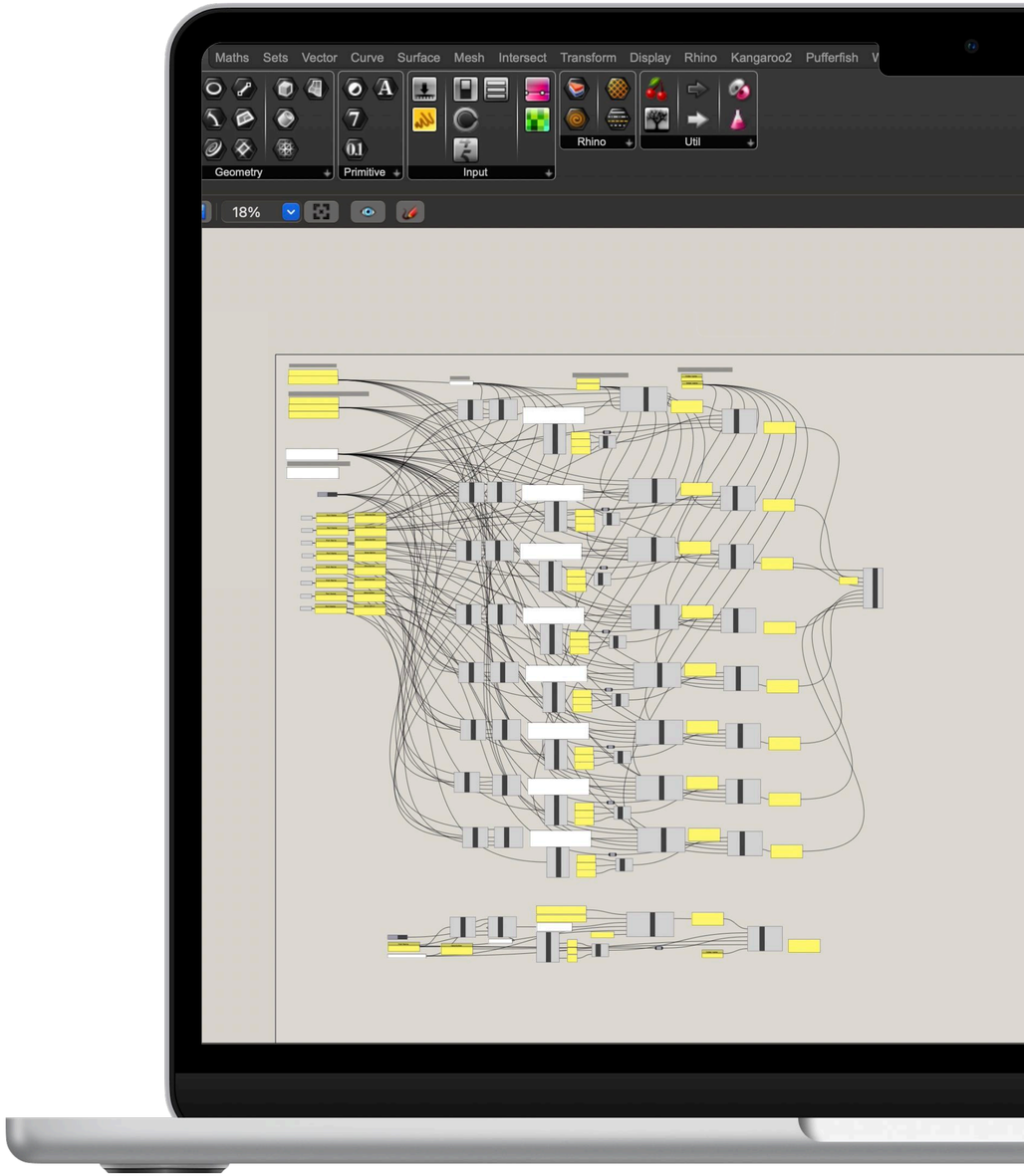
Amoeba

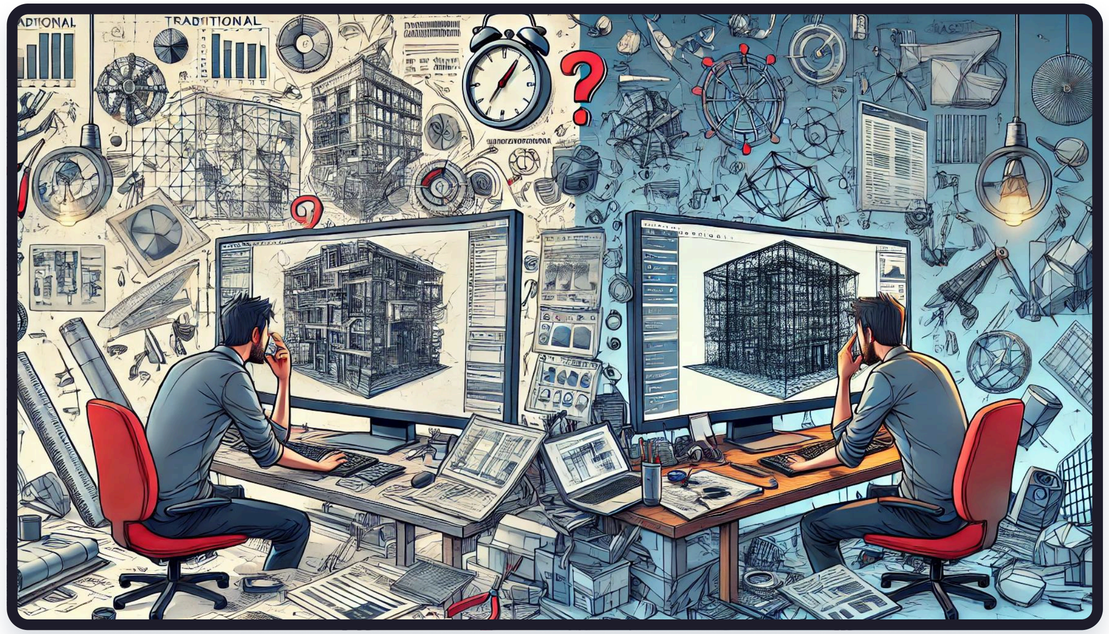
Model Smarter, Morph Faster



DESIGN 6297 | Bo Li + Rui Liu + Shiyuan Tian+ Zijie Zhou as Whatever

DESIGN CHALLENGE

Traditional processes of **3D design iteration** in the Rhino and Grasshopper environments require manual adjustments and technical expertise, which can be **time-consuming and complex**. These challenges often hinder designers from focusing on creative exploration and experimentation, leading to a **slower innovation** process.



HOW MIGHT WE:

empower designers to intuitively **explore creative possibilities** and generate innovative **design variations** to streamline the innovative 3D design iteration process?

TARGET USERS

Architects

Product Designers

Developers

Students

Artists

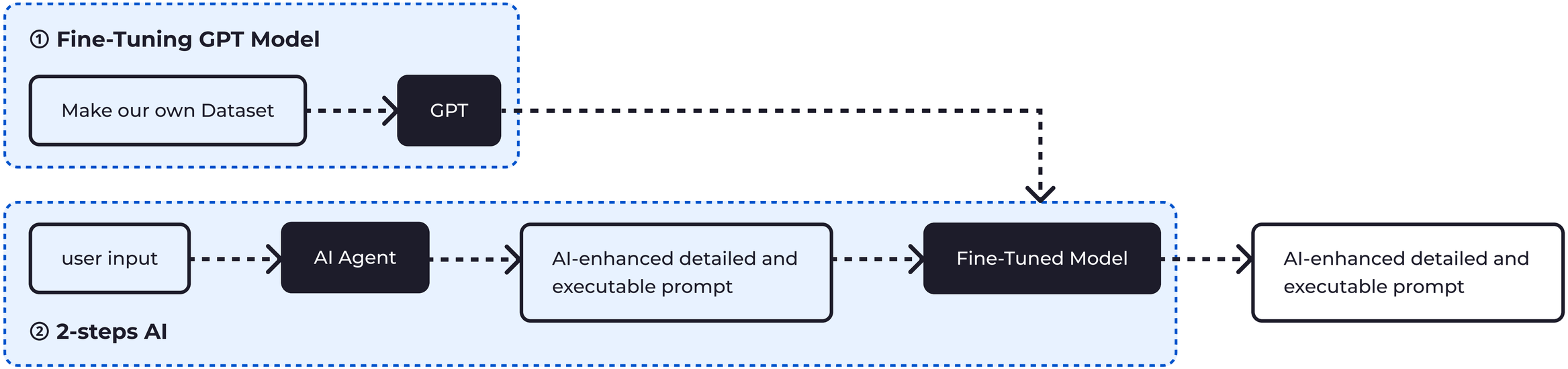
GOAL:

The goal of this project is to enable users to **modify designs intuitively using natural language**. This reduces the barrier for translating abstract ideas into tangible models, accelerates the iteration of design variations, and introduces AI-generated outputs to spark fresh inspiration.

Ultimately, our solution frees designers from complex tasks, empowers them to experiment without constraints, and fosters a more fluid, innovative design process.

Our plugin - Amoeba, integrates a **toolkit that fine-tunes GPT models** within Grasshopper, and **utilizes the fine-turned model** to edit your existing model or generate variations.

OUR APPROACH - High level overview of plugin architecture



WORKFLOWS

Training Model: Data production + Fine-Tuning GPT

① Parametric Design Generation for **data production**

② Data Generation and Semantic **Annotation** to Enhance LLM Understanding

③ Dataset **Preparation** for Fine-Tuning Models

④ **Fine-Tuning** GPT Models for Customized Design Outputs

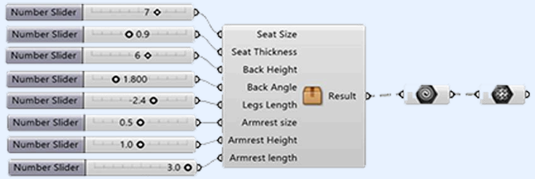
Using Model: 2-steps AI

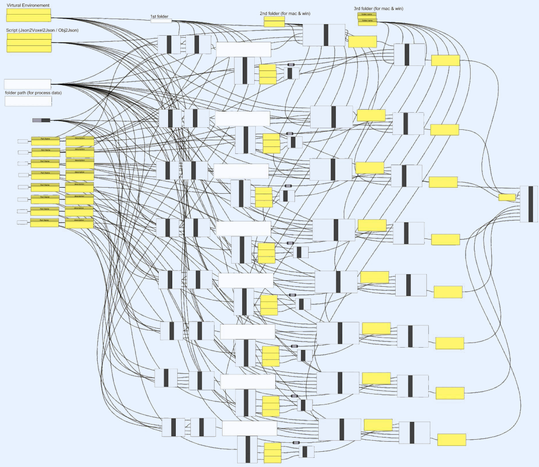
⑤ **Two-step AI process** involving an AI agent and the fine-tuned model for Design Generation

⑥ Display the AI-generated design outputs as Geometry in Rhino

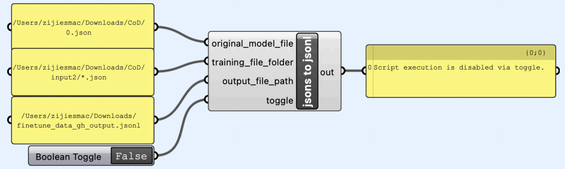
WORKFLOWS

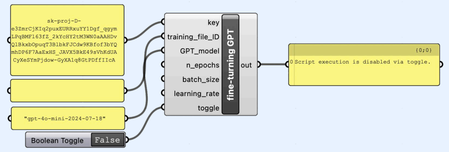
Training Model: Data production



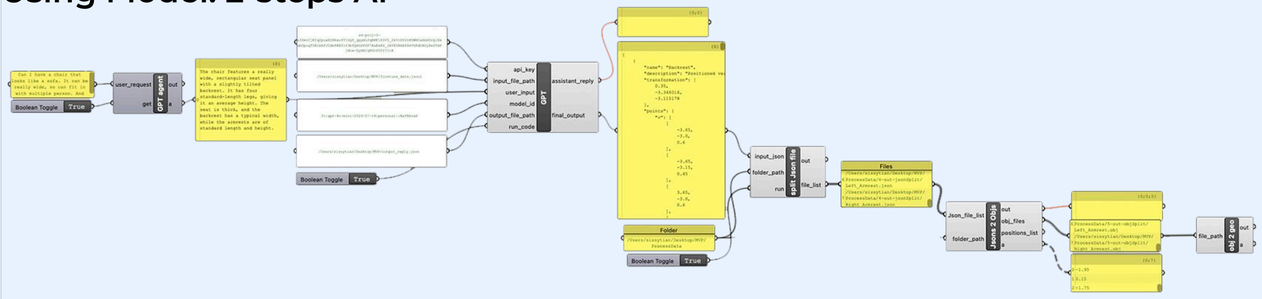


Training Model: Fine-Tuning GPT



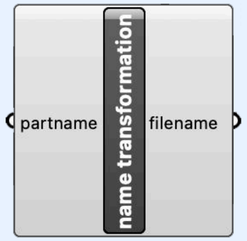


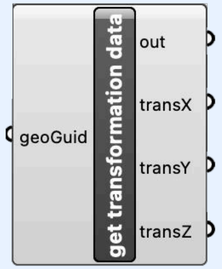
Using Model: 2-steps AI

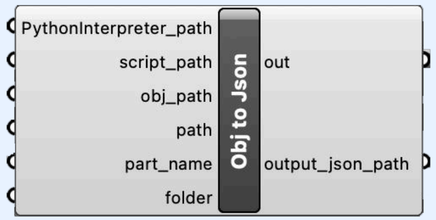


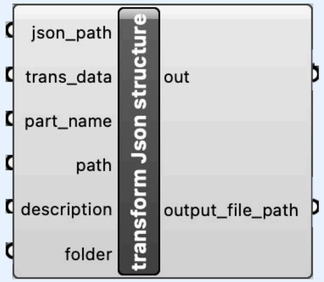
ALL PLUGIN COMPONENTS

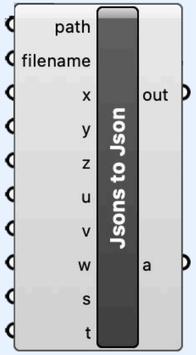
Training Model: Data production



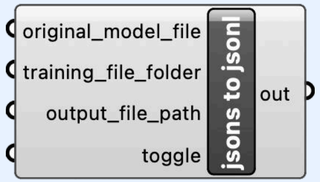


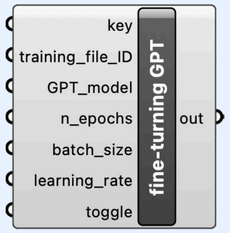




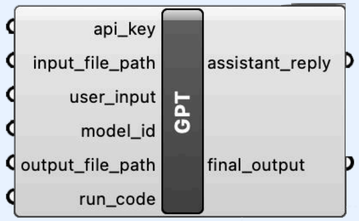


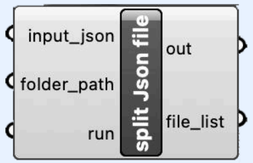
Training Model: Fine-Tuning GPT

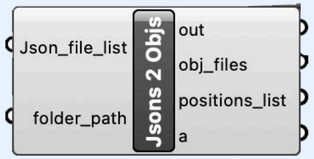


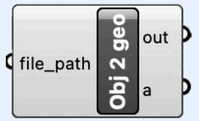


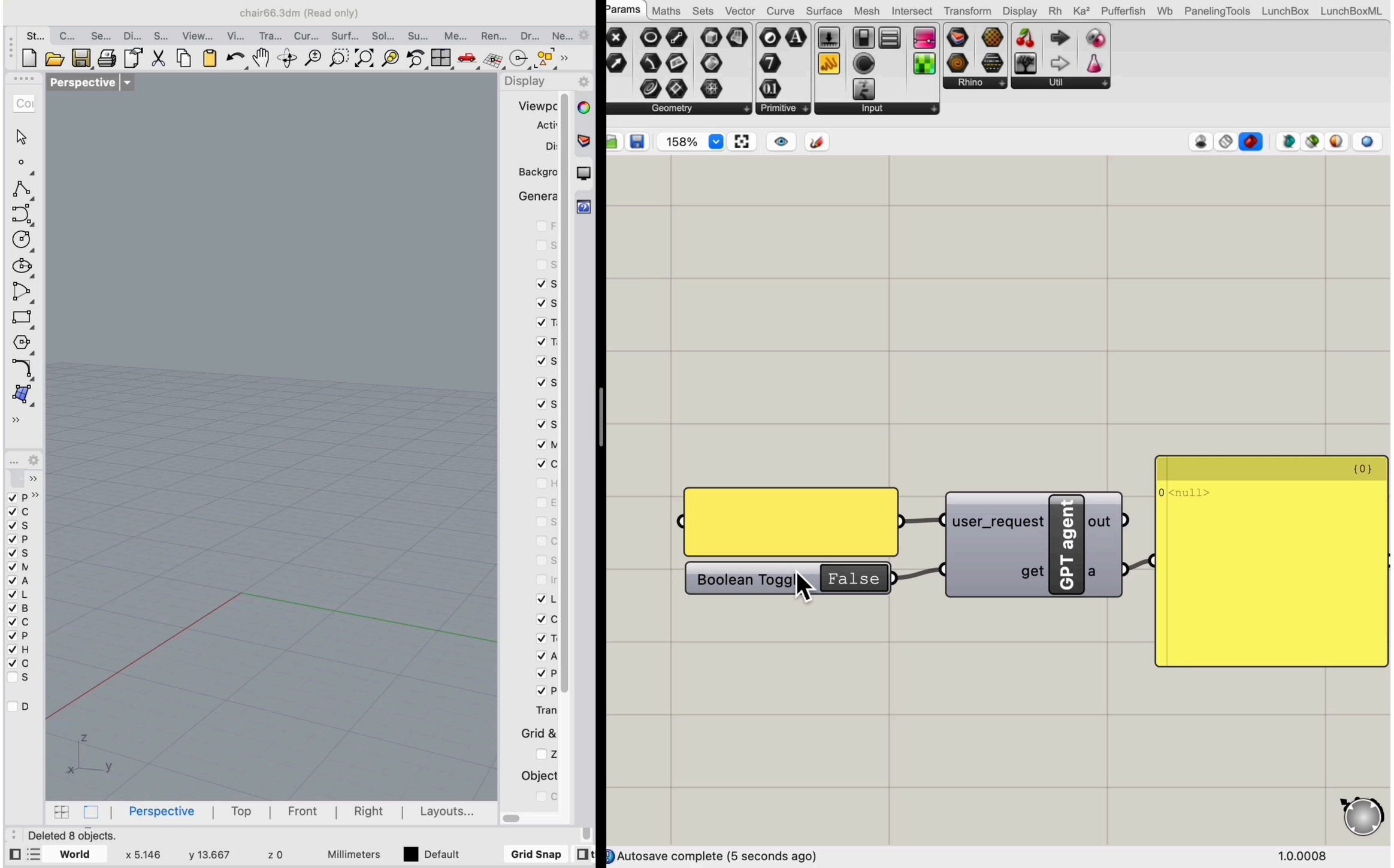
Using Model: 2-steps AI





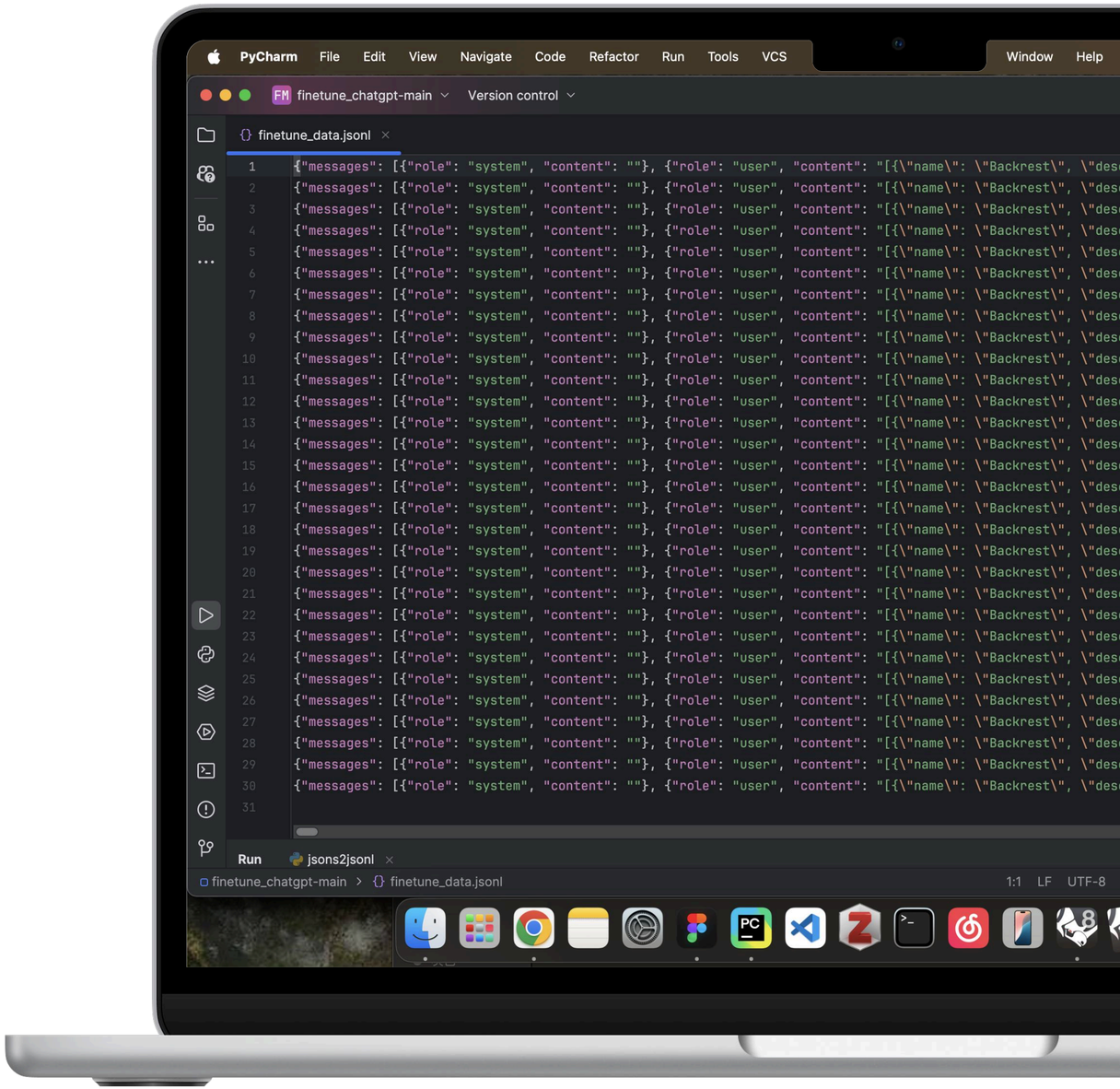




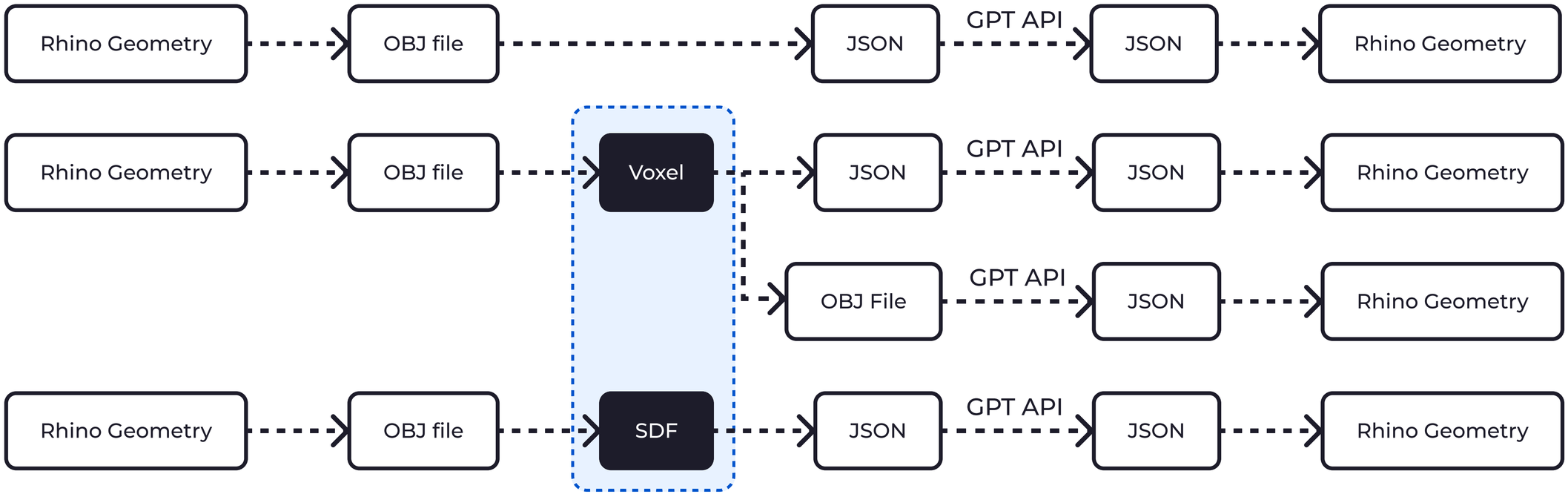

chair66.3dm (Read only)
Perspective
Display
Params
Maths
Sets
Vector
Curve
Surface
Mesh
Intersect
Transform
Display
Rh
Ka²
Pufferfish
Wb
PanelingTools
LunchBox
LunchBoxML
Geometry
Primitive
Input
Rhino
Util
158%
user_request
out
get
a
GPT agent
Boolean Toggl
False
{0}
0 <null>
Perspective
Top
Front
Right
Layouts...
Deleted 8 objects.
World
x 5.146
y 13.667
z 0
Millimeters
Default
Grid Snap
Autosave complete (5 seconds ago)
1.0.0008

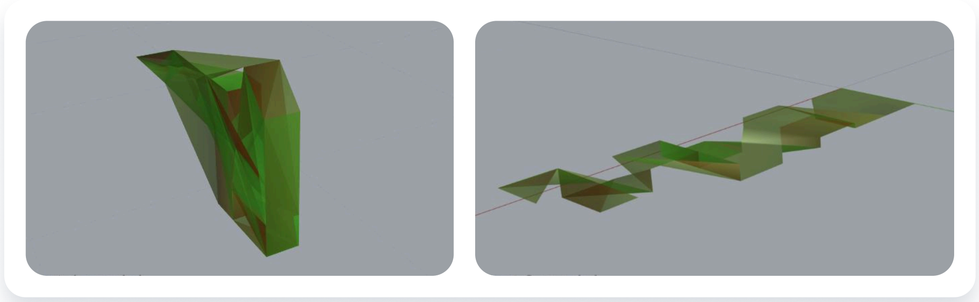
PROCESS

Process and Iterations



Initial Explorations With Different 3D Data Types

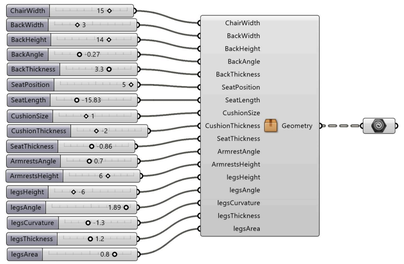




Failed - LLMs are not so good at 3D Geometry

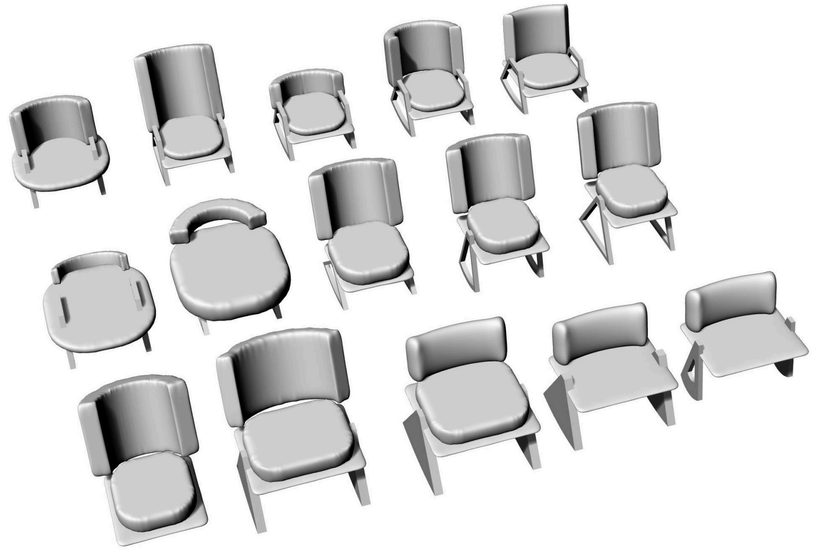
① Chair As A Demo Example - Dataset Version 1.0

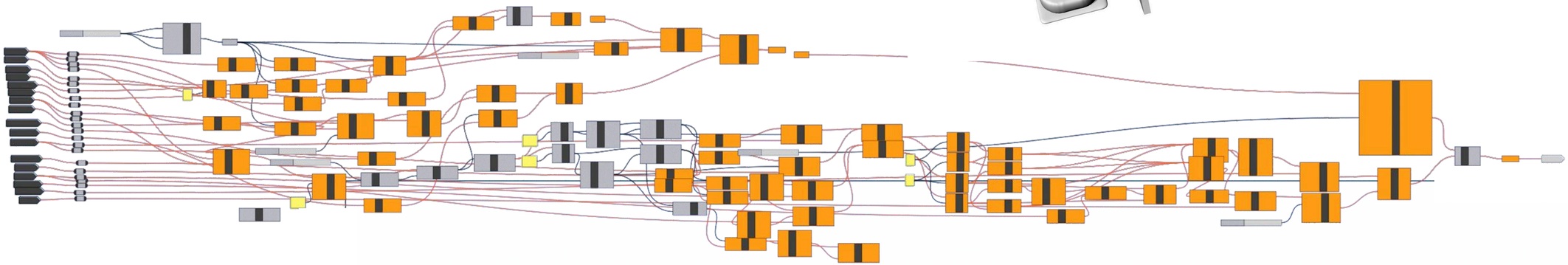
Parametric Chair for Data Production



GH Parametric Chair Version 1.0

Fine-turning Dataset





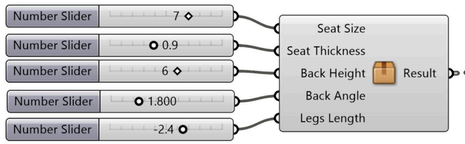
! Failed - Too much Data that over the limits of the Fine-turning

① Streamlining Data Iteratively - Dataset Version 2.0

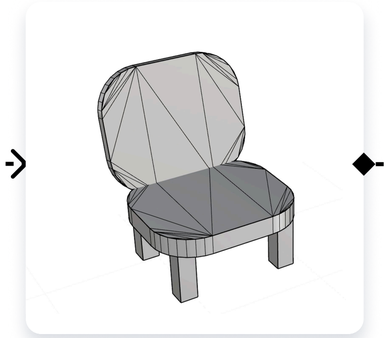
```
1 examples may be over the 65536 token limit, they will be truncated during fine-tuning
Dataset has ~65536 tokens that will be charged for during training
By default, you'll train for 25 epochs on this dataset
By default, you'll be charged for ~1638400 tokens

Process finished with exit code 0
```

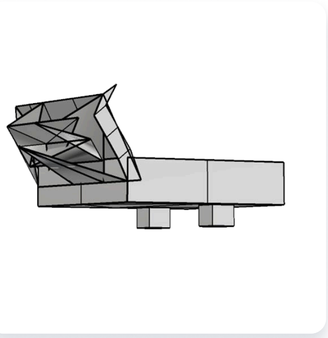
1. **Minimum** number of **points and faces** for model training and ai analysis.
2. **Enough variables** to make it easy to create enough data to train the ai model.



GH Parametric Chair Version 2.0



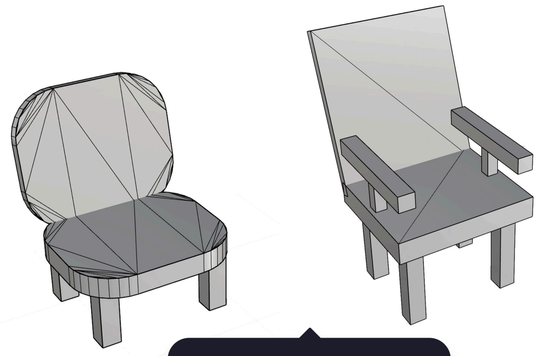
Fine-turned GPT



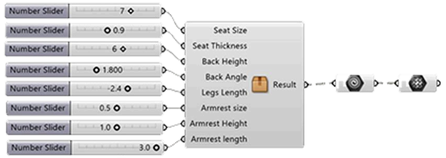
Failed - Unnecessary meshes might confused GPT

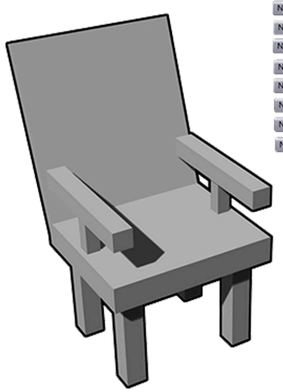
② Generating Data - Dataset Version 3.0

Chair Variations



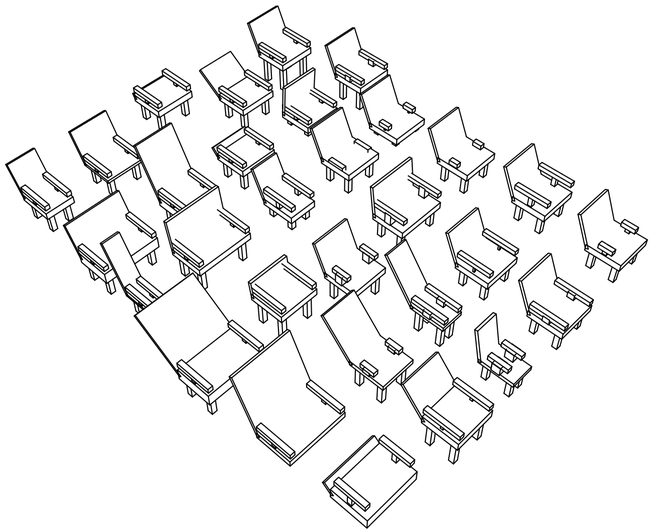
# of Meshes
Version 2 V.s. 3





GH Parametric Chair
Version 3.0

Fine-turning Dataset



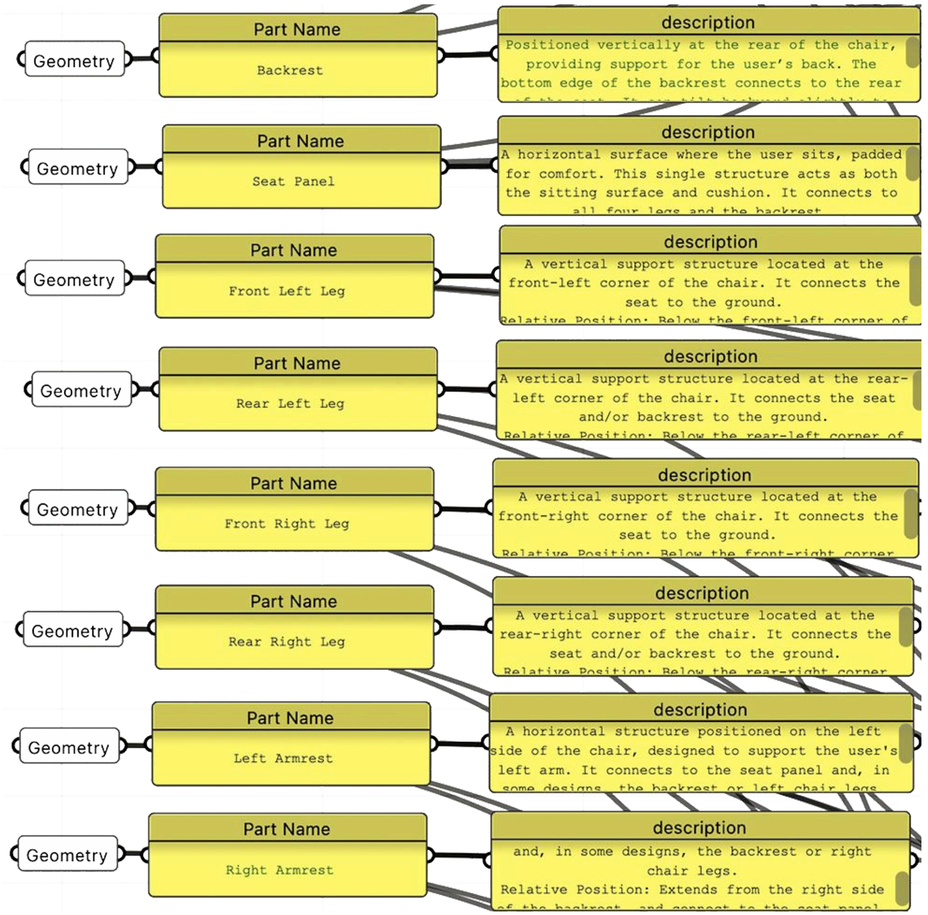
Component Data	seat size	seat thickness	back height	Back angle	legs length	Armrest size	Armrest height	Armrest length
0	7	1.2	6	2	-3.5	0.5	1	3
1	5	1.2	6	2	-3.5	0.5	1	3
2	7	0.5	6	2	-3.5	0.5	1	3
3	7	1.2	1	2	-3.5	0.5	1	3
4	7	1.2	6	2.5	-3.5	0.5	1	3
5	7	1.2	6	2	-5	0.5	1	3
6	7	1.2	6	2	-3.5	0.8	1	3
7	7	1.2	6	2	-3.5	0.5	2	3
8	7	1.2	6	2	-3.5	0.5	1	1.2
9	10	2	6	2	-3.5	0.5	1	3
10	7	1.7	10	2	-3.5	0.5	1	3
11	7	1.2	2	2.3	-3.5	0.5	1	3
12	7	1.2	6	1.5	-1.3	0.5	1	3
13	7	1.2	6	2	-4.2	0.8	1	3
14	7	1.2	6	2	-3.5	0.2	1.6	3
15	7	1.2	6	2	-3.5	0.5	0.4	0.8
16	3	0.4	9	2	-3.5	0.5	1	3
17	10	1.2	6	1.7	-4.2	0.5	1	3
18	5	1.2	6	2	-2.2	0.5	1.6	3
19	7	1.2	6	2	-3.5	0.9	0	1.5
20	7	1.2	6	2	-1	0.2	1	1
21	10	2	10	2.5	-3.5	0.5	1	3
22	7	1.2	3	1.7	-4.7	0.1	1	3
23	7	1.2	6	2	-4.3	0.9	1.7	1.5
24	9	1.2	6	1.7	-3.5	0.8	2	3
25	10	1	10	2	-1.1	0.5	1	3
26	7	1.4	6	2.3	-4.8	0.3	1.2	3
27	4	0.7	6	1.8	-3.5	1	1.5	1.7
28	4	0.7	9	2.2	-4.6	0.9	1	3
29	9	1.8	2	2.4	-1.5	0.5	2	2.5
30	6	0.8	8	2.3	-4.2	0.8	0.7	1.2

② Generating Data - Dataset Version 3.0

Adding Semantic Description to Json Data For Better LLM Understanding

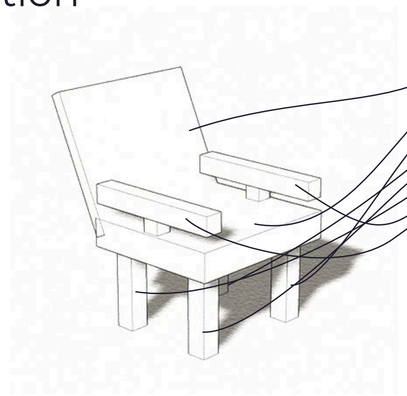
1. Dividing the whole chair into **several component** parts.
2. Adding names and descriptions to each part of the chair, **describing** both their absolute and relative **positions**.
3. Composing them into an organized JSON file.

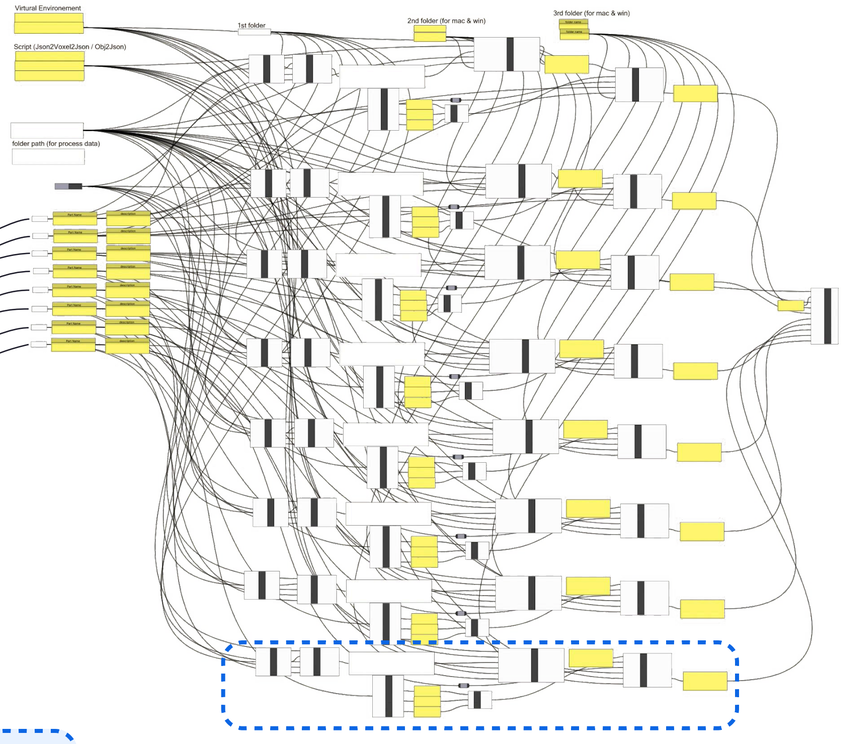
```
{
    "name": "Front Right Leg",
    "description": "A vertical support structure located at the fr
    "transformation": [
        -115.0,
        44.0,
        -2.5
    ],
    "points": {
        "v": [
            [
                114.0,
                -52.0,
                0.0
            ],
            [
```

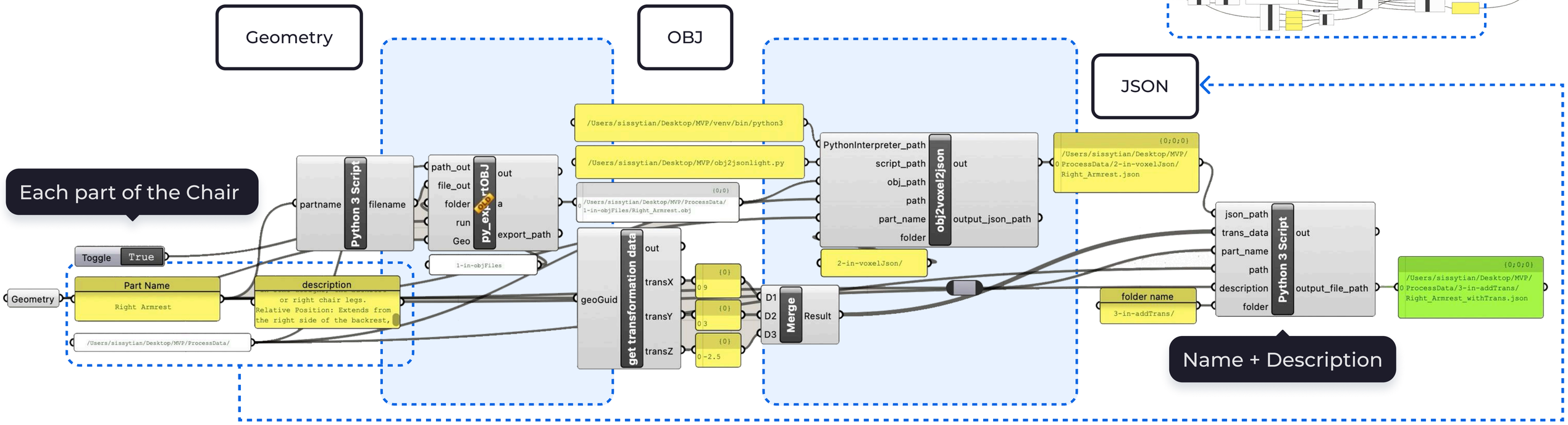


③ Generating And Preparing Data

From Geometry to Json with Semantic Description

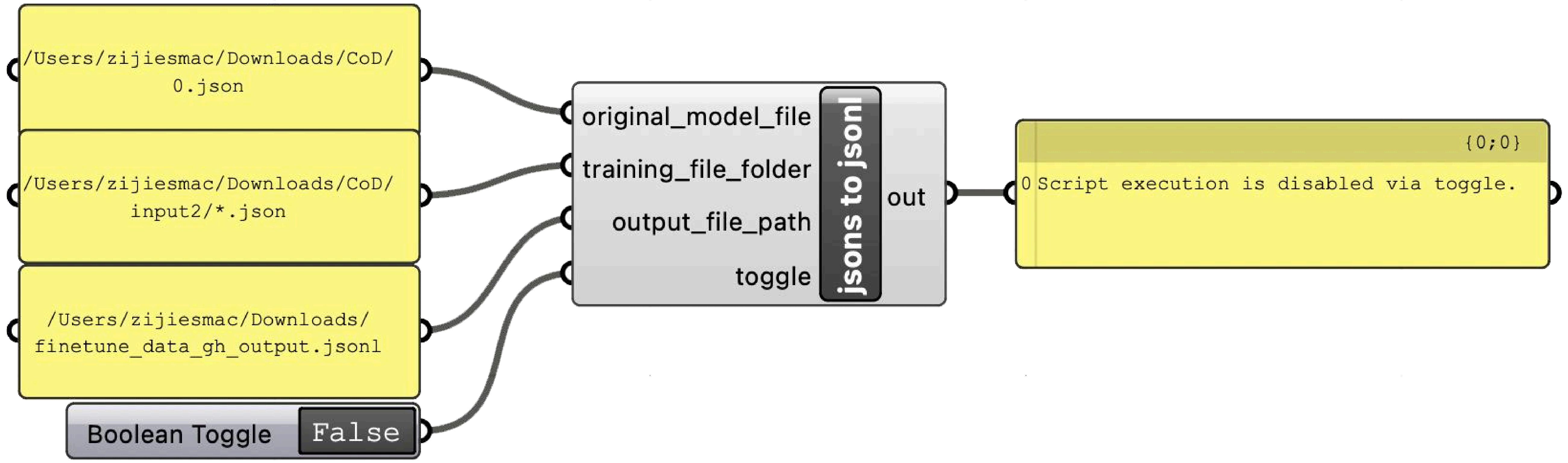






③ Preparing Data For Fine-Tuning

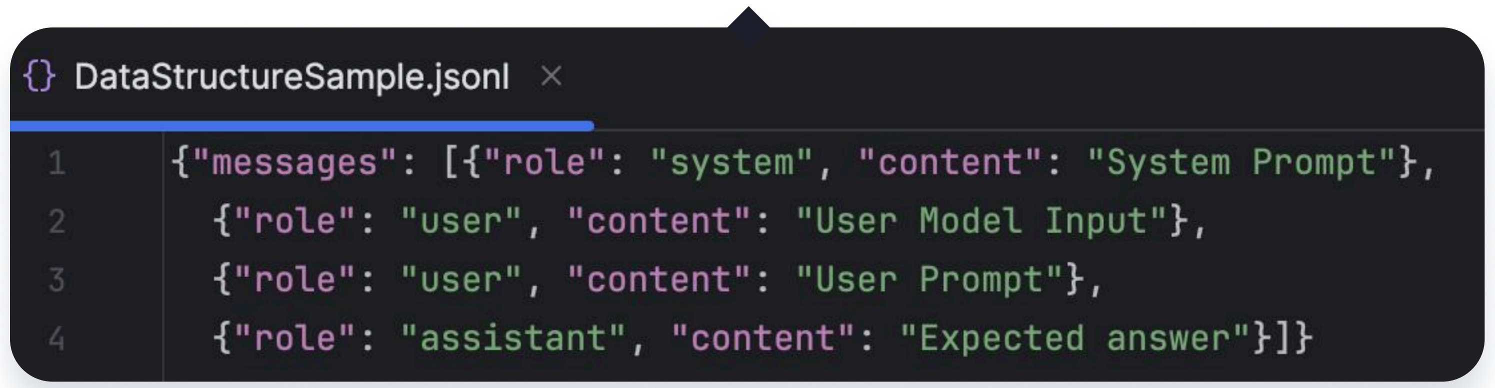
Json 2 Jsonl



```
0 Script execution is disabled via toggle.
```

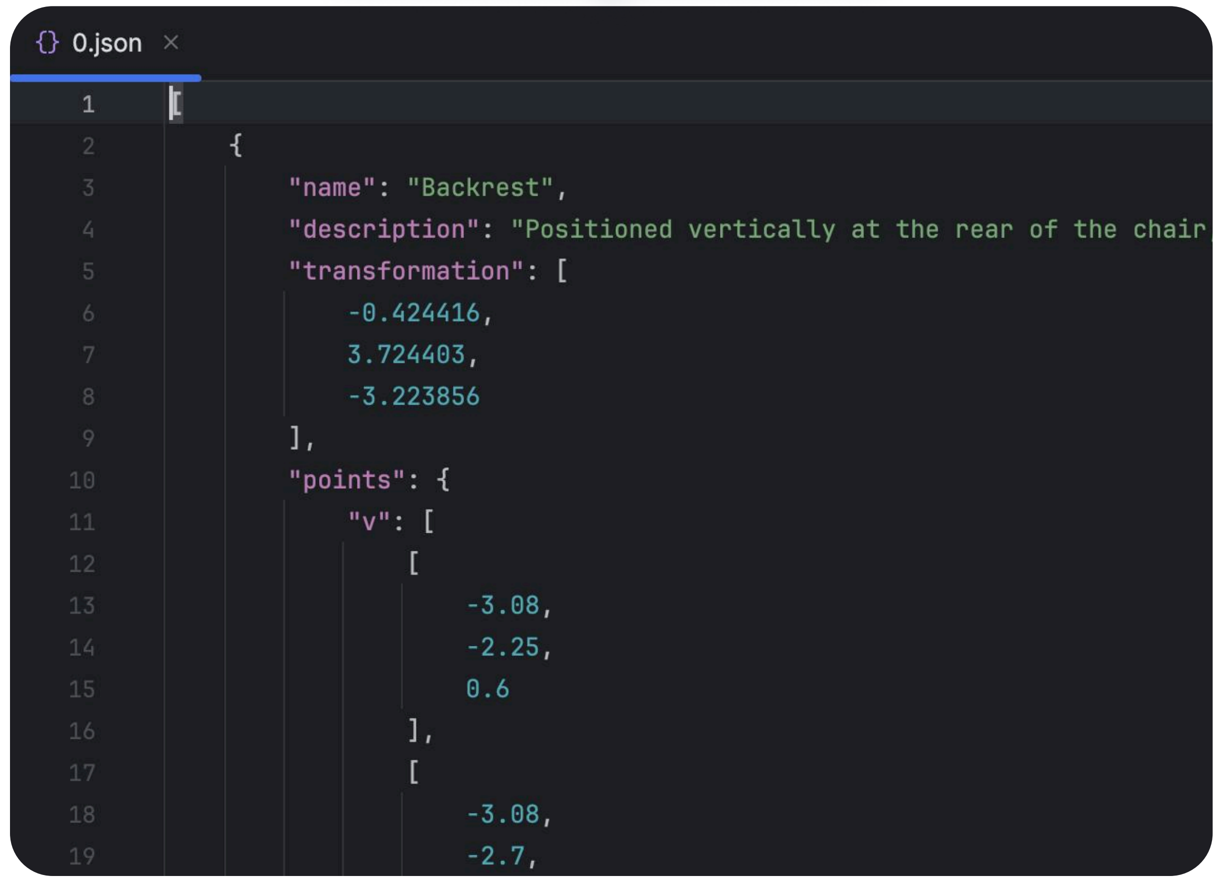
Multiple JSON files → jsons to jsonl → Single JSONL file

Single Line Data Structure in the Jsonl File



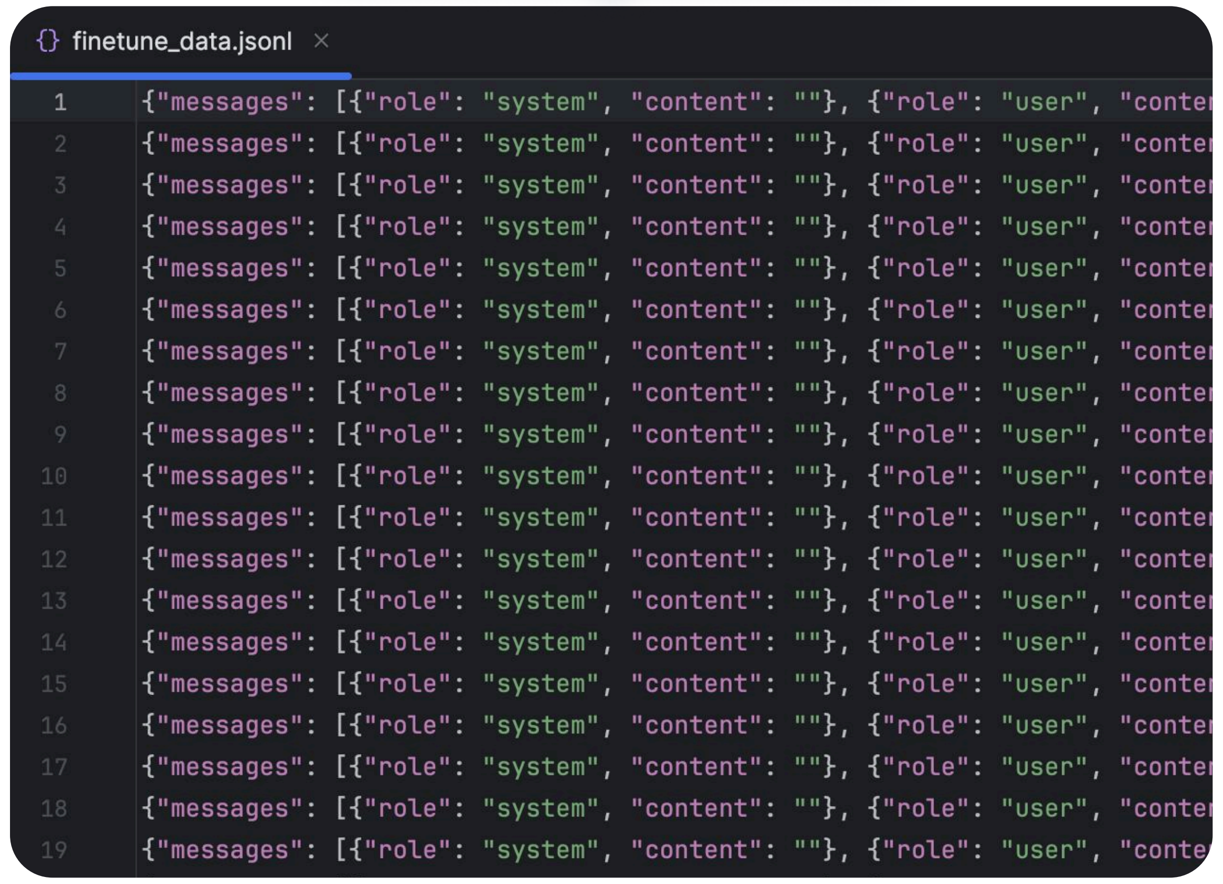
```
{"messages": [{"role": "system", "content": "System Prompt"},
  {"role": "user", "content": "User Model Input"},
  {"role": "user", "content": "User Prompt"},
  {"role": "assistant", "content": "Expected answer"}]}
```

Single Json File



```
[
    {
        "name": "Backrest",
        "description": "Positioned vertically at the rear of the chair
        "transformation": [
            -0.424416,
            3.724403,
            -3.223856
        ],
        "points": {
            "v": [
                [
                    -3.08,
                    -2.25,
                    0.6
                ],
                [
                    -3.08,
                    -2.7,
```

Single Jsonl File



```
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
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{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
{"messages": [{"role": "system", "content": ""}, {"role": "user", "conte
```
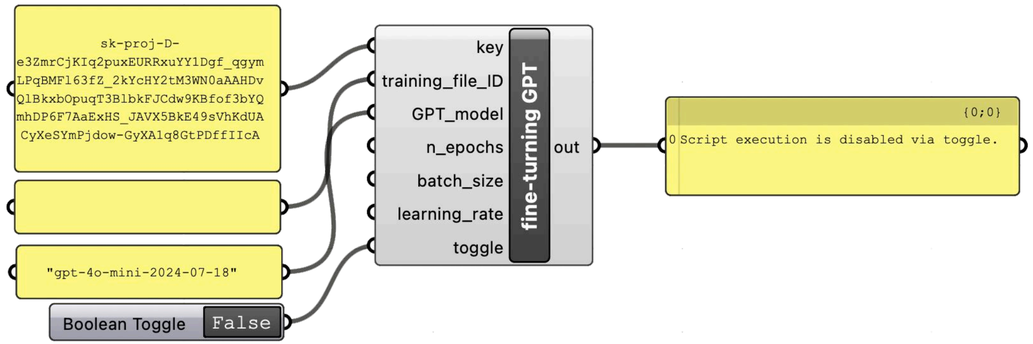
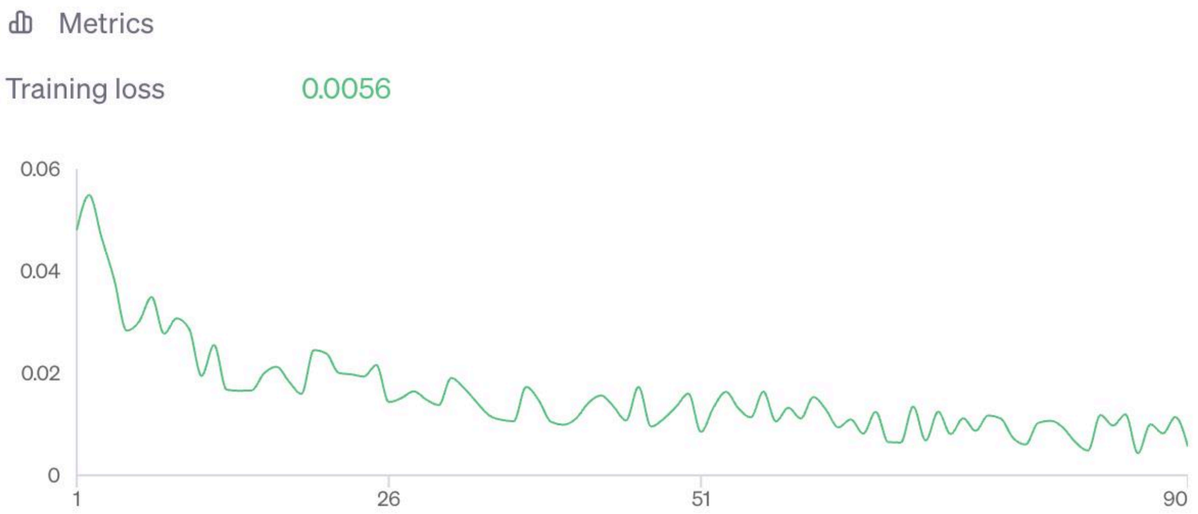

④ Fine-Tuning GPT





MODEL

ft:gpt-4o-mini-2024-07-18:personal::AaoFCHCQ

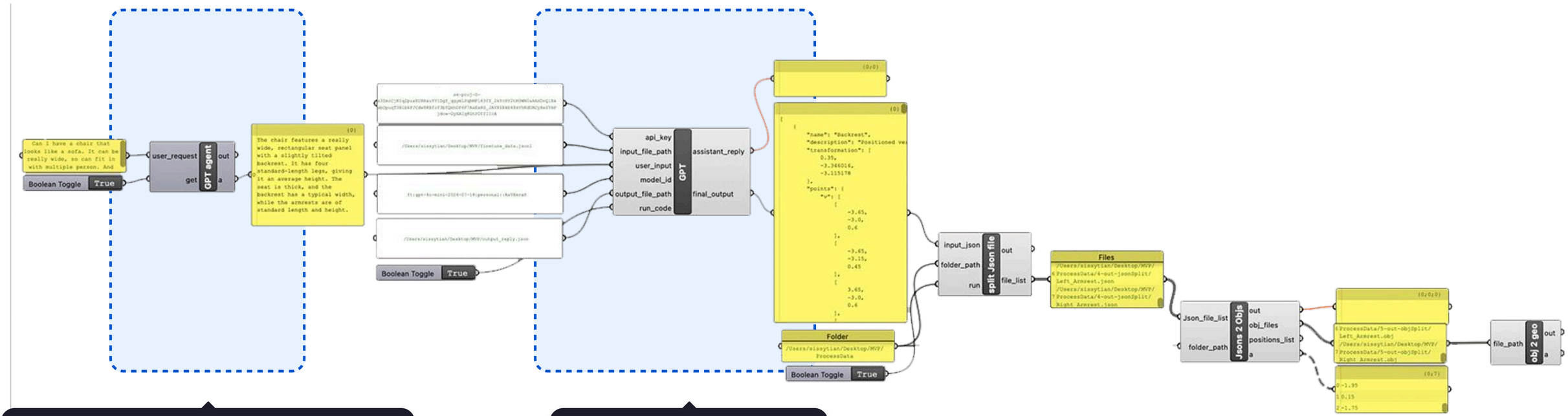
Status	Succeeded
Job ID	ftjob-qJBECNM4Z752UATXafF6EvdE
Base model	gpt-4o-mini-2024-07-18
Output model	ft:gpt-4o-mini-2024-07-18:personal::AaoFCHCQ
Created at	Dec 4, 2024, 1:11 PM
Trained tokens	1,877,220
Epochs	3
Batch size	1
LR multiplier	1.8
Seed	609415618

Time	Step	Training loss	Validation loss	Full Validation loss
13:18:19	90	0.0056	-	-
13:18:05	89	0.0114	-	-
13:18:03	88	0.0082	-	-
13:18:01	87	0.0100	-	-
13:18:00	86	0.0043	-	-
13:17:58	85	0.0119	-	-
13:17:56	84	0.0097	-	-
13:17:54	83	0.0118	-	-

⑤ Two-Step AI Process

AI agent

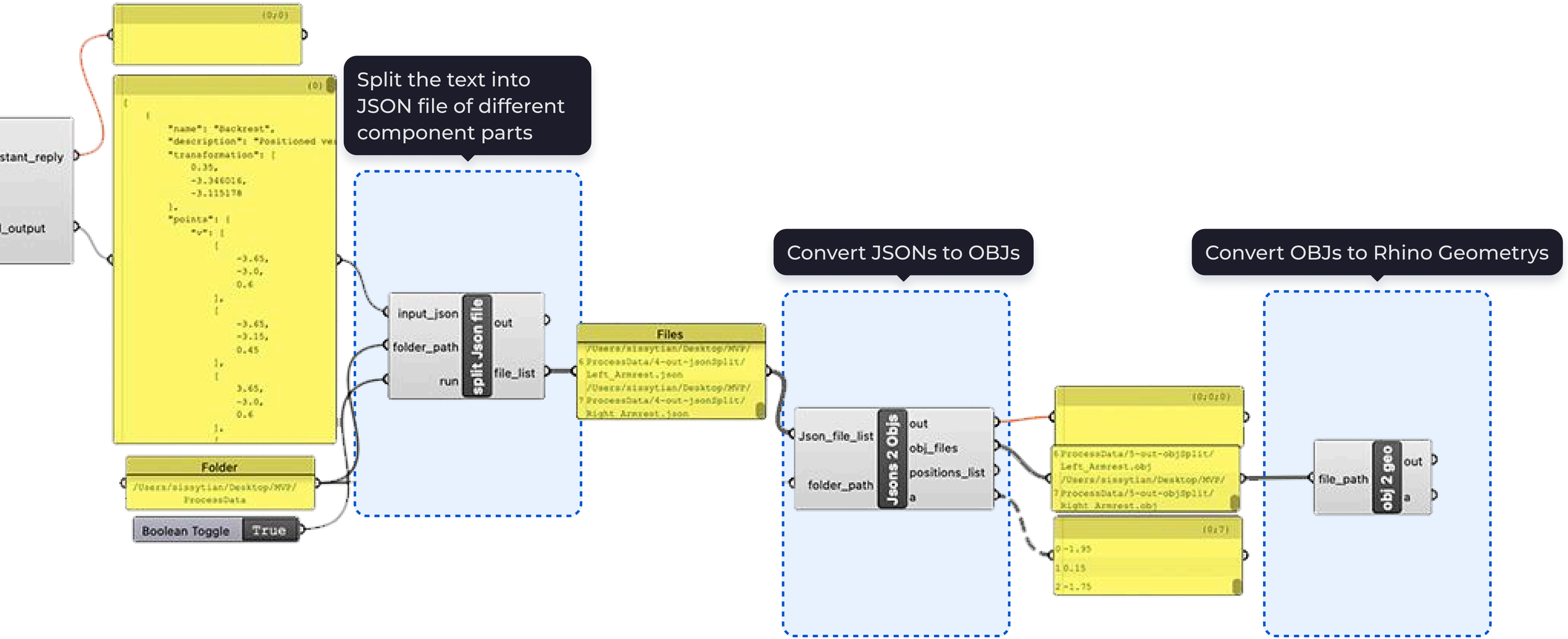
Fine-tuned model



translates abstract user input into specific design requirements and detailed and actionable prompts

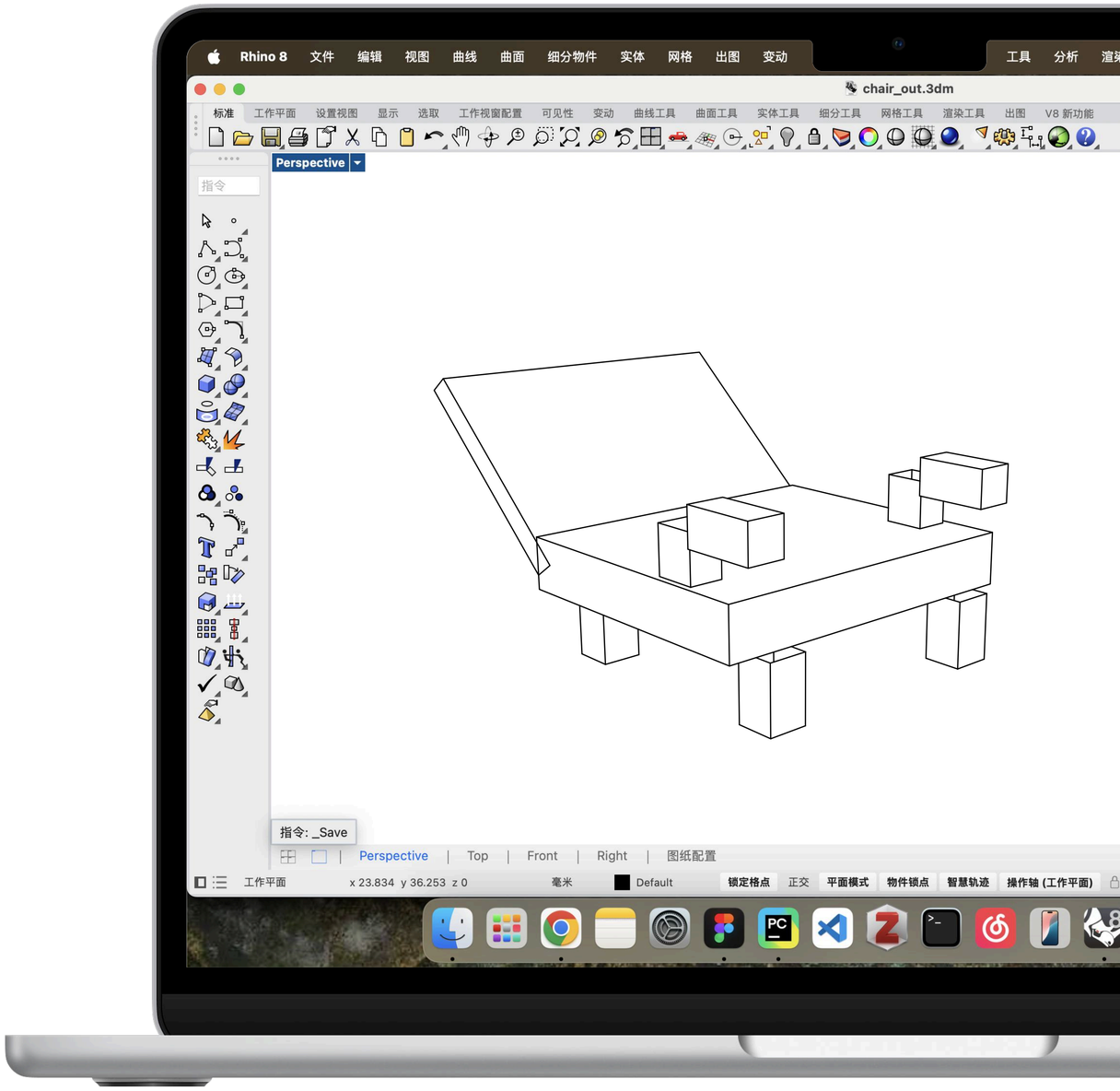
Generate Chair Designs

⑥ Display The AI-Generated Design Outputs As Geometry In Rhino

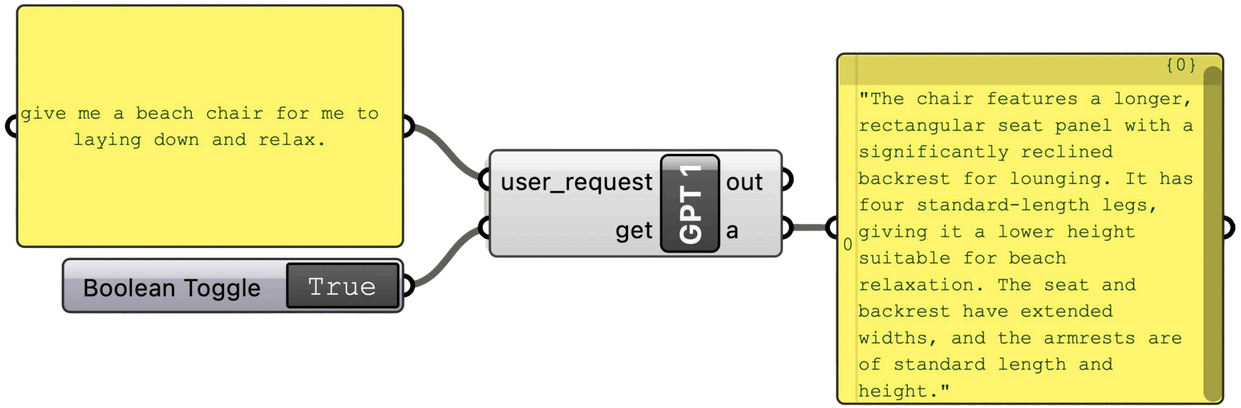


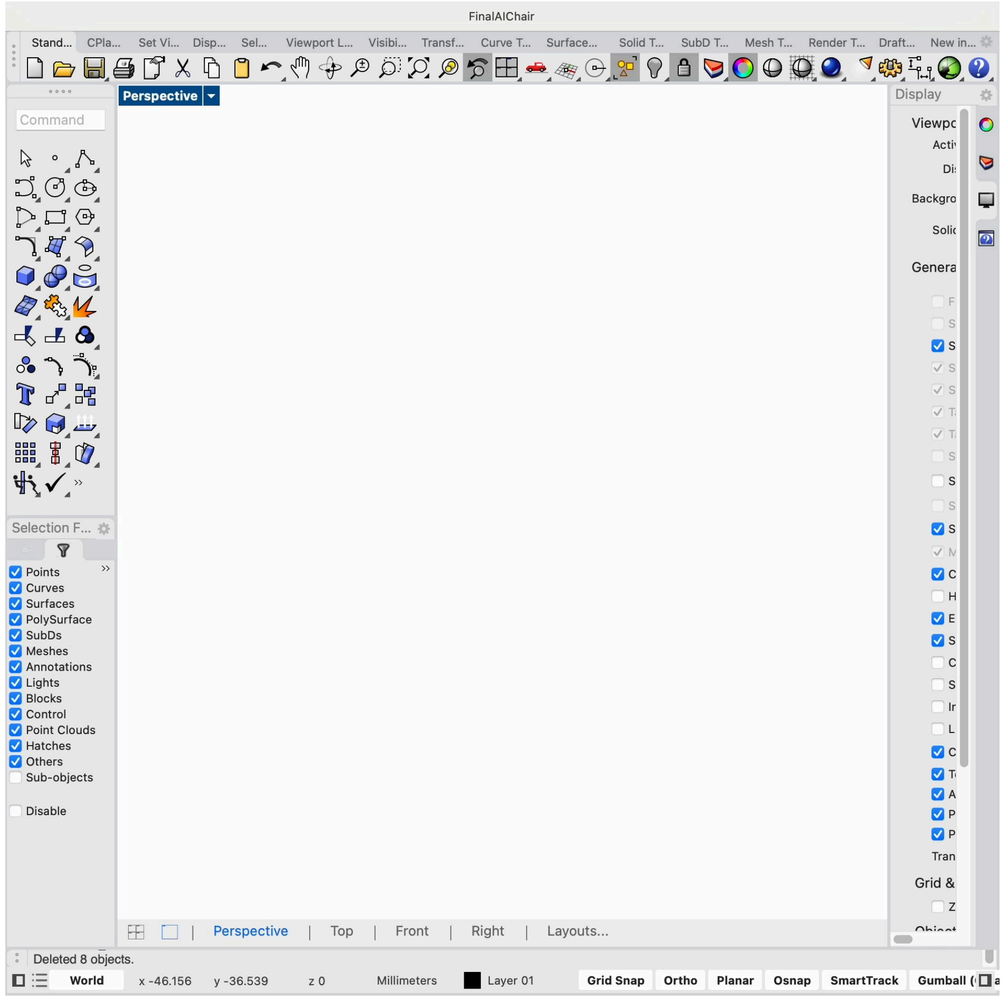
EXAMPLE OUTPUTS

Testing and examples

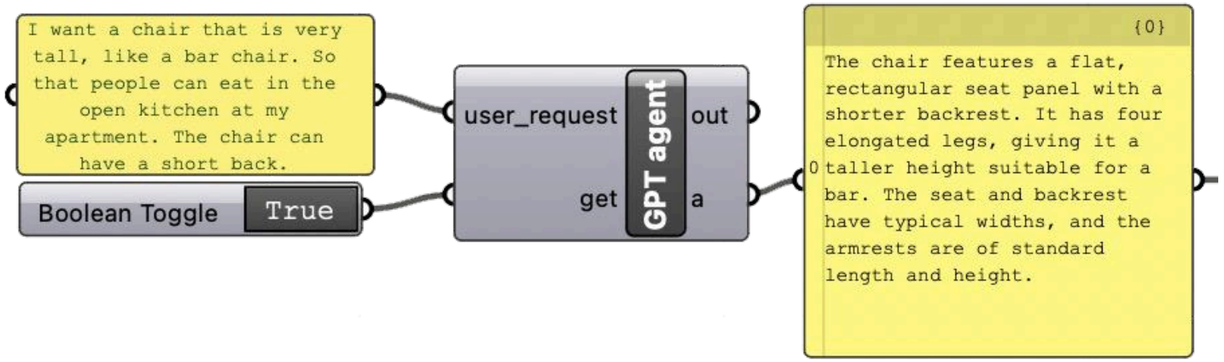


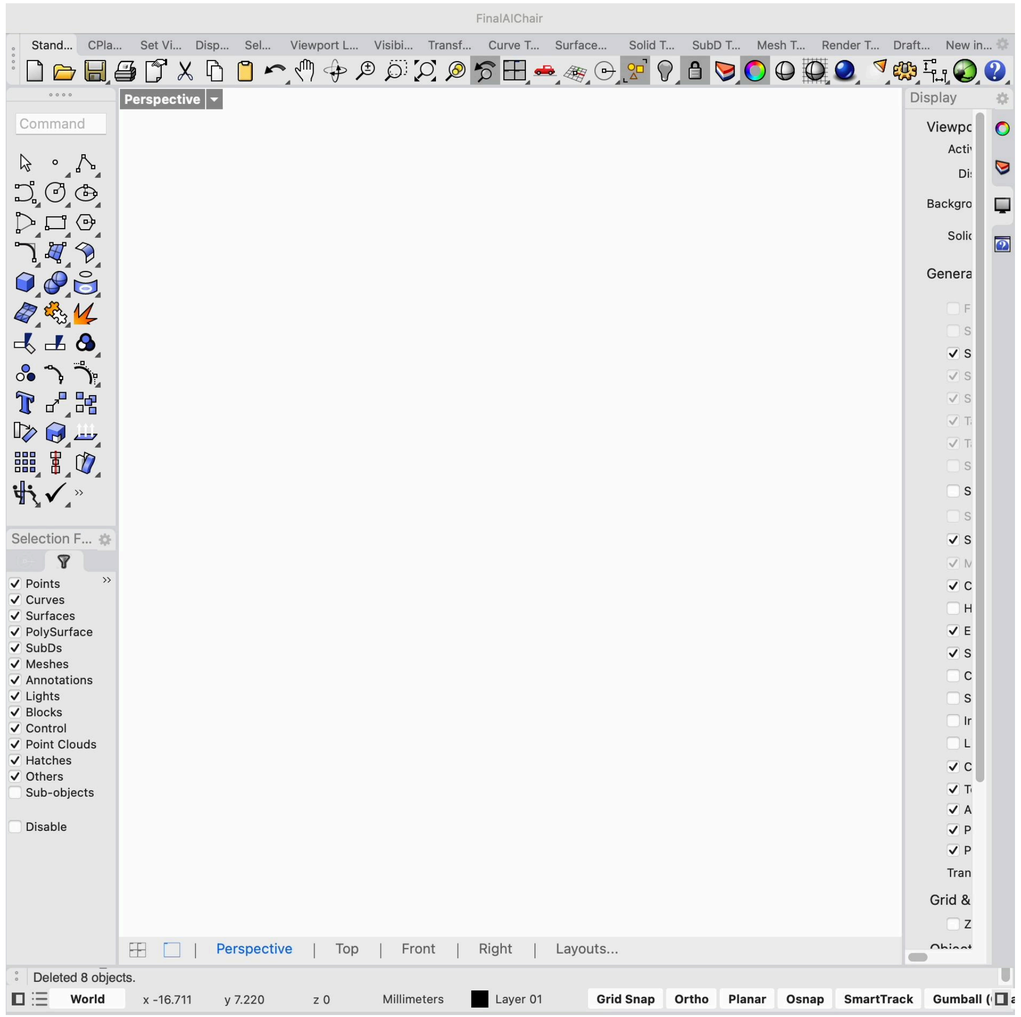
Example Outputs - #1 Beach Chair

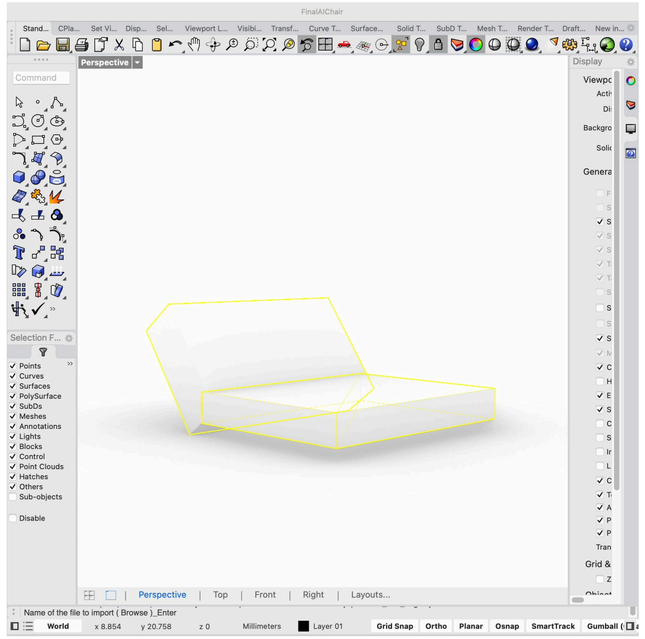


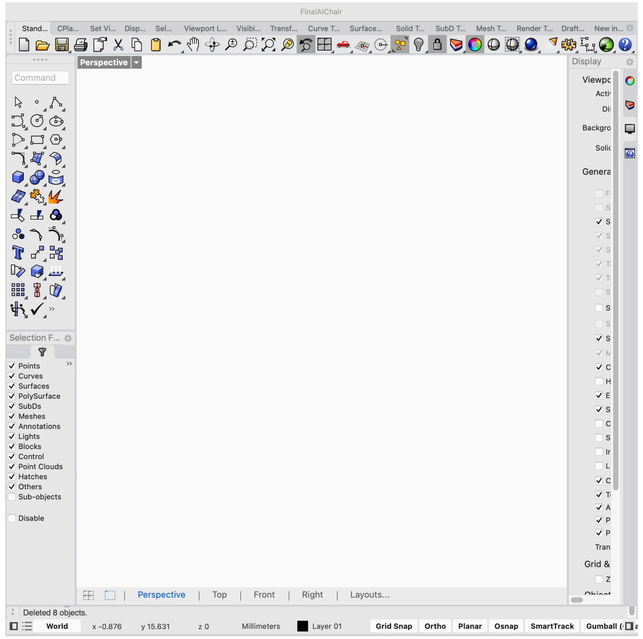


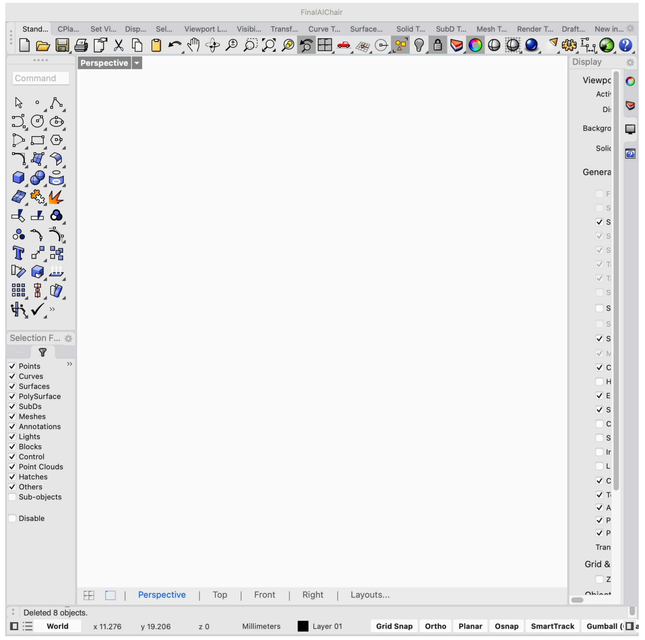
Example Outputs - #2 Bar Chair

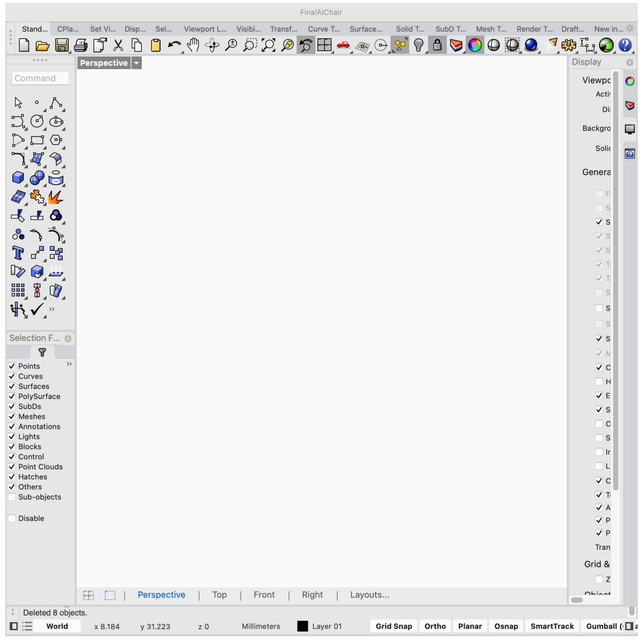





FinalAIChair
Perspective
Top
Front
Right
Layouts...
Name of the file to import (Browse)_Enter
World
x 8.854
y 20.758
z 0
Millimeters
Layer 01
Grid Snap
Ortho
Planar
Osnap
SmartTrack


FinalAIChair
Perspective
Top
Front
Right
Layouts...
Deleted 8 objects.
World
x -0.876
y 15.631
z 0
Millimeters
Layer 01
Grid Snap
Ortho
Planar
Osnap
SmartTrack


FinalAIChair
Perspective
Top
Front
Right
Layouts...
Deleted 8 objects.
World
x 11.276
y 19.206
z 0
Millimeters
Layer 01
Grid Snap
Ortho
Planar
Osnap
SmartTrack


FinalAIChair
Perspective
Top
Front
Right
Layouts...
Deleted 8 objects.
World
x 8.184
y 31.223
z 0
Millimeters
Layer 01
Grid Snap
Ortho
Planar
Osnap
SmartTrack

THANK YOU

Design 6297 | 2024 Fall | Bo Li + Rui Liu + Shiyuan Tian+ Zijie Zhou

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