


Seed 17054. Exterior view. Source:author

Curator

Step 09 : final architectural proposal

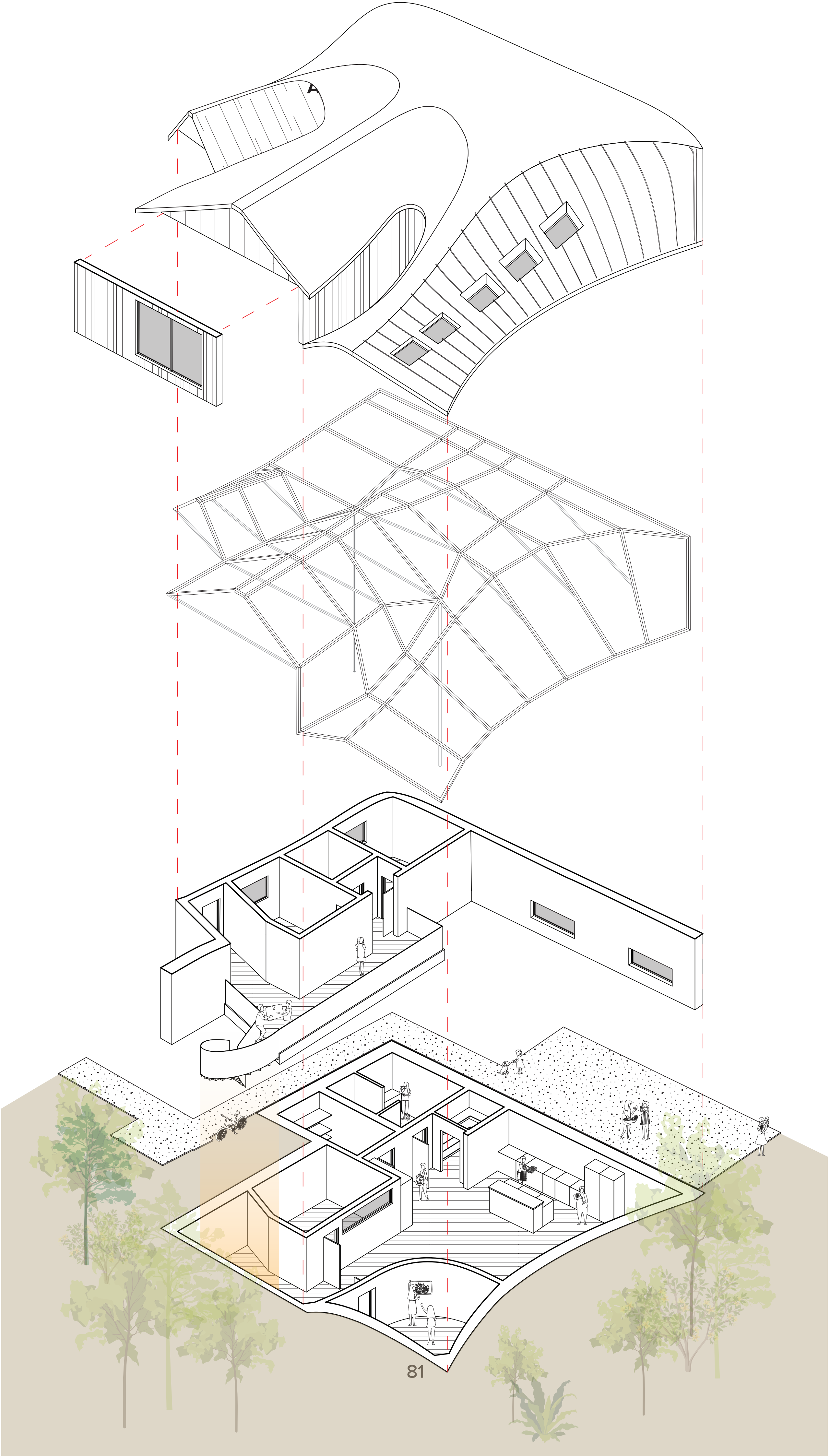
This phase marks the end of my role as a design coordinator and of the design part of my thesis. In order for this phase to succeed, I had to make a believable constructible architectural proposal, that could be a competition entry or be chosen by a client willing to build their summer house.

I developed my plans and sections into more detailed drawings, and extracted an axonometric view of the proposal. I edited the views to more realistic renders to convey the atmosphere.

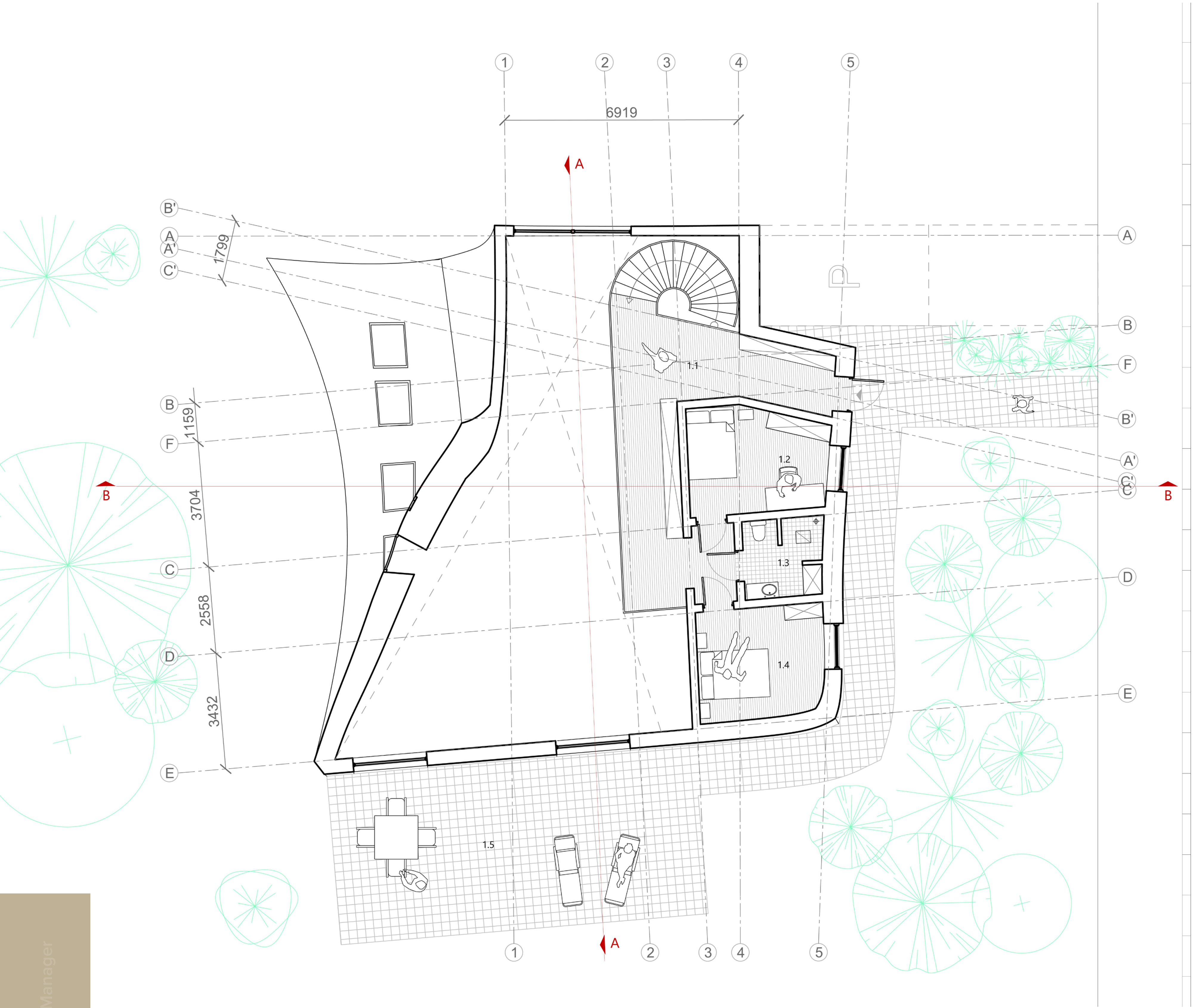
In this part of the thesis, I let myself be guided by my architectural sense. There is here an interesting reflection to consider; wether this so-called architectural sense exists and if so what is it made of. I would argue that it comes with training.

I knew what would make the most sense because I have been designing buidlings for a few years now. Of course in my studies as in practice, design is always motivated and legitimated by different factors like orientation, flows, structural impact, etc. But maybe I assimilated all these factors so inherently that they effectively form an architectural sense.

For example, it was my understanding that the roof was suggesting an underground level (see page 58). Perhaps another designer would have instead seen a ceiling that meets the ground and shelters storage. This individual understanding of the design process demonstrates that this framework leaves after all little space for the machine to truly be creative and would vary greatly depending on the collaborating architect.



Communication Manager



Seed 4197. Ground Floor Plan. 1:150 Source:author

When it comes to designing the interior layout, I had to mostly use my own creativity as I only had vague clues regarding the indoor layout of the building. I knew more or less where the windows were, at least for two facades, as well as the assumption that there was an underground level. This gave me a starting point to layout the rooms. I used standard measurements to place bedrooms, bathrooms, kitchen, etc. Because of the obvious wealth of the family who would have this house, I made sure to be consistent and include some premium features they would likely request, such as a large walk-in shower, or a kitchen island.

1.1 Entrance hall

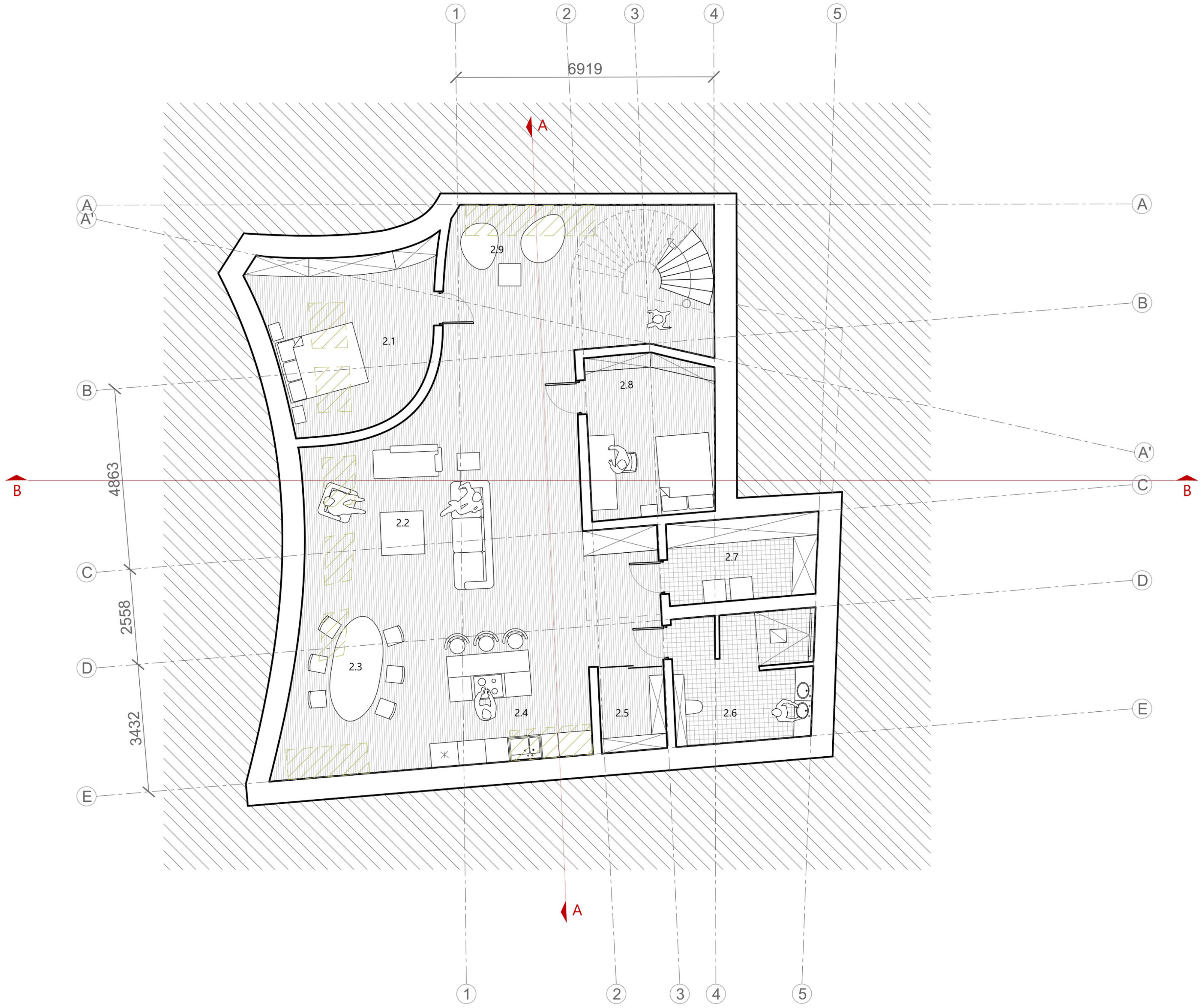
1.2 Bedroom 1

1.3 Bathroom 1

1.4 Bedroom 2

1.5 Terrace

Communication Manager



Seed 4197. Basement Plan. 1:150 Source:author

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2.1 Master Bedroom

2.2 Living room

2.3 Dining room

2.4 Kitchen

2.5 Pantry

2.6 Bathroom 2

2.7 Laundry room

2.8 Office/Guest room

2.9 Lounge

Communication Manager

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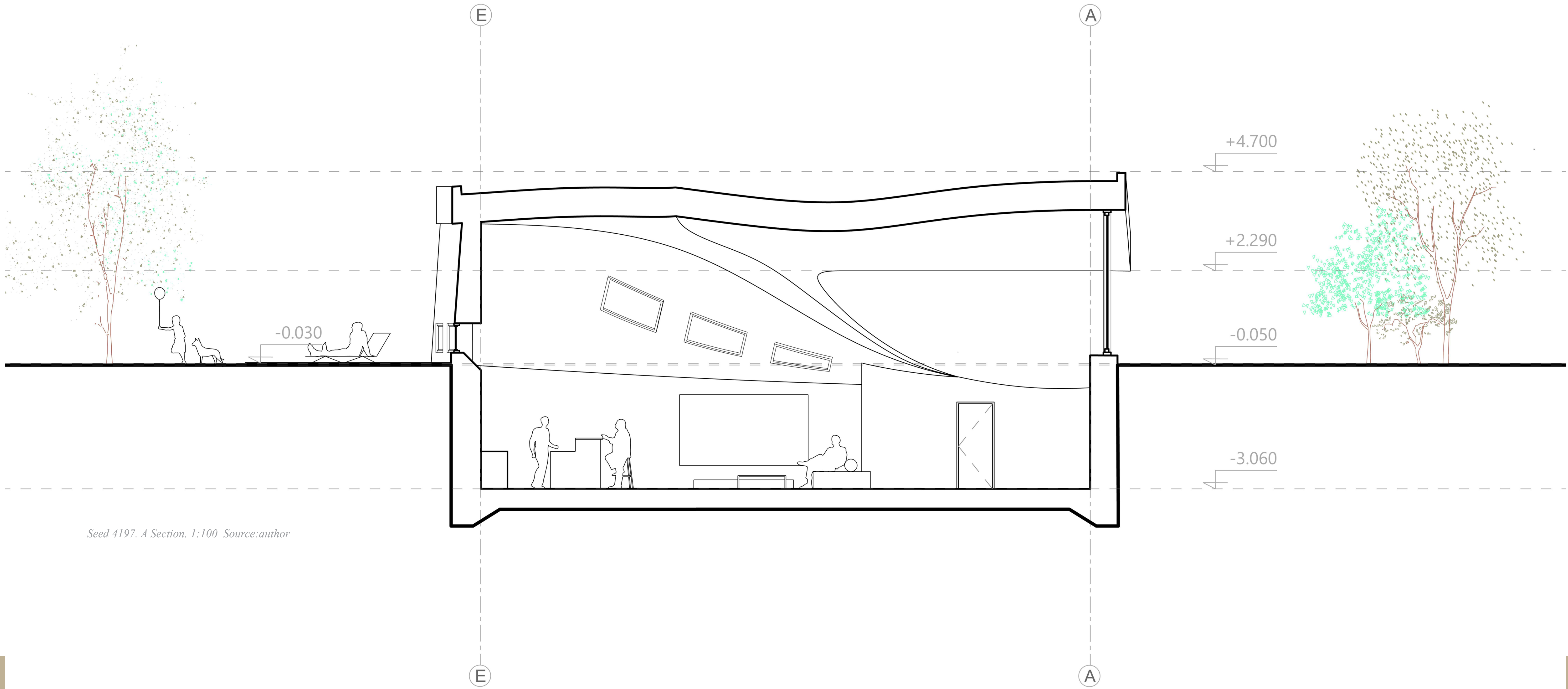
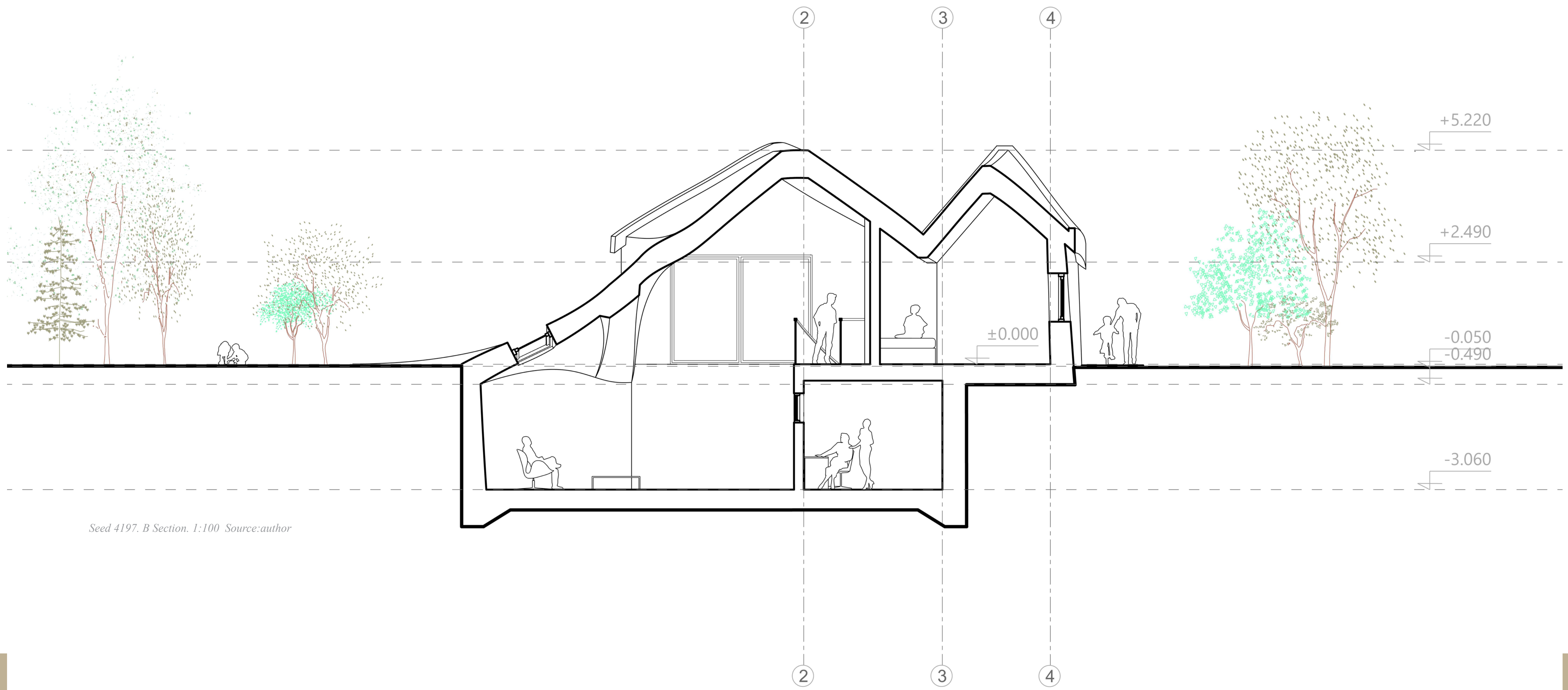


Seed 4197. A Section. 1:100 Source:author

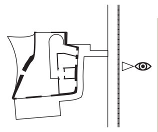
AI : Architects Inferiority?

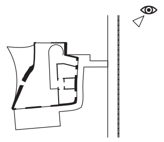


Seed 4197. B Section. 1:100 Source:author

Communication Manager

Seed 4197. Exterior view. Source:author

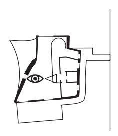




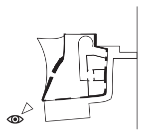
Seed 4197. Exterior view. Source:author

Communication Manager

Seed 4197. Interior view. Source:author

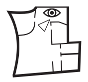


Seed 4197. Exterior view. Source:author

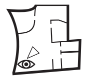


Communication Manager

Seed 4197. Interior view. Source:author



Seed 4197. Interior view. Source:author



To reflect on this last part of the design process, I would say that it is as interesting as it is hard to approach a building without contraints, at least in terms of program and layout. In plan I did try to follow the outputs of the algorithm as close as possible, which meant that some walls do curve. I extended this approach further, as the interior walls are more curvy along curvy external walls, and more orthogonal where the algorithm showcased a more conservative massing.

The design of this house was in the end mostly imagined by me, rather than by the algorithm. It is in effect a rendition of what I was able to read in the images the GAN generated. This might be a collaborative process indeed, and we will adress this question in the following chapter.

Conclusion

In this thesis I investigated the potential of GANs as a creative architectural collaborator, through the design of a summer house.
Whereas AI algorithms are mainly used today in the building industry to optimise structural beams, sunlight exposure or other numerically measurable components, I wanted to test their ability to tackle more abstract notions.
Therefore instead of using an algorithm to optimise my design, I translated the algorithm's design into an architectural proposal.
I supposed such a novel framework would prove or dismiss the potential of AI as creative architectural collaborator.

While the output images from my networks were compelling by their non-human qualities, many of them looked similar, which might have been a result of overfitting because of too small of a dataset.
Even though the outputs came in immense number, some of them were very boring or completely random. We have seen before that an outburst of ideas is not very useful if they are not properly ordered and put into form[0011] so we can argue that the creative part of the process resided with me rather than the algorithm.

I dispute the argument that GANs are creative, as they have no agency. My networks seem to fit into the base definition of creative (the images they generated were novel and useful). However I was the agent curating the outputs and evaluating their originality and usefulness, I was the entity in control of the creative process. There is here a notion that is essential to mention; human interpretation. As humans, we tend to give anthropic qualities to inanimate objects.
For example, the first instance of what is dubbed 'computer art' dates back to the 1960s when a plotter malfunctioned at Bell Labs in the United States and produced random lines that A. Michael Noll (a scientist working there with one of the world's first computers) saw as a deliberate artistic gesture.[0027] Of course there is to this day no proof that any computer ever got its own agency.
In my thesis, my role as a communication coordinator became so prevalent it proves the relevance of architects, even in a AI-driven project. The GAN

on itself could not have produce an acceptable architectural proposal. Therefore even if ML algorithms are today a new discourse for the architecture field, there is according to this thesis no proof that a professional shift will happen, from architect as designer to architect as curator.
However, I believe it is still important that we as architects keep getting educated on this discourse, so that we can take part in the discussion and prove why our job is relevant in an age where HITs (Human Intelligence Tasks) can be automated.

While I was working on this thesis, Mark Zuckerberg advertised his "Builder Bot", an "AI concept [that] enables you to describe a world, and then it will generate aspects of that world for you [in the metaverse]".[0028]
As impressive at this sounds, the creativity of the billionaire as much as the graphic aspect of his metaverse makes the whole scene feel tragic rather than groundbreaking. Granted, this technology is disruptive and could actually have game-changing applications in the architectural world. But if the metaverse is the internet revolution it claims of being, these digital spaces should be shaped by people with architectural design background.

This video illustrates precisely why architects would still be needed, even in a world where buildings were to be machine-generated; You can have the most complex generator program with the easiest input method (voice-control in this case), if the human in control is unable to properly articulate the premises and curate the machine-generated results, the build environment could turn into a hellscape.
While ML algorithms might produce an immense amount of architectural sketch concepts, someone who is spatially and designedly educated is still needed to curate or create a training dataset and assess the outputs.
The human factor here is more important than the machine's and for this reason this particular thesis does not prove that the framework I use is an effective way for GANs to be creative collaborators.

However there could be other type of framework where the machine has more control over the process, and less importance is given to buildability or different ways to use these algorithms in the architecture profession. One of them could be generating precedents, instead of sketch proposals. In that scenario, I would have looked at the results the networks would have given me as a source of inspiration, taking some aspects from one, some aspects from another and imagining a new building based on these.

A sad example of what lack of creativity looks like. Source:Mark Zuckerberg[1015]

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AI : Architects' Inferiority?
AAHM10 : Degree Project in Architecture - Spatial Experiments

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June 2022