

# Exploring a **Collaborative** and **Intuitive** Framework for **Combined** Application of AI Art Generation Tools in Architectural Design Process

2023 Convention of the Society for the Study of  
Artificial Intelligence and Simulation of Behaviour (Computational Creativity)

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Xi'an Jiaotong-Liverpool University | University of Liverpool

14 April 2023

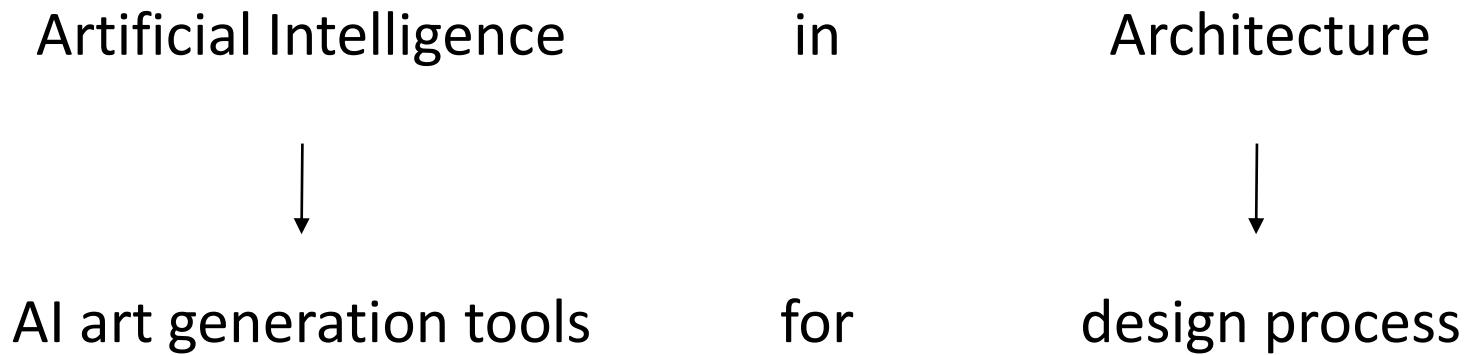
# Research context

Artificial Intelligence

in

Architecture

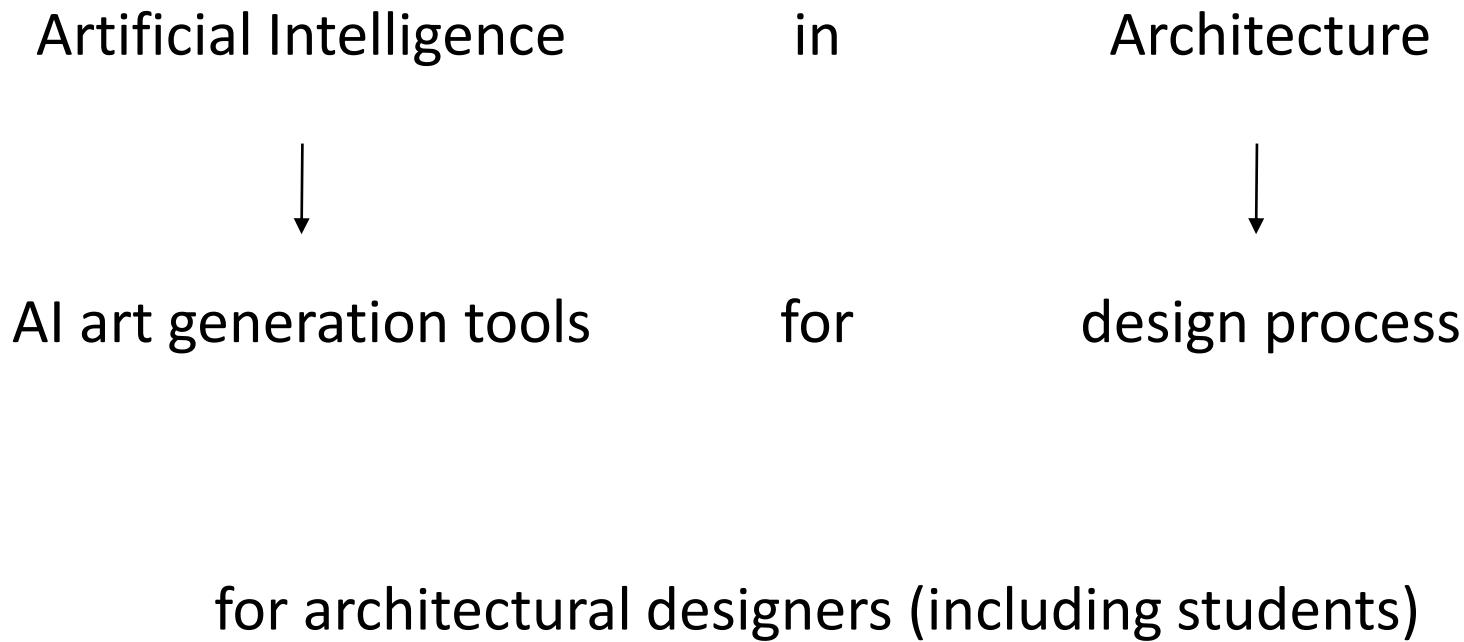
# Research context



A. N. Wu, R. Stouffs, and F. Biljecki, 'Generative Adversarial Networks in the built environment: A comprehensive review of the application of GANs across data types and scales', Building and Environment, vol. 223, Sep. 2022, doi: 10.1016/j.buildenv.2022.109477.

M. L. Castro Pena, A. Carballal, N. Rodríguez-Fernández, I. Santos, and J. Romero, 'Artificial intelligence applied to conceptual design. A review of its use in architecture', Automation in Construction, vol. 124, p. 103550, Apr. 2021, doi: 10.1016/j.autcon.2021.103550.

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M. L. Castro Pena, A. Carballal, N. Rodríguez-Fernández, I. Santos, and J. Romero, 'Artificial intelligence applied to conceptual design. A review of its use in architecture', *Automation in Construction*, vol. 124, p. 103550, Apr. 2021, doi: 10.1016/j.autcon.2021.103550.

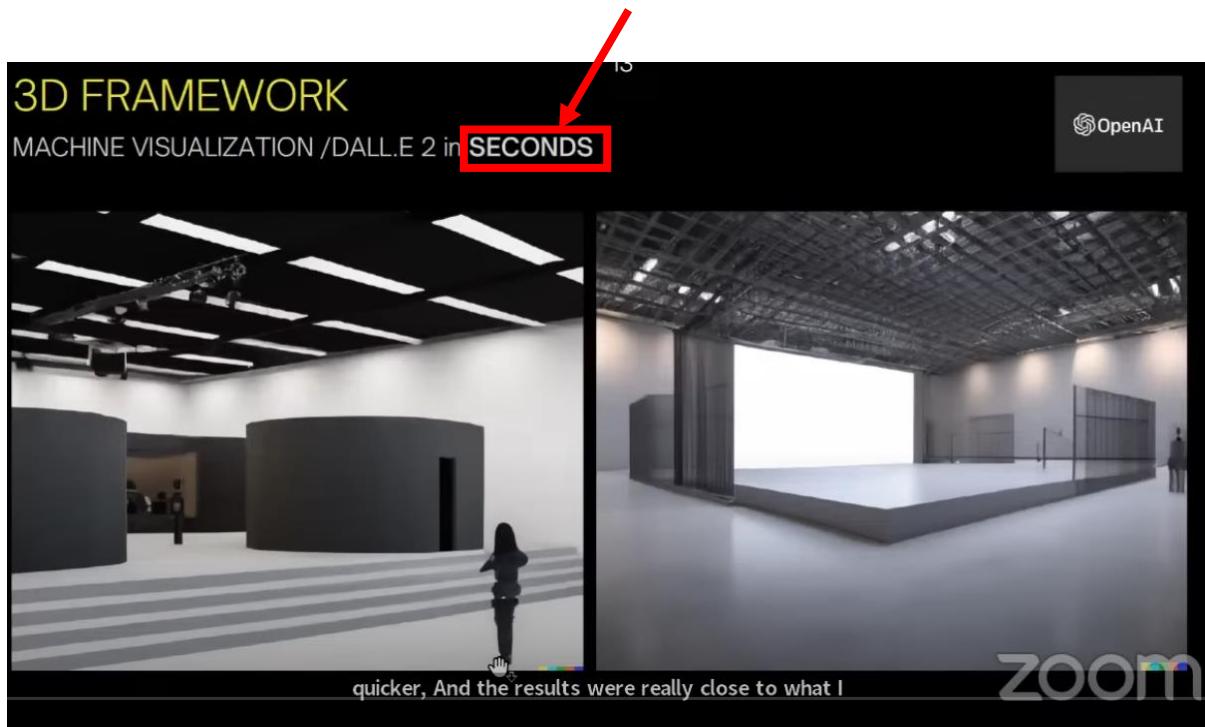
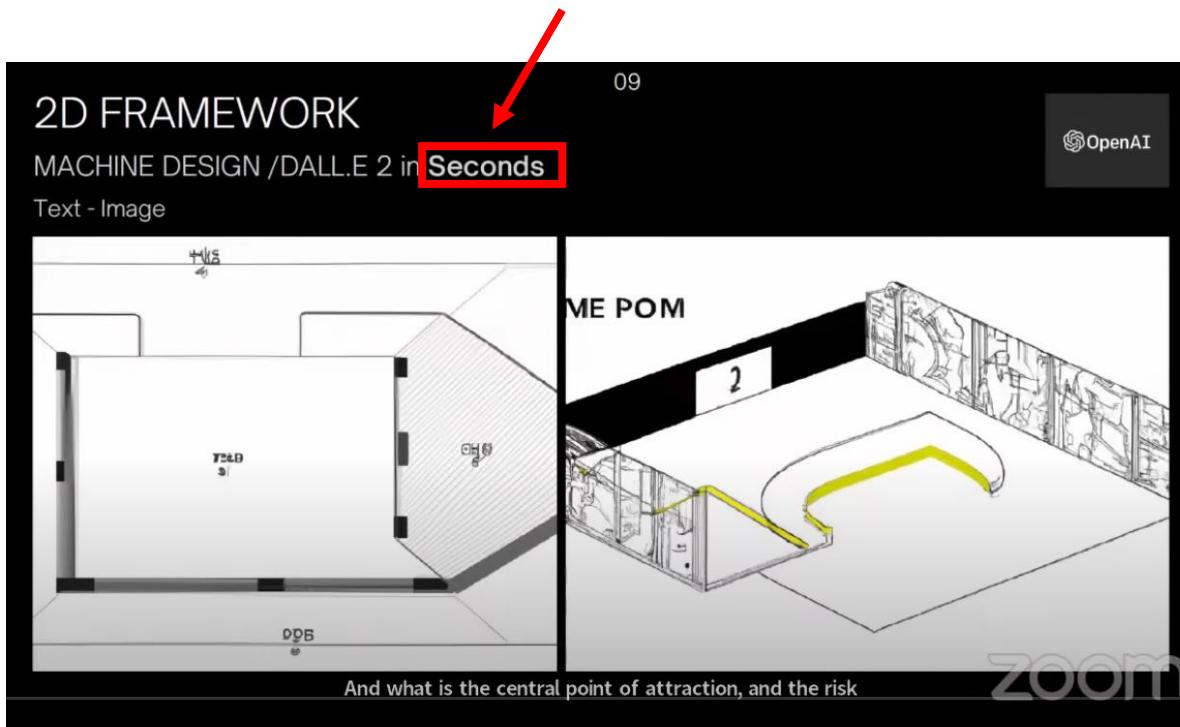
# Content

AI in architectural design

Proposed framework

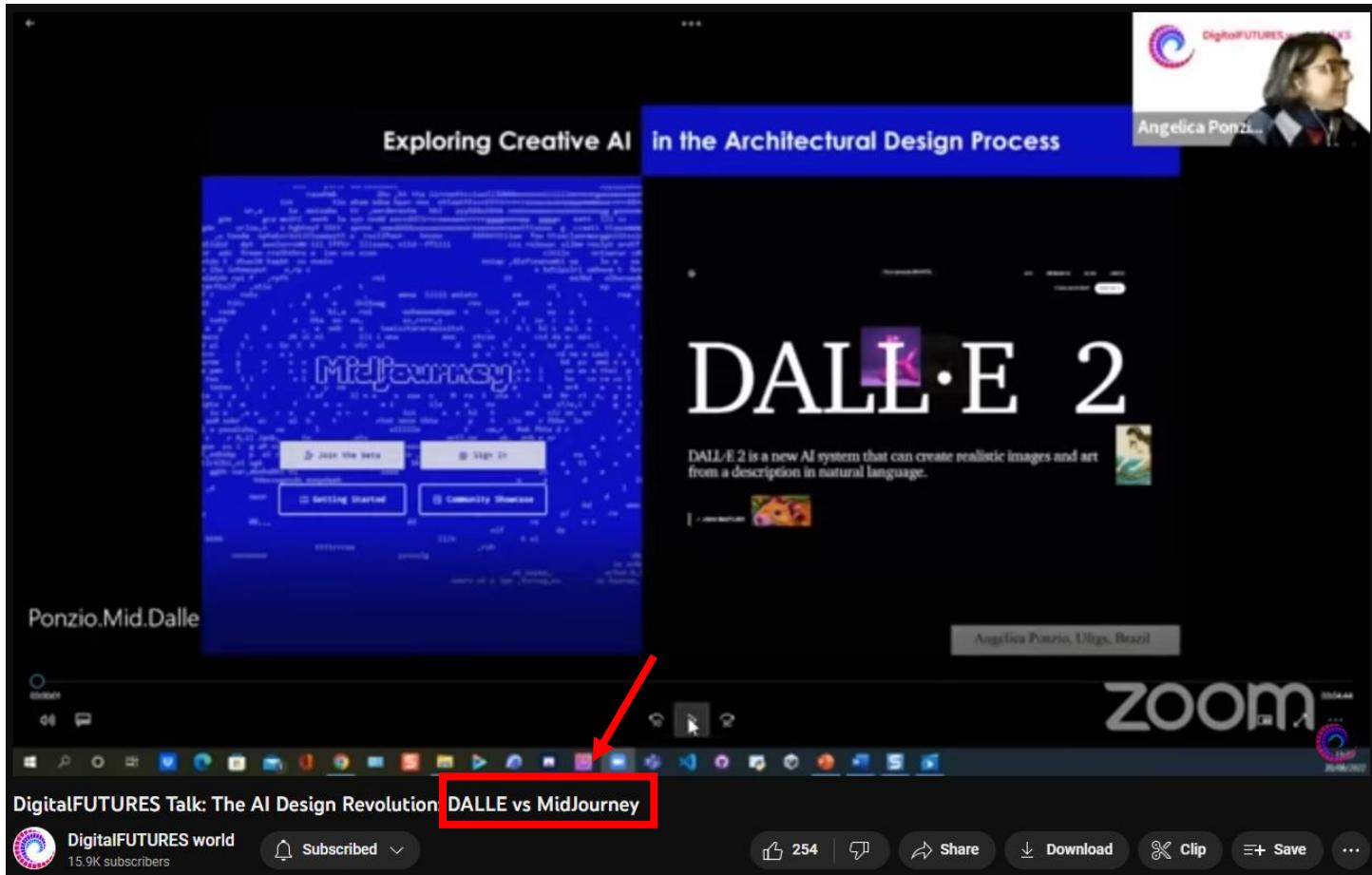
Case studies (2020, 2021, 2022-23)

# Observation 1 – automatic process



[https://www.youtube.com/watch?v=chhs0zW4DF0&ab\\_channel=DigitalFUTUREworld](https://www.youtube.com/watch?v=chhs0zW4DF0&ab_channel=DigitalFUTUREworld)

# Observation 2 – select the best tool



<https://www.youtube.com/watch?v=ButDfjQohB0>

# Observation 3 – complete new techniques

**FROM SKETCH TO RENDERING?** 

**AI IMAGES BY MIDJOURNEY**

**ARCHITECTURE PROMPTS IN MIDJOURNEY**

**Types:**

architectural photography, futurism architecture, modernist architecture, modern architecture, rustic architecture, architectural photography, post-apocalyptic city

hyperrealism, contemporary, hyperrealistic, Gothic architecture, Contemporary architecture, Postmodern architecture

modern facade, waves concrete, drawing of the stone facade of xxx tower, futuristic facade, terrain landscape architecture

modern landscape design, modern landscape plaza, people walking, modernist urban plaza, stylish tree-house with a forest background, garden on top of a contemporary highrise, urban landscape, community park, modern kids play area, playground landscape architecture, with pavement, modern pavement

**Details:**

cinematic, cinematic lighting hyper-detailed, 8K, aerial views 8k unreal engine CGI, perspective view, high definition, Photorealism, extreme detail, Unreal Engine, V-Ray, cyberpunk lights, Professional Architectural Photograph Exterior, cinematic photo, moody foggy environment

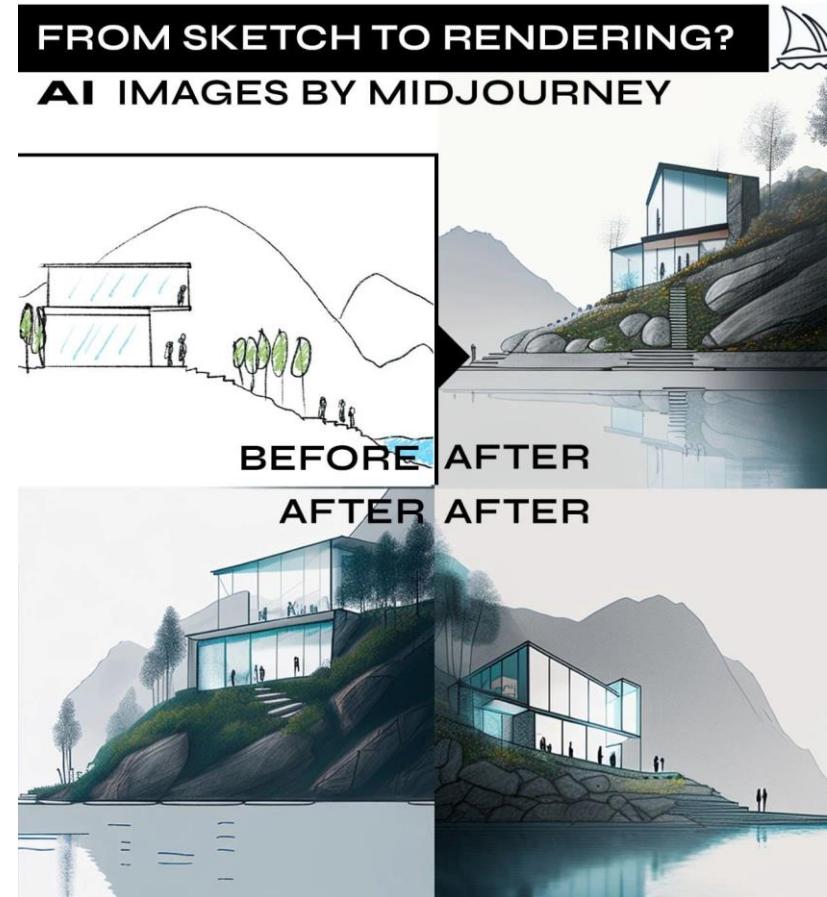
**Render:**

Zaha Hadid, award-winning architects, mir rendering, octane render, blender, corona renderer, 3ds max, architecture sketch, watercolor architecture

**Diagram:**

isometric illustration, isometric architecture diagram, isometric clean art of outside of xxx building, axonometric architecture, isometric building outside

**MORE:**  
[HTTPS://LANDSCAPEARCHITECTURE.STORE/BLOG/](https://landscapearchitecture.store/blog/)



<https://landscapearchitecture.store/2023/02/27/keywords-for-architecture-prompts-in-midjourney/>

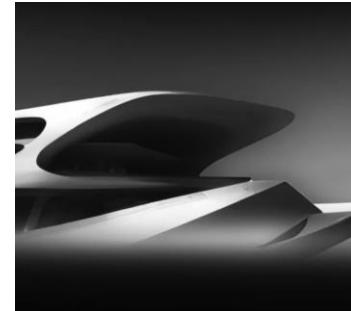
Enjellina, E. V. P. Beyan, and A. G. C. Rossy, 'A Review of AI Image Generator: Influences, Challenges, and Future Prospects for Architectural Field', Journal of Artificial Intelligence in Architecture, vol. 2, no. 1, Art. no. 1, Feb. 2023, doi: 10.24002/jarina.v2i1.6662.

E. Ulberg, D. C. Llach, and D. Byrne, 'Hand-Crafting Neural Networks for Art-Making', In Proceedings of the 11th International Conference on Computational Creativity, 508-511. 2020.

E. Ulberg, 'Crafting the Weights of a Convolutional Neural Network to Make a Drawing', thesis, Carnegie Mellon University, 2021. doi: 10.1184/R1/14135663.v1.

# Criticisms

- **John Frazer** - "risking trivializing their work or Zaha's work"



- **Daniel Bolojan** - overfitting as a style? Blender



- And more...

M. Radhakrishnan, 'Is Midjourney-AI the New Anti-Hero of Architectural Imagery & Creativity?', vol. 11, pp. 94–114, Jan. 2023, doi: 10.11216/gsj.2023.01.102270.

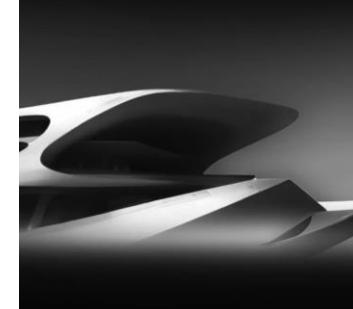
DigitalFUTURES World. DigitalFUTURES / Legends : John Frazer. (June 29, 2022). Accessed: Mar. 4, 2023. [Online Video]. Available: [https://www.youtube.com/watch?v=\\_GE2Psl2Tdw](https://www.youtube.com/watch?v=_GE2Psl2Tdw).

DigitalFUTURES World. Doctoral Consortium: Creative AI in Architecture--Daniel Bolojan. (June 13, 2022). Accessed: Mar. 4, 2023. [Online Video]. Available: [https://www.youtube.com/watch?v=A8r0Q\\_tbmTU](https://www.youtube.com/watch?v=A8r0Q_tbmTU).

E. Yildirim, 'Text-to-Image Generation AI in Architecture', in Art and Architecture: Theory, Practice and Experience, 1st Ed. Livre de Lyon, 2022, pp. 97–120.

# Three observations + awareness

	Current observation
Architectural design process	Automatic
AI art generation tool selection criteria	Best image <b>quality</b> , fastest generation <b>speed</b>
Designer-friendly	Need to learn ' <b>prompt-engineering</b> ' and AI to adjust the tool



# Content

AI in architectural design

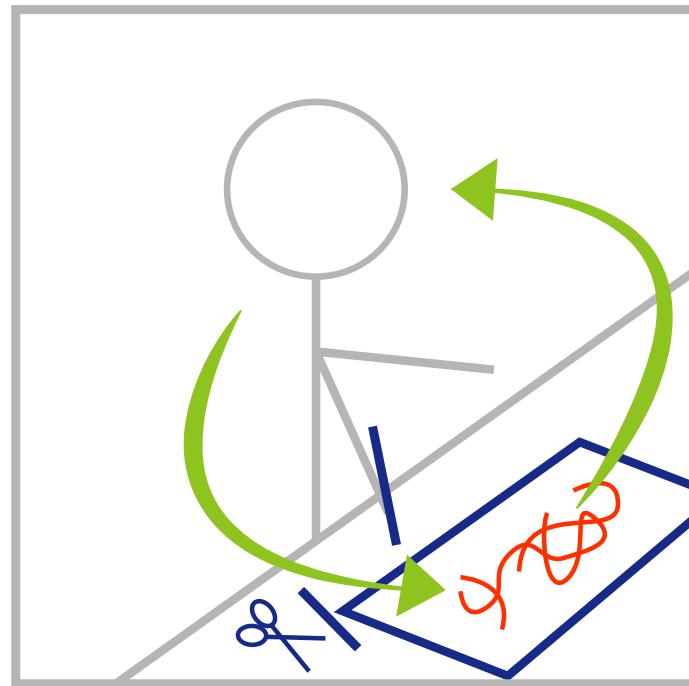
Proposed framework

Case studies (2020, 2021, 2022-23)

# Architectural design process

Design problem nature:  
Wicked, no immediate solution

- Design outputs
- Design tools
- Design process



# Architectural design process

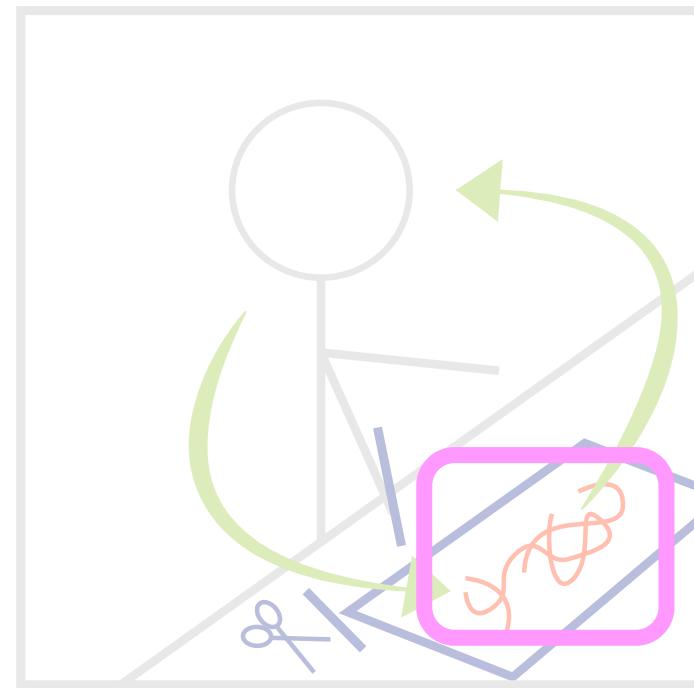
Design problem nature:

Wicked, no immediate solution

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— Design process

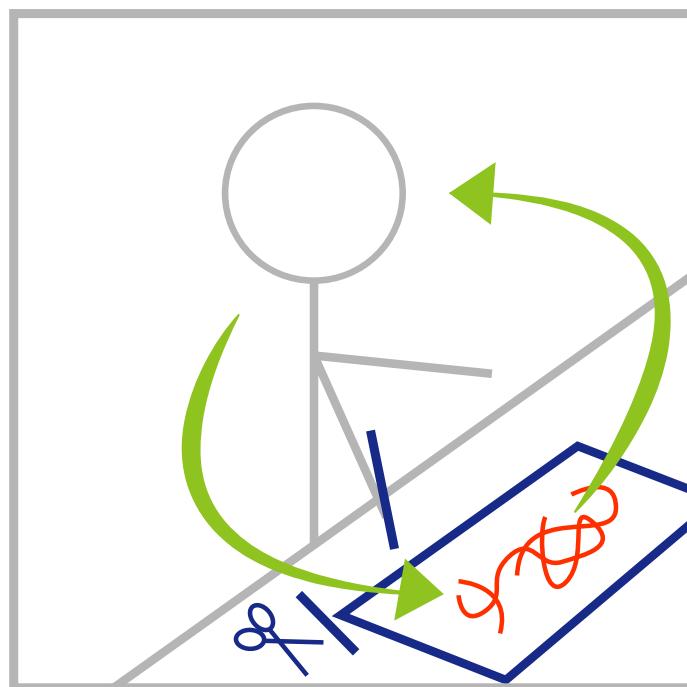


explorative thinking rather than explicit representations of thought

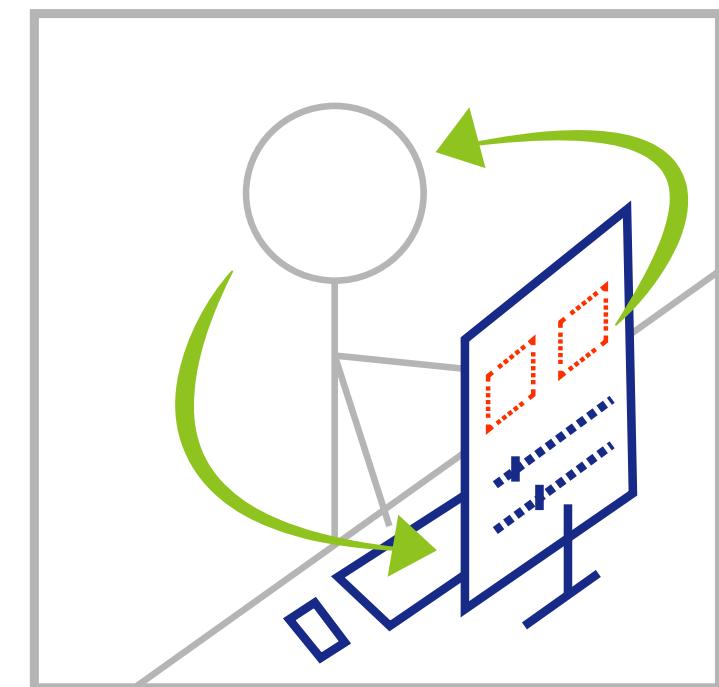
# Attitude towards AI art generation tools

Design problem nature:  
Wicked, no immediate solution

- Design outputs
- Design tools
- Design process

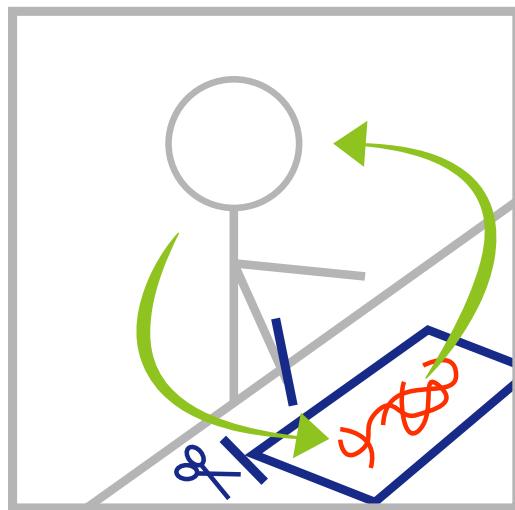


without AI



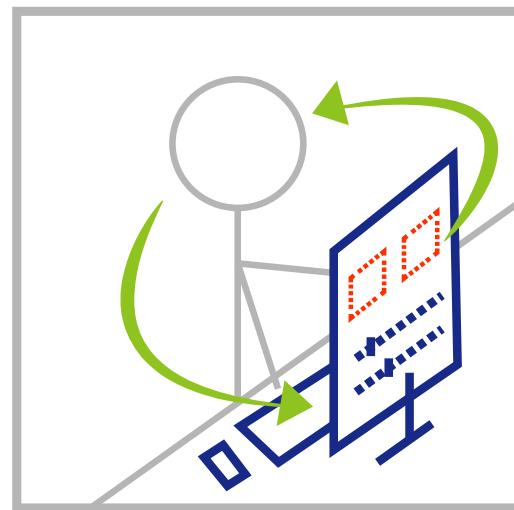
with AI art generation tool

# Observations and proposal



without AI

— Design outputs      — Design tools      — Design process



with AI art generation tool

— Design outputs      — Design tools      — Design process

	Current observation	Proposal
Architectural design process	Automatic	Collaborative, iterative, conversational
AI art generation tool selection criteria	Best image quality, fastest generation speed	Combinational uses according to design need
Designer-friendly	Need to learn 'prompt-engineering' and AI to adjust the tool	Intuitive for immediate widely-use

# Content

AI in architectural design

Proposed framework

Case studies (2020, 2021, 2022-23)

# Three case studies

2020

XJTLU architectural design modules



2021

DigitalFutures online workshop



2022-2023

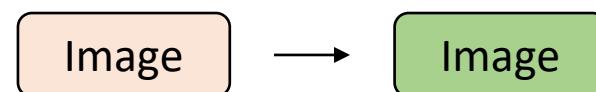
Three attempts with the proposed framework



# Case study 1



- XJTLU Master of Architectural Design ARC 411 Module in 2020 (two-week)
- Who: Twelve architecture master year two students (with little to no programming knowledge)
- Tools explored: Deepdream and StyleTransfer on Colab



Google Colab Notebooks used:

Deepdream:

[https://colab.research.google.com/drive/1T4RbQsmeVABxQv\\_Kdl4G6wS1NYP0vxFO?usp=sharing](https://colab.research.google.com/drive/1T4RbQsmeVABxQv_Kdl4G6wS1NYP0vxFO?usp=sharing)

StyleTransfer:

[https://colab.research.google.com/drive/1FUscVRUcjZ5\\_Oy8LjSWNL9N1bPO\\_zj0i?usp=sharing](https://colab.research.google.com/drive/1FUscVRUcjZ5_Oy8LjSWNL9N1bPO_zj0i?usp=sharing)

# Challenge: Input [tool]

## ▼ Choose your style image and content image:

```
▶ content_path: "/content/drive/My Drive/ARC411/1008/1015/content10153.jpg"
▶ style_path: "/content/drive/My Drive/ARC411/1008/1015/style10153.jpg"
```

## ▼ 2) Let's deep dream ! -- Customize your own neural style

You can adjust the sliders to change the strength of the deep dream, and how many scales it is applied over.

```
[ ] octave_n = 2 #@param {type:"slider", max: 10}
octave_scale = 3.8#@param {type:"number"}
iter_n = 20 #@param {type:"slider", max: 50}
strength = 312 #@param {type:"slider", max: 1000}
layer = "mixed3a" #@param ["mixed3a", "mixed3b", "mixed4a", "mixed4c", "mixed5a"]
final = render_deepdream(tf.square(T(layer)), img0)
```



Setup

- Import and configure modules
- Functions to visualize the input.
- Choose your style image and content image:

```
▶ content_path: "/content/drive/My Drive/ARC411/1008/1015/content10153.jpg"
▶ style_path: "/content/drive/My Drive/ARC411/1008/1015/style10153.jpg"
```

Style Transfer Step-by-Step Implementation

- Run/Loop a few epochs/rounds to test:

```
[ ] train_step(image)
train_step(image)
train_step(image)
tensor_to_image(image)
```

Since it's working, perform a longer optimization:

```
[ ] import time
start = time.time()
epochs = 10
steps_per_epoch = 100
step = 0
for n in range(epochs):
    for m in range(steps_per_epoch):
        step += 1
        train_step(image)
        print(".", end='')
        display.clear_output(wait=True)
        display.display(tensor_to_image(image))
        print("Train step: {}".format(step))
        print("Train epochs: {}".format(n))

end = time.time()
print("Total time: {:.1f}".format(end-start))
```

Run/Loop for 100 rounds(epocs)

Choose a weight for the total\_variation\_loss:

```
[ ] total_variation_weight=30
```

Now include it in the train\_step function:

```
@tf.function()
def train_step(image):
    with tf.GradientTape() as tape:
        outputs = extractor(image)
        loss = style_content_loss(outputs)
        loss += total_variation_weight*tf.image.total_variation(image)

    grad = tape.gradient(loss, image)
    opt.apply_gradients([(grad, image)])
    image.assign(tf.clip(0, 1, image))
```

Reinitialize the optimization variable:

```
[ ] image = tf.Variable(content_image)
```

And run the optimization:

```
[ ] import time
start = time.time()

epochs = 500
steps_per_epoch = 100
step = 0
for n in range(epochs):
    for m in range(steps_per_epoch):
        step += 1
        train_step(image)
        print(".", end='')
        display.clear_output(wait=True)
        display.display(tensor_to_image(image))
        print("Train step: {}".format(step))

    end = time.time()
    print("Total time: {:.1f}".format(end-start))

    # save the result
    file_name = "stylized-image.png"
    tensor_to_image(image).save(file_name)
```

File Edit View Insert Runtime Tools Help All changes saved

Files

- sample\_data

+ Code + Text

Run/Loop a few epochs/rounds to test:

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train_step(image)
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        display.clear_output(wait=True)
        display.display(tensor_to_image(image))
        print("Train step: {}".format(step))

    end = time.time()
    print("Total time: {:.1f}".format(end-start))

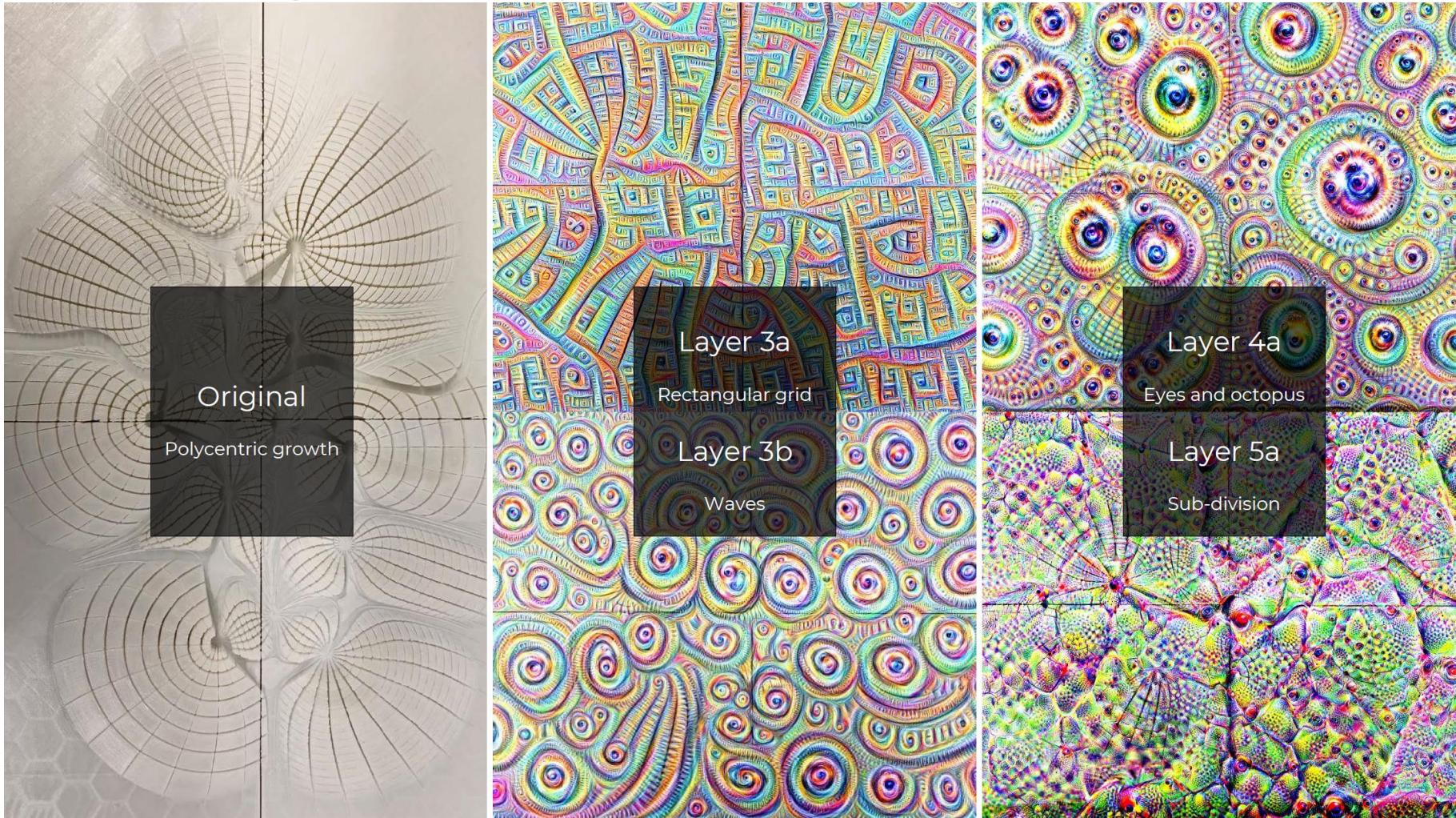
    # save the result
    file_name = "stylized-image.png"
    tensor_to_image(image).save(file_name)
```

# Challenge: Outputs [collaborative]



What? Why? So what?

# Challenge: Outputs [collaborative]

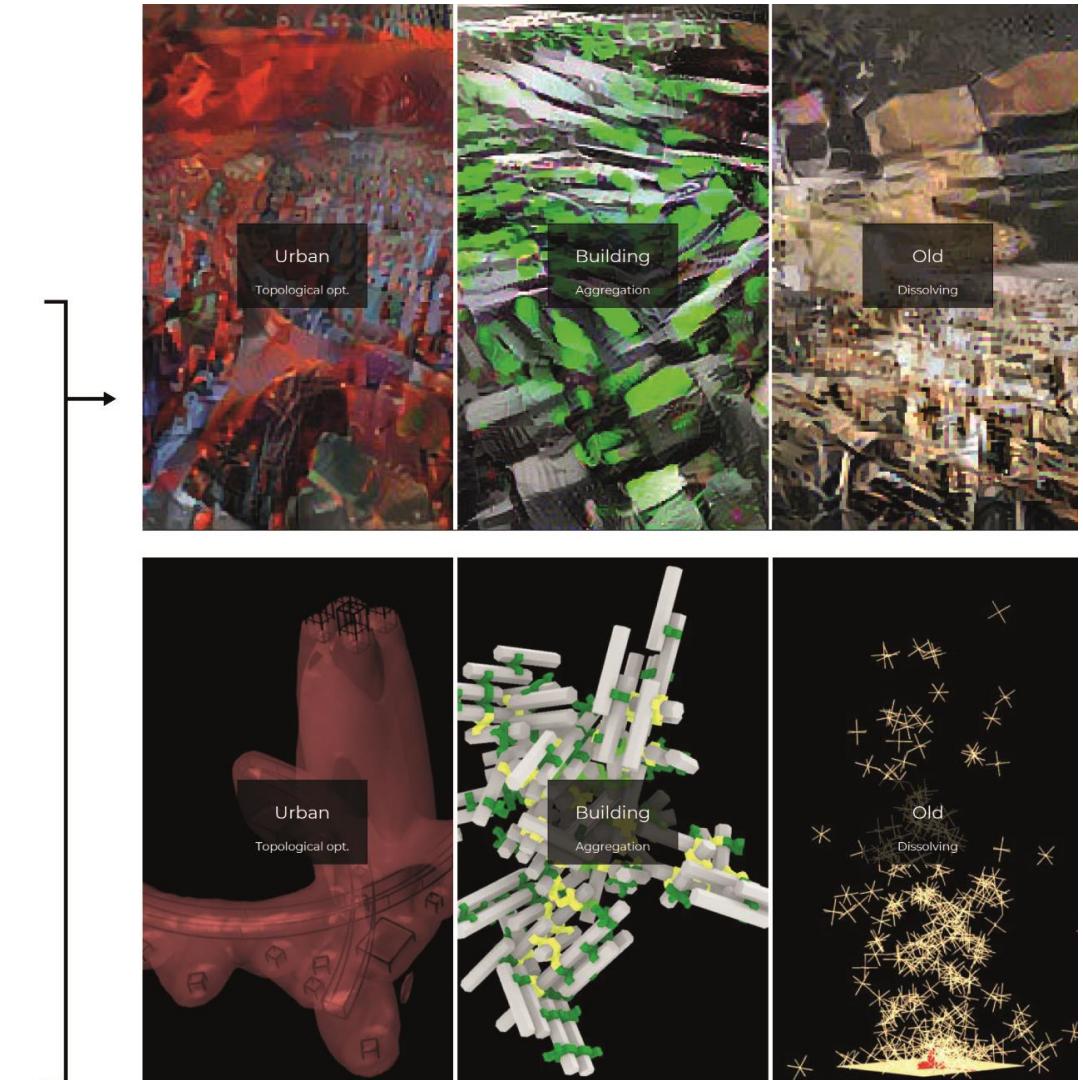
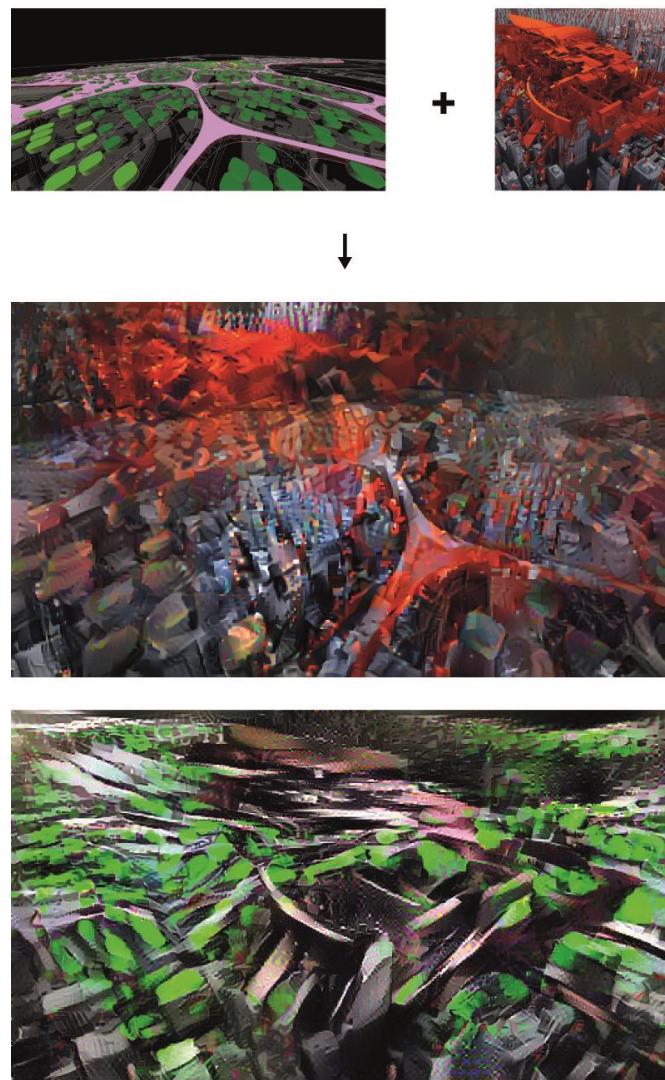


Try to make sense

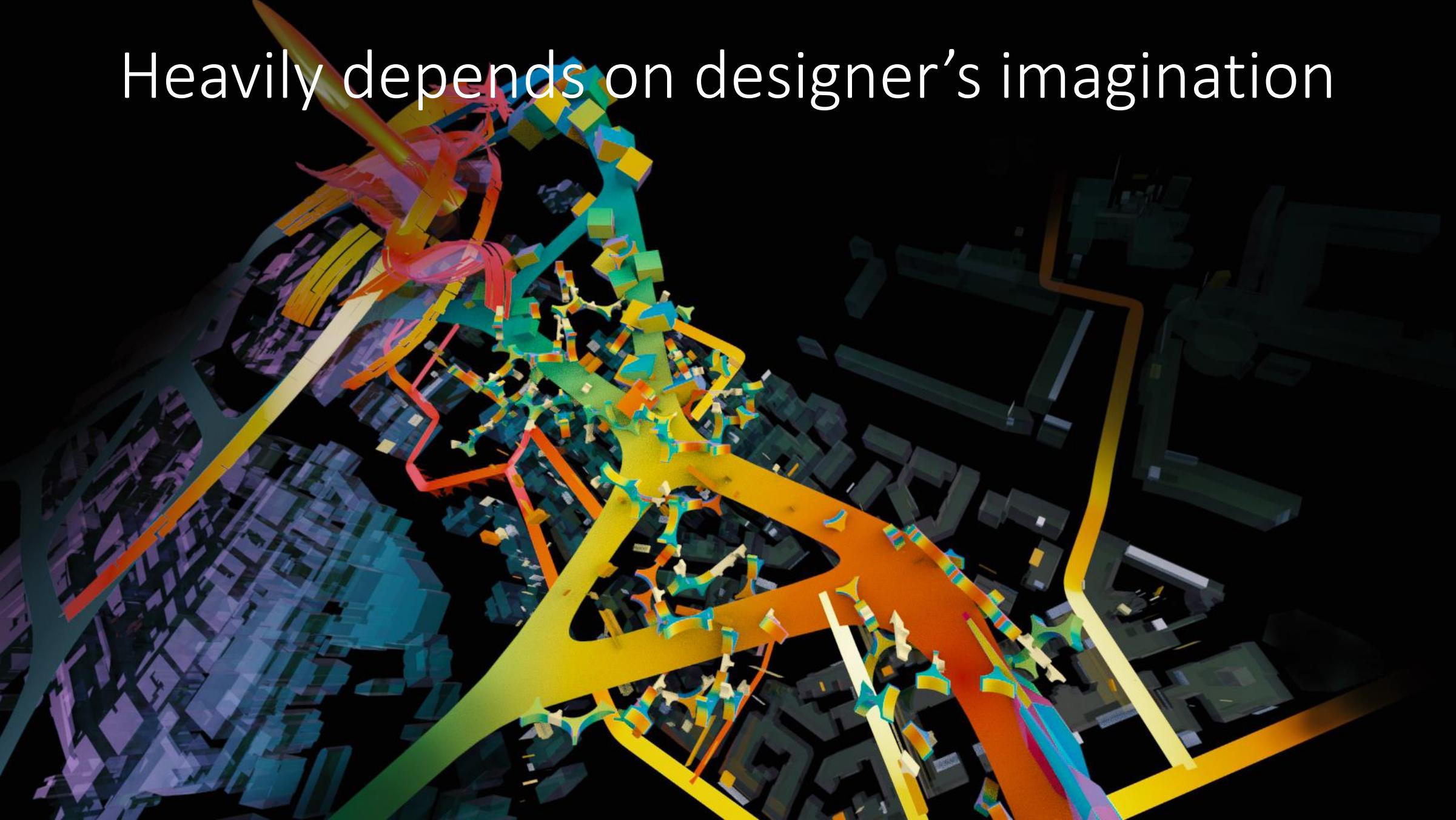
# StyleTransfer [collaborative]

Content  
+ → Image  
Texture

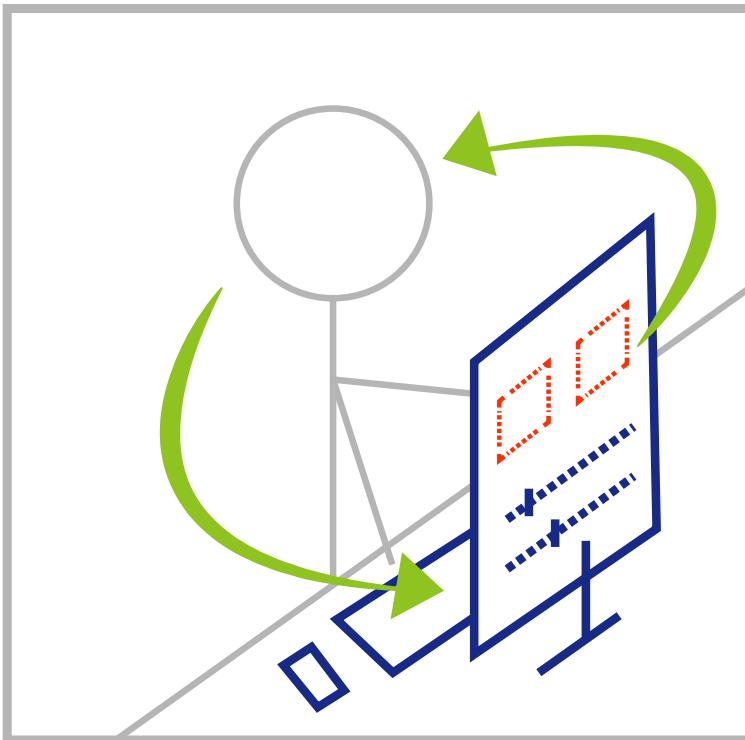
Concept > actual result



Heavily depends on designer's imagination



# Case study 1 conclusion



## Deepdream

1 image as input, few designer-understandable parameters

Confusing with limited default settings

## StyleTransfer

2 images as inputs (content and texture), few designer-understandable parameters

Confusing and underwhelmed by the outputs

Depends heavily on designer's imagination

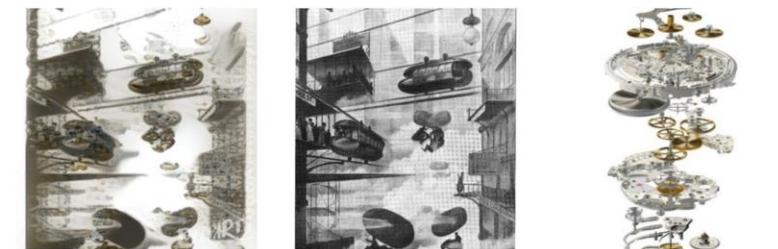
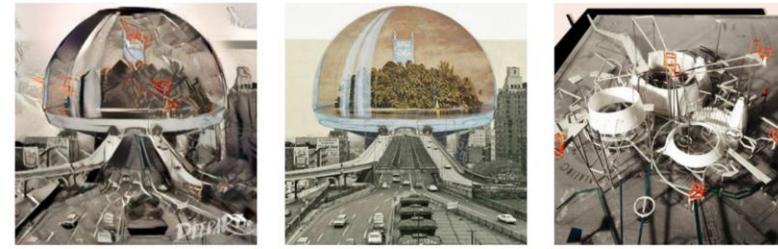
# Case study 2



- "Hacking Machine Learning Style Transfer",  
DigitalFUTURES online workshop (4-day) in 2021

## Day 1

Works by Student Lakita

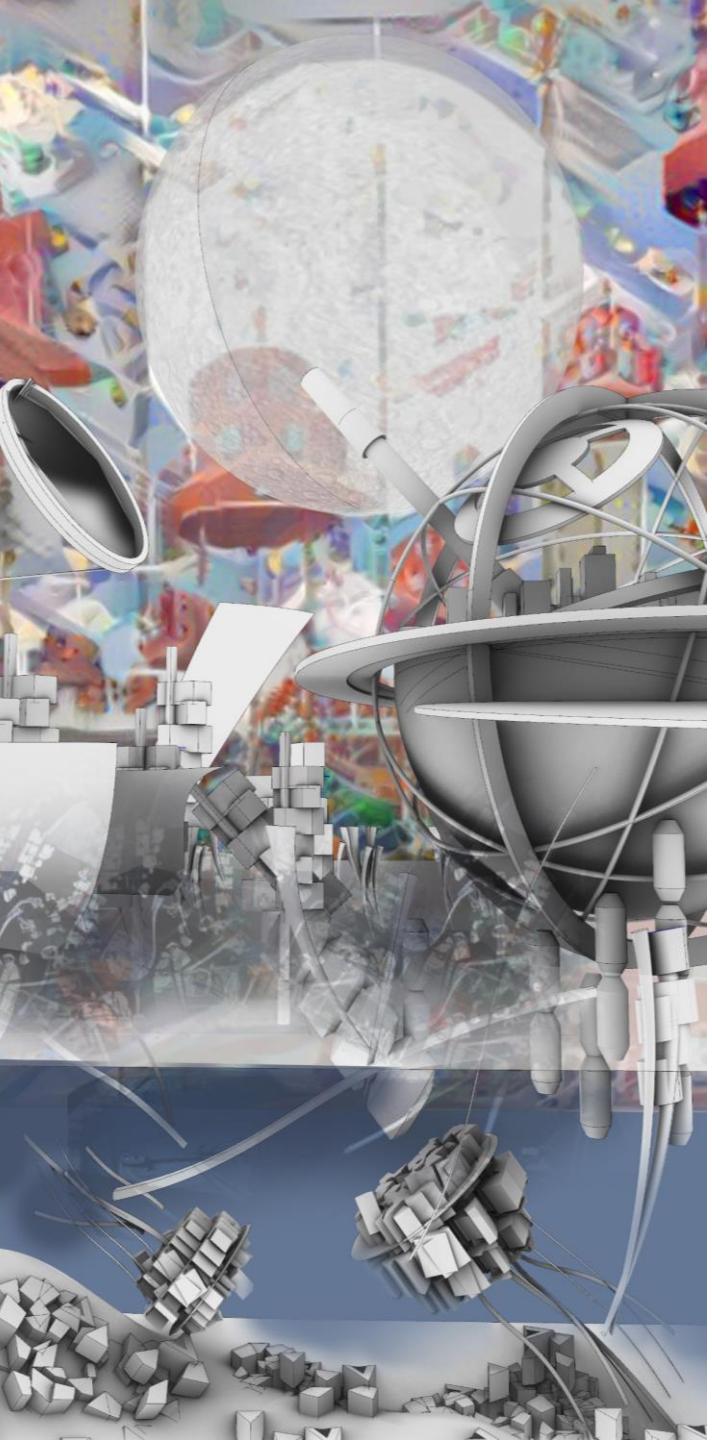




# Day 2-3



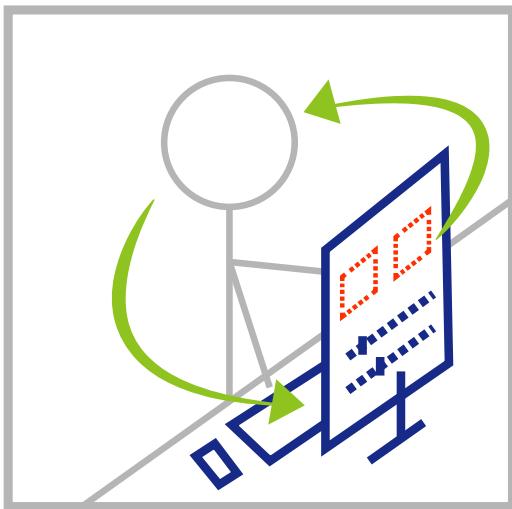
Works by Student Xinyi Zhang



# Day 4



# Case study 2 conclusion



Web application (DeepArt.io) with sliders

Understandable and adjustable parameters

Less confusing after setting an expected outcome (2D collage, 3D model)

→  
[intuitive]  
[collaborative]

Still depends heavily on imagination and manual inputs (underuse AI)

# Case study 3

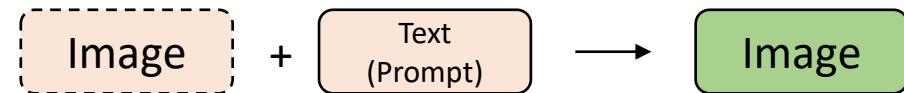


- Aim for designers with
  - 3.1 little to no AI knowledge
  - 3.2 little experience in AI
  - 3.3 most experience / intended to develop further
- Compare tools and identify application scenarios
- Different tools for different designers, but same framework

1<sup>st</sup> wave: Computer vision



2<sup>nd</sup> wave: Computer vision + natural language processing



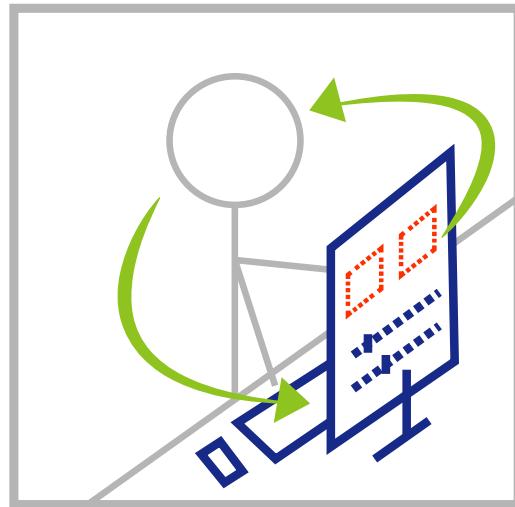
# Case study 3

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  - 3.3 most experience / intended to develop further
- Compare tools and identify application scenarios
- Different tools for different designers, but same framework

	Advantages	Limitations	Potential uses
DeepDream	Intuitive, Free	Limited uses	Understand Colab environment
StyleTransfer	Intuitive, Free	Difficult to iterate	Understand Colab environment
Midjourney	High quality	Less intuitive, <b>25 free quota</b>	High quality
DALL-E 2	High-quality, <b>intuitive UI</b>	50 free quotas (Monthly reset to 15 credits)	High quality, Edit, expand, combine images
StableDiffusion	<b>Intuitive, Free</b> , with WebUI	Need basis of Google Colab	Developable
Playground.AI	<b>Intuitive, 1000 free</b> images/day	Couldn't expand/combine	Image-to-image as the starting point
InvokeAI	All-rounded	Using local machine	When have powerful machine

# Case study 3.1

- For designers with **little to no AI knowledge**



**Image** + **Text (Prompt)** → **Image**

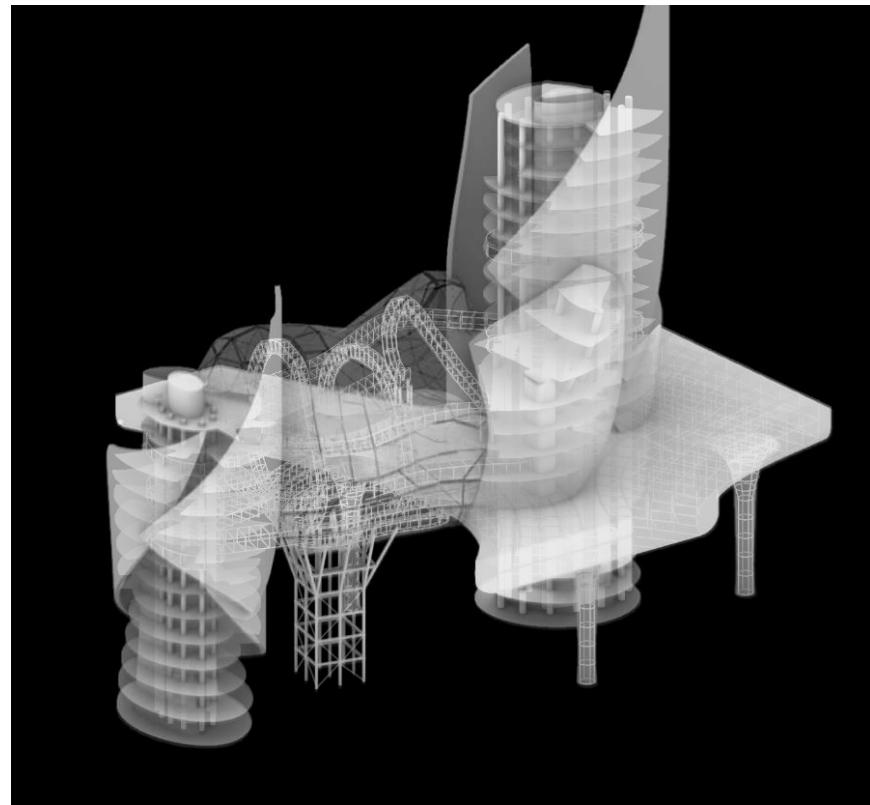
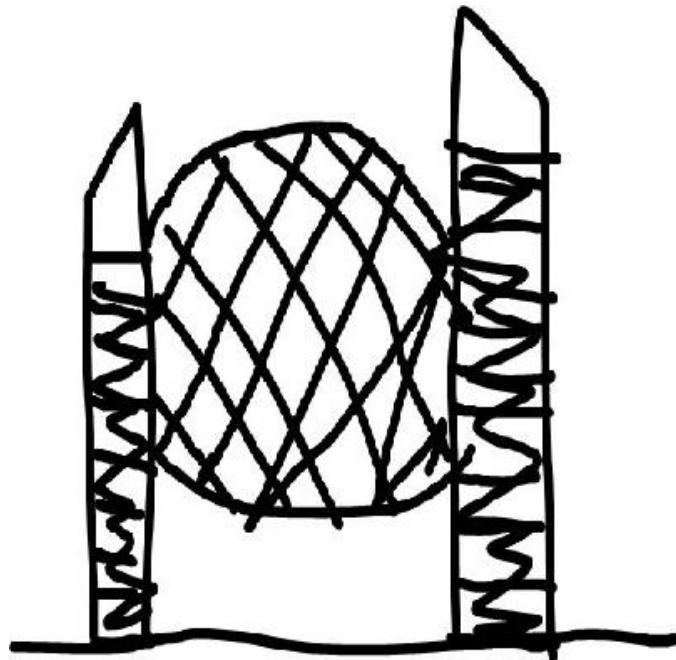
Web application, with images as input

Variations for initial design, editable for design development

Adjustable parameters that designers can understand

	Advantages	Limitations	Potential uses
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# Simulation scenario background (2021)



Designer: *What if I had AI as a collaborator?*

[Intuitive]  
[Collaborative]

Designer's sketch as initial input  
Understandable parameters

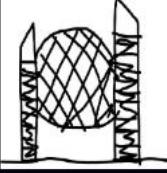
**Playground**  Search

**Prompt**  
What do you want to see? You can use a single word or a full sentence.

**Tower design, Lebbeus Woods style, futuristic, photorealistic 4K, Blue sky, zaha hadid style**

**inputs**

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
**ugly**

**Image to Image**  
Upload or draw an image to use as inspiration.  


**inputs & parameters**

**Image strength**  19

Edit with Mask

Generate

**+ IMPORT IMAGE TO EDIT**

Columns

**Image Dimensions**  
Width × Height of the finished image.

512 × 512   1024 × 1024   640 × 384  
384 × 640   768 × 512   512 × 768

Buy a Pro plan for any width or height up to 1536px

**Prompt Guidance**  
Higher values will make your image closer to your prompt.  
 10

**Quality & Details**   
More steps will result in a high quality image but will take longer.  
 30

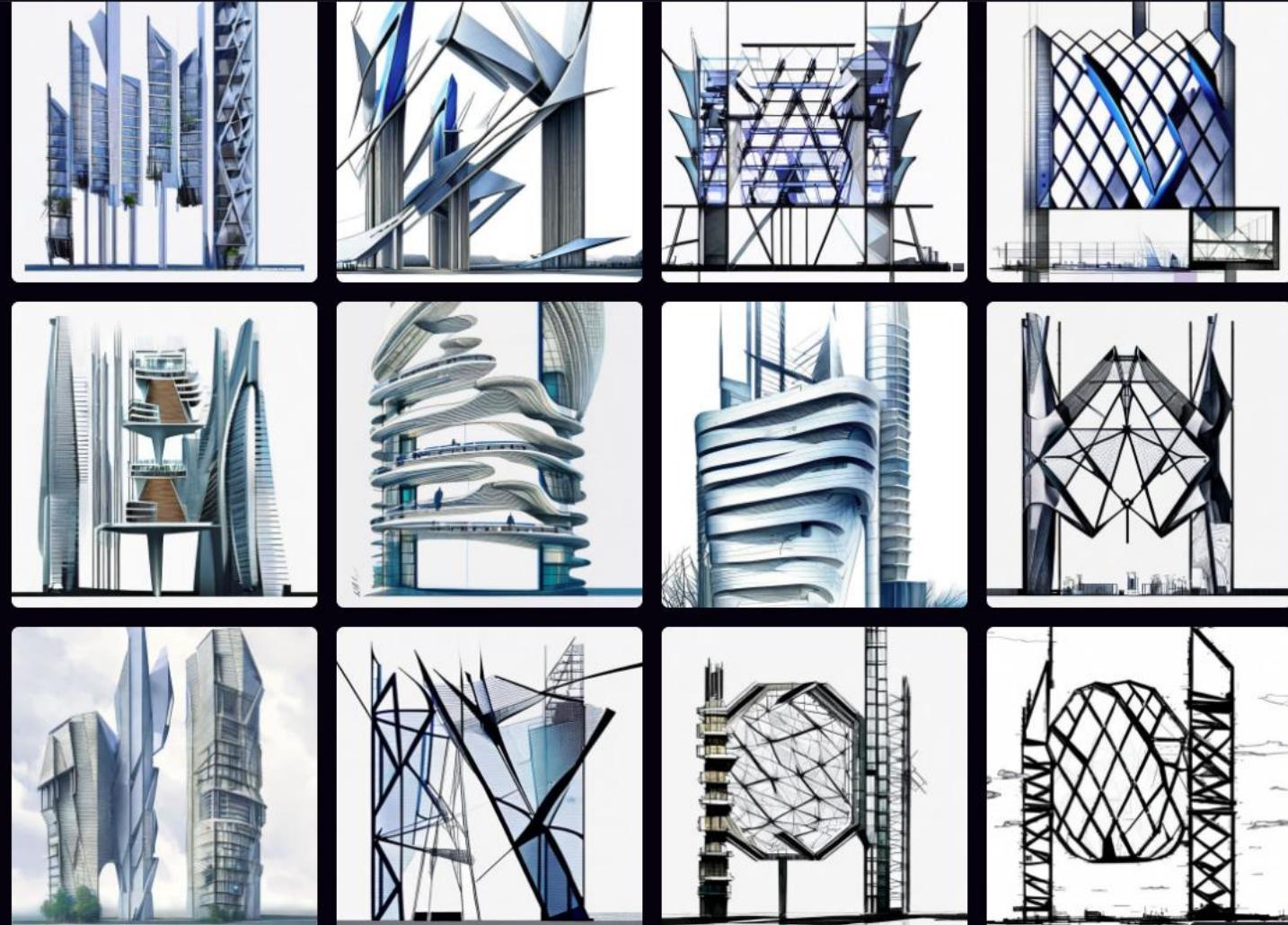
**parameters**

**Seed**  
Different numbers result in new variations of your image.

Randomize each number to get new variations

Show Advanced Options

**Number of Images**  
Select the number of images you would like to



# The actual design process: understanding the tool from the outputs

Playground  Search

**Prompt**  
What do you want to see? You can use a single word or a full sentence.

Tower design, Lebbeus Woods style, futuristic, photorealistic 4K, Blue sky, zaha hadid style

**inputs**

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Describe details you don't want in your image like color, objects, or a scenery.  
ugly

**Image to Image**  
Upload or draw an image to use as inspiration.

**inputs & parameters**

**Image strength**  19

**Edit with Mask**

**Generate**

**Import Image To Edit**

Columns

**Image Dimensions**  
Width x Height of the finished image.

512 x 512  1024 x 1024  640 x 384   
364 x 640  768 x 512  512 x 768

Buy a Pro plan for any width or height up to 1536px

**Prompt Guidance**  10

**Quality & Details**  30

**parameters**

**Seed**  
Different numbers result in new variations of your image.

Randomize each number to get new variations

Show Advanced Options

**Number of Images**  
Select the number of images you would like to

# The actual design process: learning and designing (iteratively)

Playground  Search

**Prompt**  
What do you want to see? You can use a single word or a full sentence.

Tower design, Lebbeus Woods style, futuristic, photorealistic 4K, Blue sky, zaha hadid style

**inputs**

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
ugly

**Image to Image**  
Upload or draw an image to use as inspiration.  


**inputs & parameters**

**Image strength**  19

**Edit with Mask**

**Generate**

**Import Image To Edit**

Columns

**Image Dimensions**  
Width x Height of the finished image.

512 x 512  1024 x 1024  640 x 384   
364 x 640  768 x 512  512 x 768

Buy a Pro plan for any width or height up to 1536px

**Prompt Guidance**  
Higher values will make your image closer to your prompt.  
 10

**Quality & Details**  30 **parameters**

More steps will result in a high quality image but will take longer.

**Seed**  
Different numbers result in new variations of your image.

Randomize each number to get new variations

Show Advanced Options

**Number of Images**  
Select the number of images you would like to

Understand the sliders -> Adjust parameters

Too far... 

No change... 

Feedback

The actual design process: something right, let's explore in this direction

Playground Search

Prompt

What do you want to see? You can use a single word or a full sentence.

Tower design, Lebbeus Woods style, futuristic, photorealistic 4K, Blue sky, zaha hadid style

inputs

Remove From Image toggle

Describe details you don't want in your image like color, objects, or a scenery.

ugly

Image to Image

Upload or draw an image to use as inspiration.

inputs & parameters

Image strength slider 19

Edit with Mask

Generate

IMPORT IMAGE TO EDIT

selected output for iterations

“just right”

Understand the sliders -> Adjust parameters

Too far...

No change...

Feedback

columns slider

Image Dimensions

Width × Height of the finished image.

512 × 512 1024 × 1024 640 × 384  
384 × 640 768 × 512 512 × 768

Buy a Pro plan for any width or height up to 1536px

Prompt Guidance

Higher values will make your image closer to your prompt.

parameters

Quality & Details slider 10

More steps will result in a high quality image but will take longer.

Seed

Different numbers result in new variations of your image.

Randomize each number to get new variations

Show Advanced Options

Number of Images

Select the number of images you would like to

The image shows a user interface for generating images based on a prompt. On the left, there's a 'Prompt' section with a text input containing a complex architectural description. Below it are 'Remove From Image' and 'Image to Image' options. The main area displays a 3x4 grid of generated images. A red circle highlights the third image in the top row, which is described as 'just right'. Another red circle highlights the second slider in the 'inputs & parameters' section, with the text 'Understand the sliders -> Adjust parameters' overlaid. Labels 'inputs' and 'parameters' are placed in blue boxes around their respective sections. Labels 'Too far...' and 'No change...' are placed over the first and last images in the bottom row respectively. The right side of the interface includes sections for 'Image Dimensions', 'Prompt Guidance', 'Quality & Details', 'Seed', and 'Number of Images'.

# Design variations, but not a random “blender”

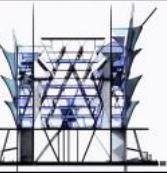
**Playground**  Search

**Prompt**  
What do you want to see? You can use a single word or a full sentence.

Tower design, Lebbeus Woods style, futuristic, photorealistic 4K, Blue sky, zaha hadid style, diagrid, architectural detail, museum

**Remove From Image**  
Describe details you don't want in your image like color, objects, or a scenery.

ugly

**Image to Image**  
Upload or draw an image to use as inspiration.  


**Image strength**

**Stable Diffusion 1.5**

**Image Dimensions**  
Width × Height of the finished image.

512 × 512   1024 × 1024   640 × 384  
384 × 640   768 × 512   512 × 768

Buy a Pro plan for any width or height up to 1536px

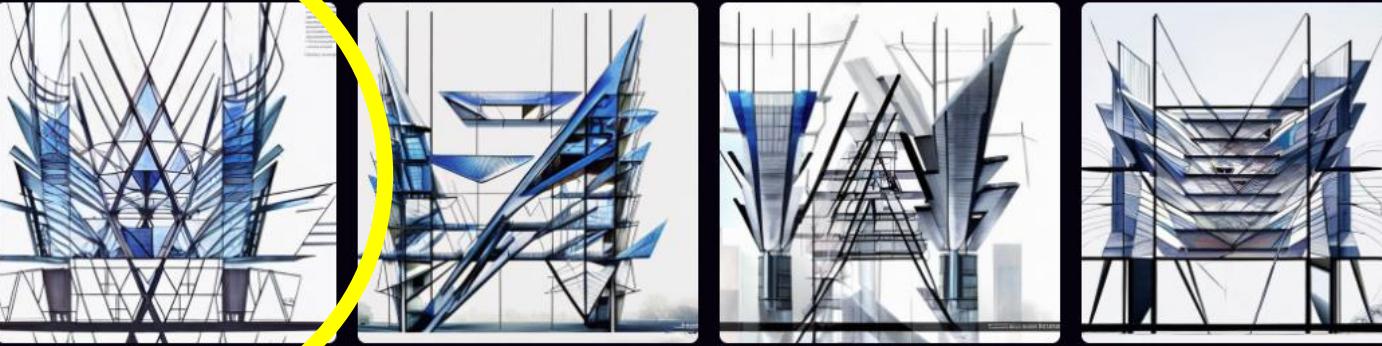
**Prompt Guidance**  
Higher values will make your image closer to your prompt.

**Quality & Details**  
More steps will result in a high quality image but will take longer.

**Seed**  
Different numbers result in new variations of your image.

Randomize each number to get new variations

Generate  Feedback  Show Advanced Options



# Further development – new sliders, another conversation process

Playground Search /

Learn how to edit ▶

**Edit Instruction**  
Describe how you want to change the image.

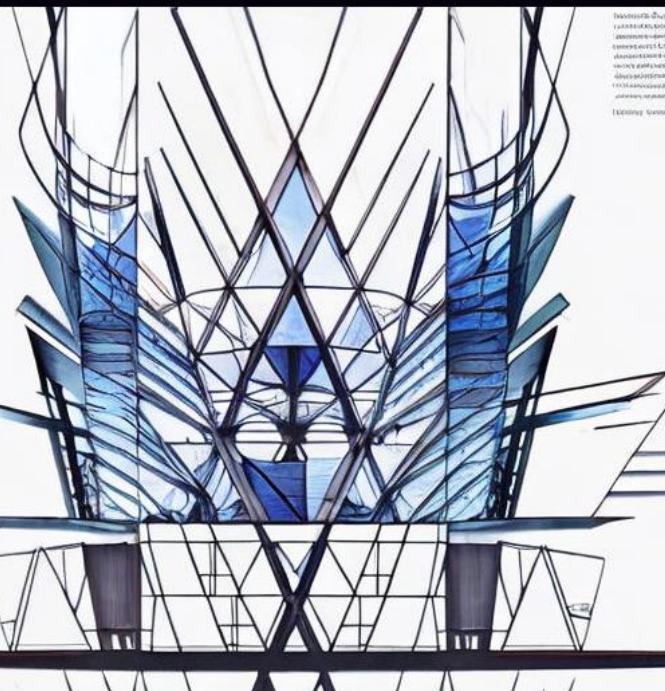
Make the building more complete and as a photorealistic rendering, more colourful, dynamic and futuristic

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**  
Describe details you don't want in your image like color, objects, or a scenery.

ugly

+ Generate

Original 

Cancel Save Changes

**Edit Instruction Strength** 12.25  
Higher values will make your edited image closer to your instruction.

**Quality & Details**  
More steps will result in a high quality image but will take longer.

**Seed**  
Different numbers result in new variations of your image.  
100641531  Randomize each number to get new variations

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

Feedback

# The actual design process: learning, experimenting (iteratively)

**Playground**  Search /

[Learn how to edit](#) ▶

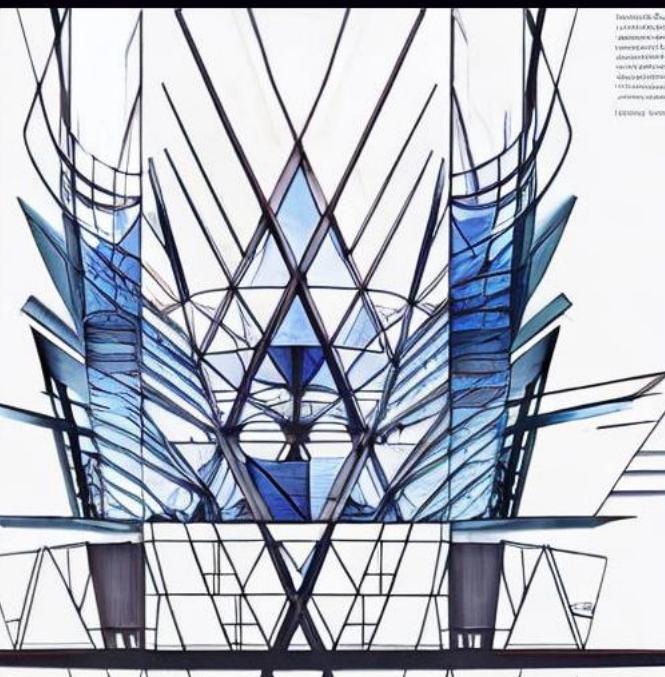
**Edit Instruction**  
Describe how you want to change the image.

Make the building more complete and as a photorealistic rendering, more colourful, dynamic and futuristic

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image** toggle  
Describe details you don't want in your image like color, objects, or a scenery.  
**ugly**

**Generate** + Generate

**Original** 

**“Ah-ha”** 

**Cancel** **Save Changes**

**Edit Instruction Strength** 4.5  
Higher values will make your edited image closer to your instruction.

**Quality & Details** 30  
More steps will result in a high quality image but will take longer.

**Seed**  
100641531  
 Randomize each number to get new variations

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

Feedback

# The actual design process: learning, experimenting (iteratively)

**Playground**  Search

**Learn how to edit**

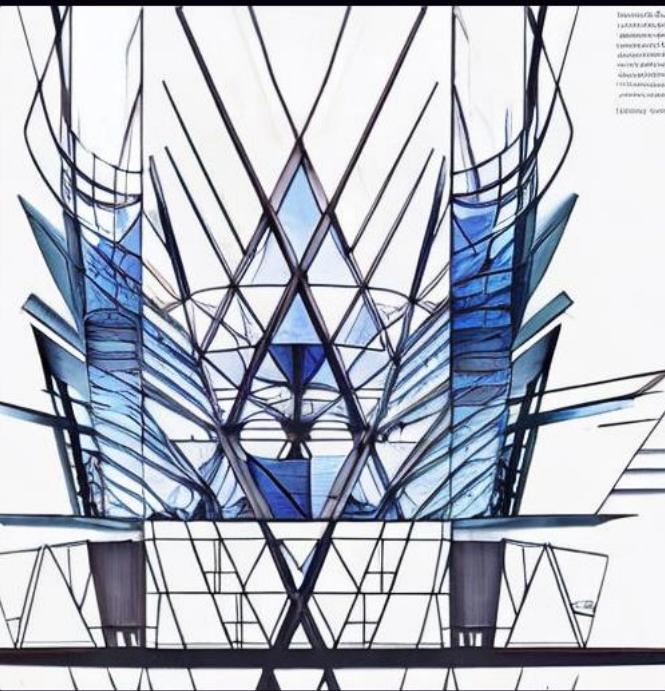
**Edit Instruction**  
Describe how you want to change the image.

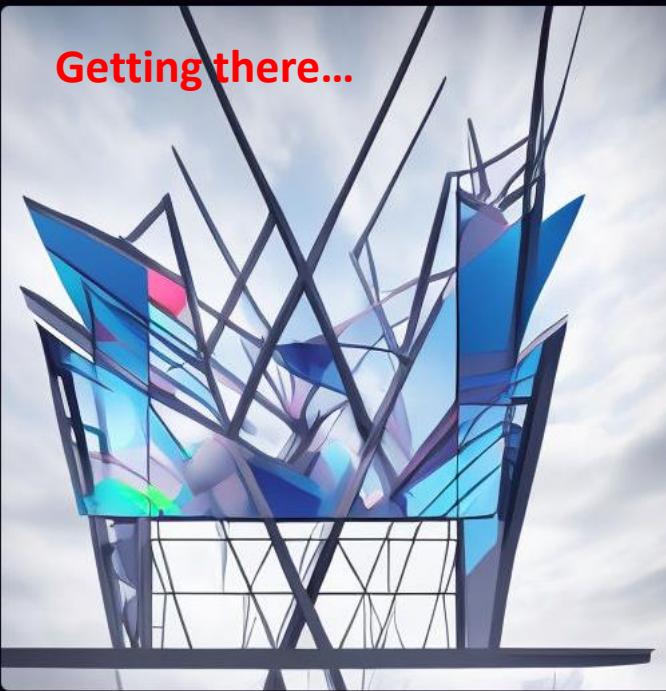
photorealistic rendering, more colourful, dynamic and futuristic, with architectural details, keep the external structural frames

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
ugly

**Generate**

**Original** 

**Getting there...** 

**Cancel** **Save Changes**

**Edit Instruction Strength**  5.25  
Higher values will make your edited image closer to your instruction.

**Quality & Details**  
More steps will result in a high quality image but will take longer.  
 30

**Seed**  
Different numbers result in new variations of your image.  
100641531  
 Randomize each number to get new variations

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

**Feedback**

# The actual design process: getting close!

**Playground**  Search

**Learn how to edit**

**Edit Instruction**  
Describe how you want to change the image.

photorealistic rendering, dynamic and futuristic, with architectural details, keep the external structural frames, with slabs, mullions, real curtain wall reflections

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
ugly

**Generate**

**Original**

**Too much...**

**Cancel** **Save Changes**

**Edit Instruction Strength** Higher values will make your edited image closer to your instruction. **7**

**Quality & Details**  
More steps will result in a high quality image but will take longer. **30**

**Seed**  
Different numbers result in new variations of your image.  
**100641531**  **Randomize each number to get new variations**

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a **Pro plan** to persist this setting across sessions.

**Feedback**

# The actual design process: Select output and further massage

**Playground**  Search

**Learn how to edit**

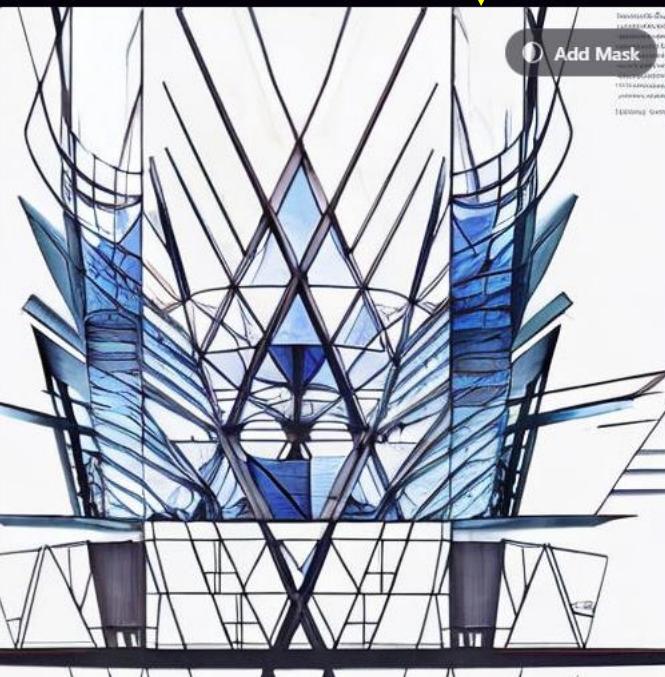
**Edit Instruction**  
Describe how you want to change the image.

photorealistic rendering, dynamic and futuristic, with architectural details, keep the external structural frames, with slabs, mullions, real curtain wall reflections, keep diagrid structural frame, keep the diagrid structure in the middle

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
**ugly**

**Generate**

**Original**  

**“Ah-ha”  
Façade details...** 

**Cancel** **Save Changes**

**Edit Instruction Strength** 7  
Higher values will make your edited image closer to your instruction.

**Quality & Details**  
More steps will result in a high quality image but will take longer. 30

**Seed**  
Different numbers result in new variations of your image.  
100641531  Randomize each number to get new variations

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

**Feedback**

Not pure-manual photoshopping, but partial editing with AI

**Playground**  Search

**Learn how to edit**

**Edit Instruction**  
Describe how you want to change the image.

Add architectural details, add slab lines, keep diagrid structures, add curtain wall details, make it more detail

**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.  
ugly

**Generate**

**Original**

**Getting there...**

**Cancel** **Save Changes**

**Edit Instruction Strength** Higher values will make your edited image closer to your instruction.

**Quality & Details**  
More steps will result in a high quality image but will take longer.

**Seed**  
Different numbers result in new variations of your image.  
100641531  Randomize each number to get new variations

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

**Feedback**

**Mask Controls**

# As a collaborative process

**Playground**  Search

**Learn how to edit**

**Edit Instruction**  
Describe how you want to change the image.

show people, activities inside the building,  
Diagrid facade, keep glass facade

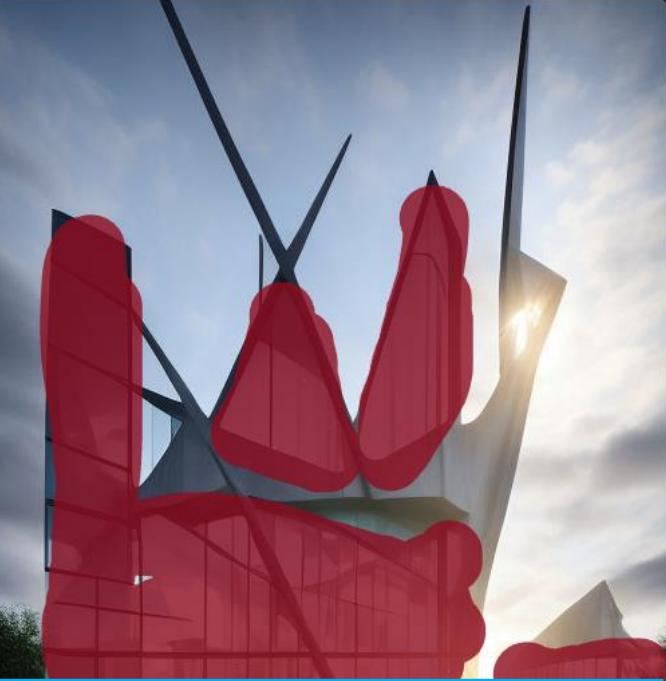
**Pro Tip**  
Try adding, removing, or thinking of styles you could use to modify the image. Examples: Turn the cat into a dog, Change the flowers to red, Make it more like van gogh

**Remove From Image**   
Describe details you don't want in your image like color, objects, or a scenery.

ugly, clouds

**Generate**

**Mask Controls**    49

**Original** 

**Great!** 

**Cancel** **Save Changes**

**Edit Instruction Strength**  Higher values will make your edited image closer to your instruction. **9.5**

**Quality & Details**  
More steps will result in a high quality image but will take longer.  **30**

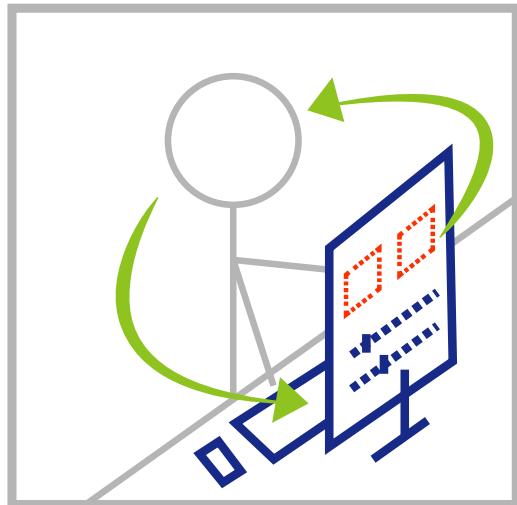
**Seed**  
Different numbers result in new variations of your image.  
**100641531**  **Randomize each number to get new variations**

**Private Session**  
Images will only be visible to you until you're ready to share them. Buy a Pro plan to persist this setting across sessions.

**Feedback**

## 3.1 Conclusion

- For designers with **little to no AI design experience**



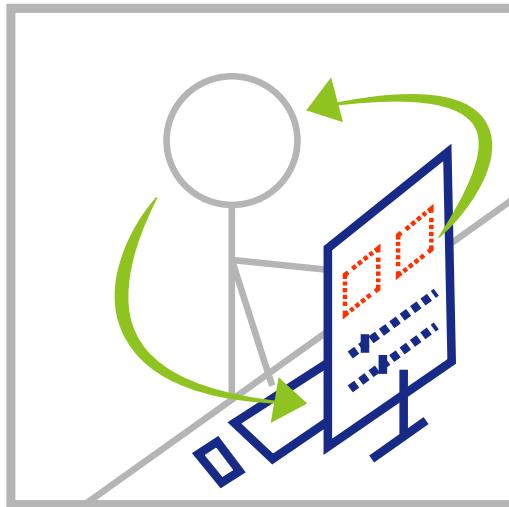
With **images, prompts and sliders** as input (mild prompt-adaptation)

**Controllable variations** for both initial design and design development

Parameters, editing choices (e.g. masking) that **designers can understand and “talk”**

# Case study 3.2

- For designers with **more AI knowledge**



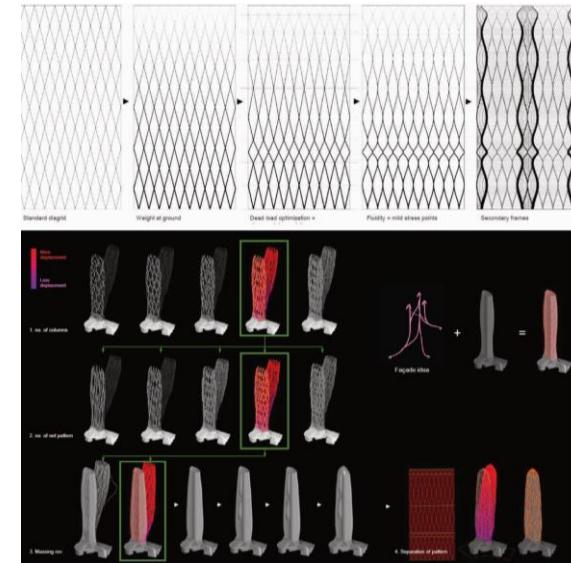
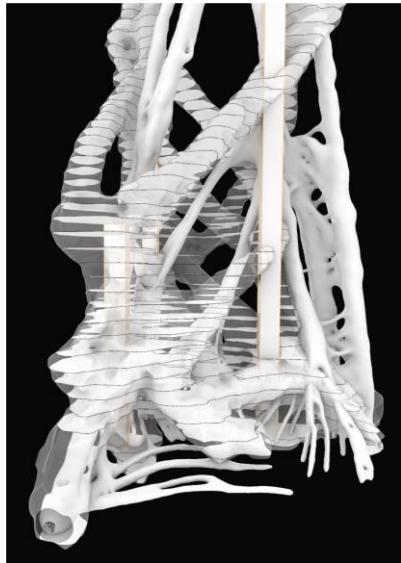
**Image** + **Text (Prompt)** → **Image**

Notebook used (simplified and revised from FastAI teaching materials)

StableDiffusion (Img2img):  
<https://colab.research.google.com/drive/1ruMnNuKizQ7Umznz5T59ZcVIUvEyr-e?usp=sharing>

	Advantages	Limitations	Potential uses
DeepDream	Intuitive, Free	Limited uses	Understand <b>Colab</b> environment
StyleTransfer	Intuitive, Free	Difficult to iterate	Understand <b>Colab</b> environment
Midjourney	High quality	Less intuitive (command-base), 25 free quota	High quality
DALL-E 2	High-quality, <b>intuitive</b> UI	50 free quotas (Monthly reset to 15 credits)	High quality, Edit, expand, combine images
StableDiffusion	<b>Intuitive</b> , Free, with WebUI	Need basis of <b>Google Colab</b>	Developable
Playground.AI	<b>Intuitive</b> , <b>1000 free</b> images/day	Couldn't expand/ combine	Image-to-image as the starting point
InvokeAI	All-rounded	Using local machine	When have powerful machine

# Simulation scenario background (2020)



Designer: *What if I had AI as a collaborator?*

# Google Colab

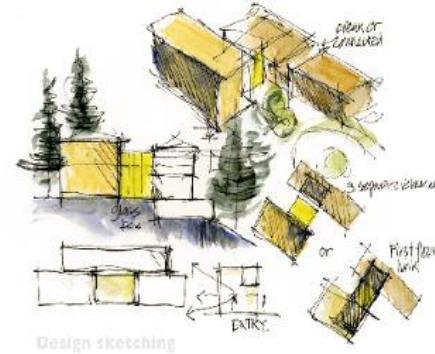
- Transition from intuitive UI to **coding environment**
- But **only with codes that designers need to know**
- Provide **alternatives with instructions** for uploading images

Method 1: upload a photo by a link

```
[ ] p = FastDownload().download('https://lizsteel.com/wp-content/uploads/2019/11/LizSteel-Design-sketching.jpg')
im1 = Image.open(p).convert("RGB")

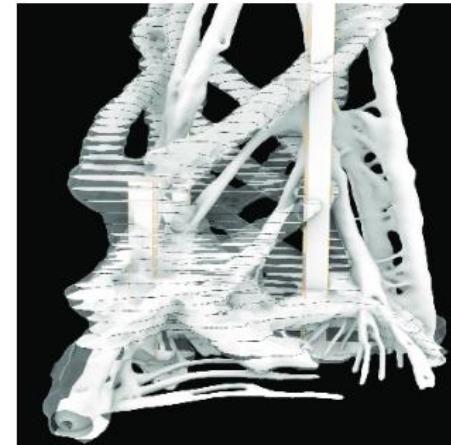
width = 400
height = 400
im2 = im1.resize((width, height), Image.NEAREST)
im2
```

100.31% [229376/228659 00:00<00:00]



Method 2: upload a photo on left-hand-side. 先去左邊file icon按一下, 然後在左邊介面右鍵按, upload 來上傳自己的圖, 上傳後鼠標指著新上傳的檔案, 檔案名字右邊會出現三點, 右鍵選Copy path, 貼到下方 image.open ('這裡')

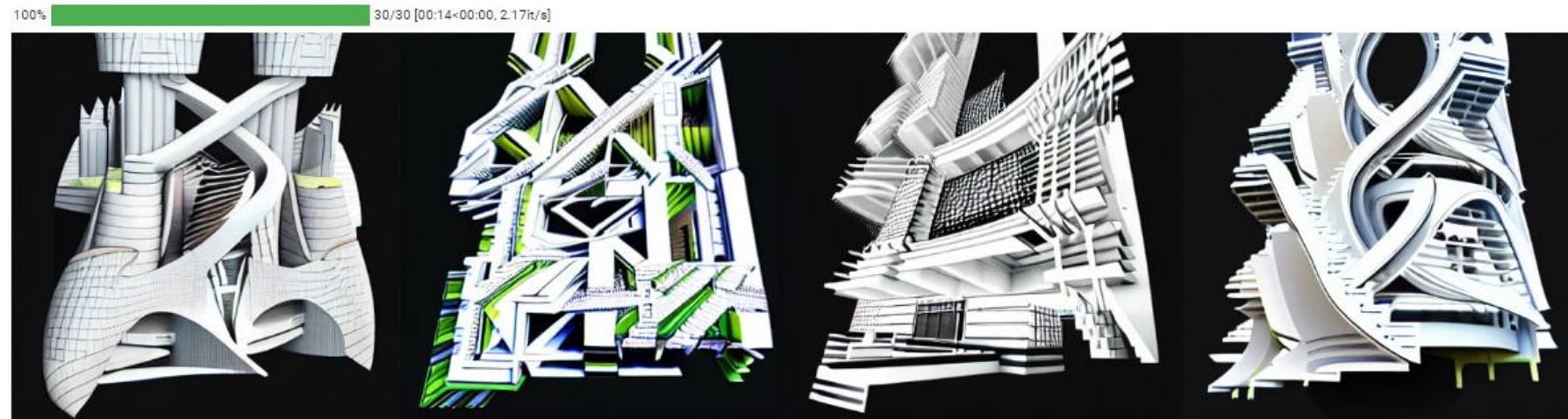
```
[ ] im1 = Image.open("/content/Parametric.jpg").convert("RGB")
width = 400
height = 400
im2 = im1.resize((width, height), Image.NEAREST)
im2
```



# Inputs

- Only keeping relevant parameters for designers

```
[ ] torch.manual_seed(1000)
sentence = "tower design, Archigram style, complex, sophisticated, futuristic, detail, photorealistic 4k, branching concept, swarming design process"
images = pipe(prompt=sentence, num_images_per_prompt=4, init_image=im2, strength=0.6, num_inference_steps=50).images
image_grid(images, rows=1, cols=4)
```



```
torch.manual_seed(1000)
```

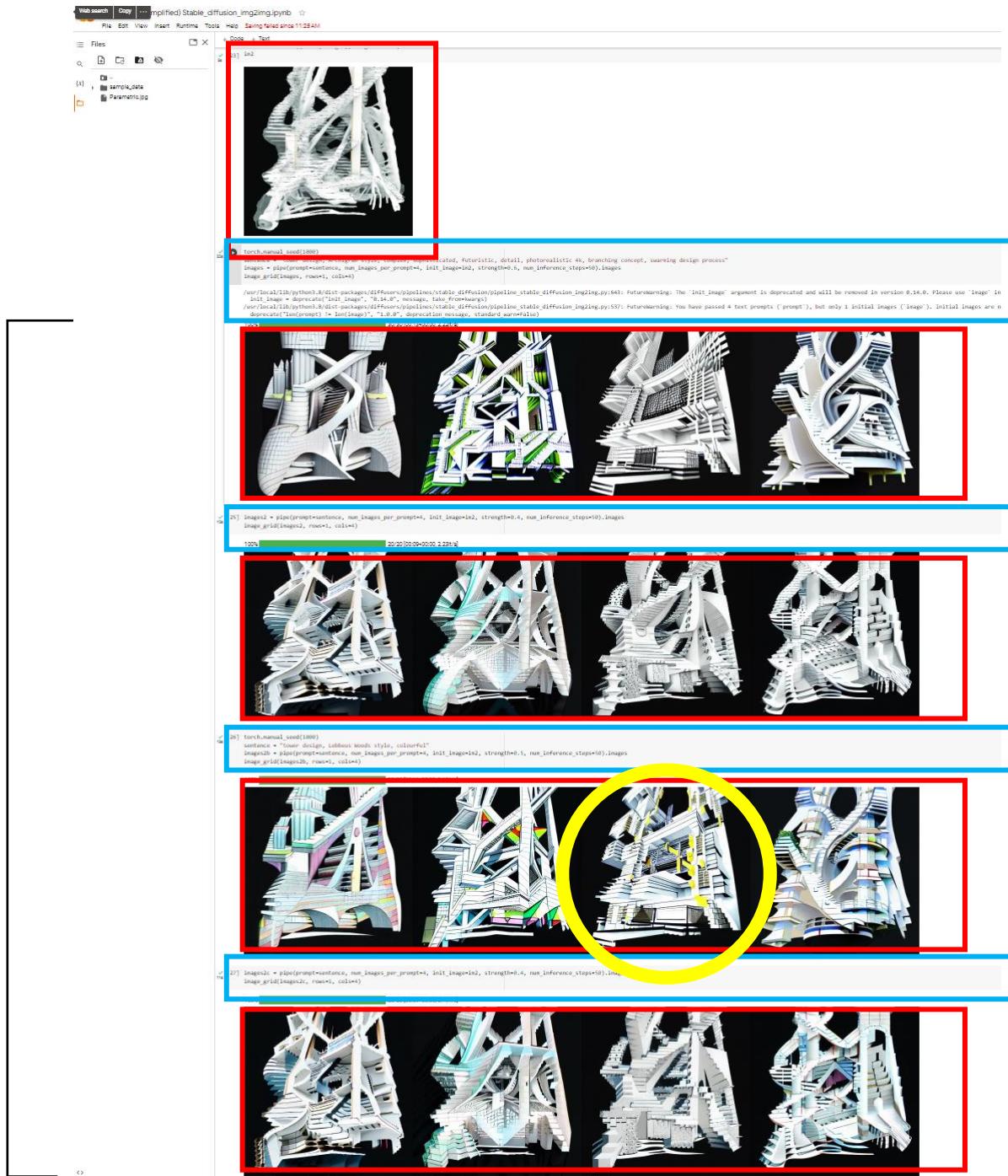
```
sentence = "tower design, Archigram style, complex, sophisticated, futuristic, detail, photorealistic 4k, branching concept, swarming design process"
```

```
images = pipe(prompt=sentence,
              num_images_per_prompt=4,
              init_image=im2,
              strength=0.6,
              num_inference_steps=50).images

image_grid(images, rows=1, cols=4)
```

[intuitive]

## Designer's sketch



Select preferred option

Further iterate by other rounds of testing prompt (texts) and strengths

Select preferred option  
(for design development)



# [Combined] Edit with DALL-E 2 - expand

DALL-E History Collections

< Edit image

Edit Tower design, Lebbeus Woods style, energetic, detail glass facade, with mullion

Generation frame: 1024 x 1024

Image editing is now in beta.

Erase part of the image to edit, or add a generation frame to extend the image.

While this is in beta the full images won't be saved, so consider downloading often to save your work.

Undo

Generation frame: 1024 x 1024

Cancel Accept

# Edit with AI (partial generation)

DALL-E History Collections

< Edit image

Edit Tower design, Lebbeus Woods style, energetic, detail glass facade, with mullion, Chinese city context

Generation frame: 1024 x 1024

Image editing is now in beta.

Erase part of the image to edit, or add a generation frame to extend the image.

While this is in beta the full images won't be saved, so consider downloading often to save your work.

Undo

▶ ⌂ ⌂ ⌂ ⌂ ⌂

Generation frame: 1024 x 1024

Generation frame: 1024 x 1024

Generation frame: 1024 x 1024

Cancel Accept

Generation frame: 1024 x 1024

Cancel Accept

# Edit with AI (combine)

DALL-E History Collections

< Edit image

Edit: Futuristic city, Zaha Hadid style, Photorealistic 4K, energetic

Generation frame: 1024 x 1024

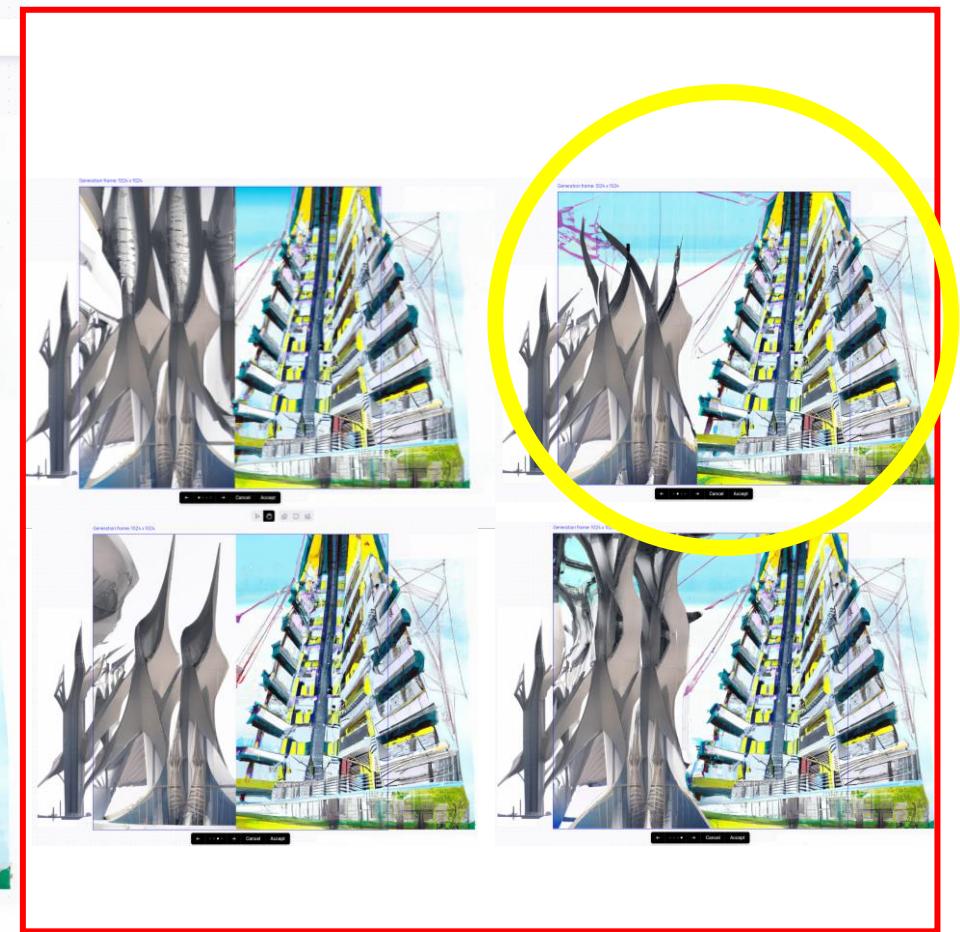
Image editing is now in beta.

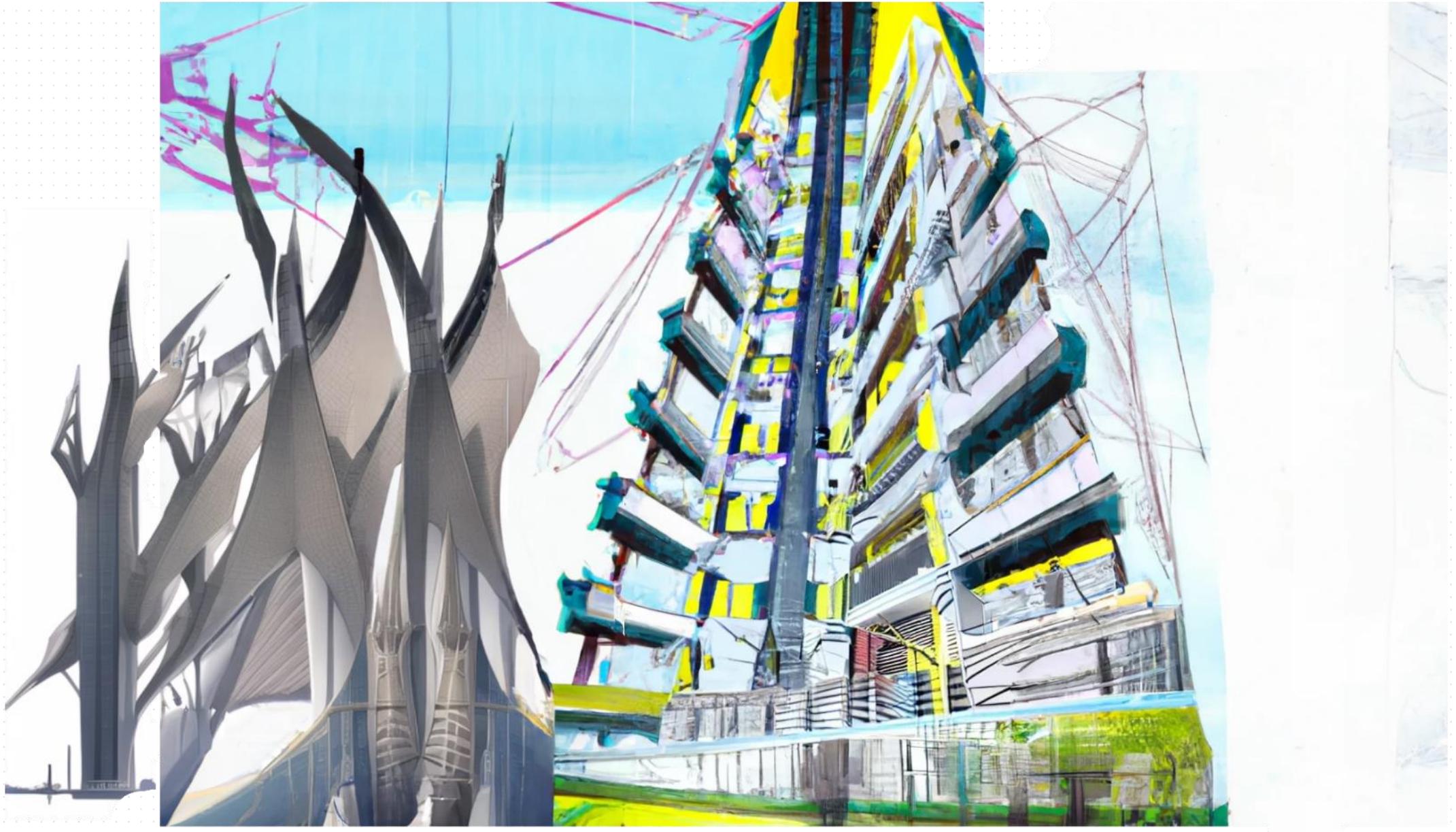
Erase part of the image to edit, or add a generation frame to extend the image.

While this is in beta the full images won't be saved, so consider downloading often to save your work.

Undo

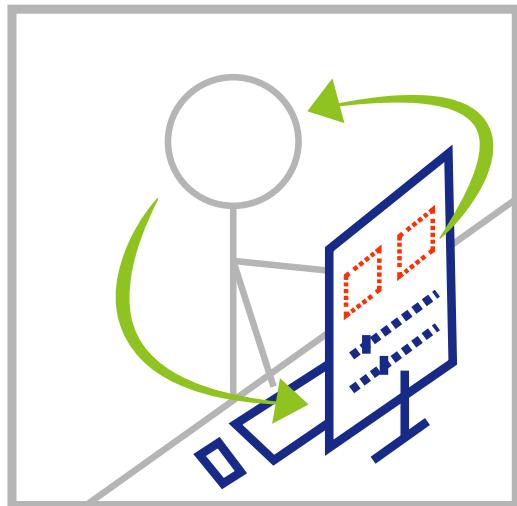
Cancel Accept





## 3.2 Conclusion

- For designers with **AI design experience**



Partial code-based environment, with images, prompts and parameters as input (mild prompt-adaptation, minimum knowledge of coding)

**Controllable variations for both initial design and design development**

Parameters, editing choices (such as masking, expansion, combination) **that designers can understand and “talk”**

# Case study 3.3

- For designers with intention to further customize the tool
- Simulated scenario: colour combinations test for illustrations (similar to the concept StyleTransfer)



Notebook used (Modified based on:

<https://github.com/AUTOMATIC1111/stable-diffusion-webui>

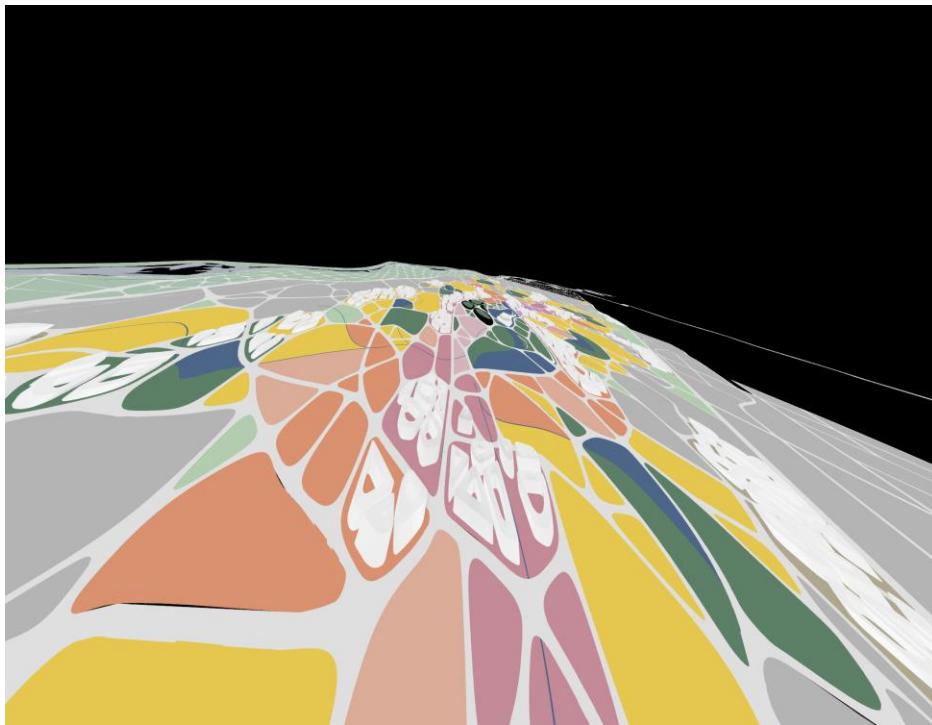
StableDiffusion with WebUI and ControlNet, with the LoRA model:

<https://drive.google.com/drive/folders/1xhIIL3-wj4WbG94RV2KHTpkoiJDYtcf?usp=sharing>

	Advantages	Limitations	Potential uses
DeepDream	Intuitive, Free	Limited uses	Understand Colab environment
StyleTransfer	Intuitive, Free	Difficult to iterate	Understand Colab environment
Midjourney	High quality	Less intuitive (command-base), 25 free quota	High quality
DALL-E 2	High-quality, <b>intuitive</b> UI	50 free quotas (Monthly reset to 15 credits)	High quality, Edit, expand, combine images
<b>StableDiffusion</b>	<b>Intuitive,</b> <b>Free</b> , with <b>WebUI</b>	Need basis of <b>Google Colab</b>	<b>Developable</b>
Playground.AI	<b>Intuitive, 1000 free</b> images/day	Couldn't expand/ combine	Image-to-image as the starting point
InvokeAI	All-rounded	Using local machine	When have powerful machine

# Simulation scenario background (2020)

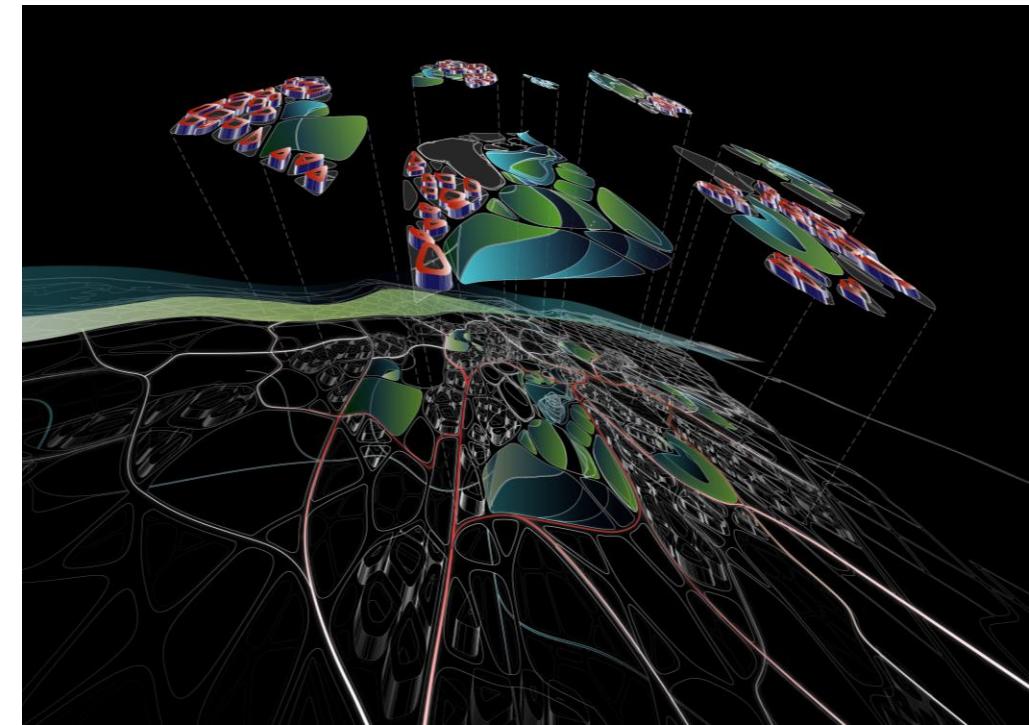
Urban design abstract diagram with Subbarthi Guha at conceptSG, London, 2020



3D model screenshot



Style references

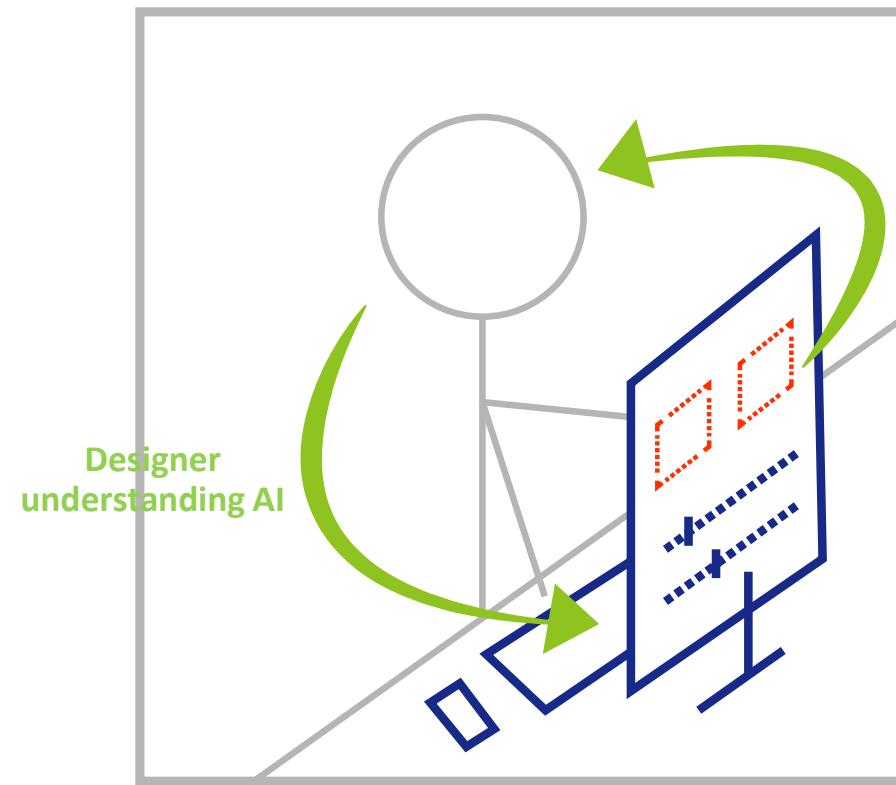


Final illustrations

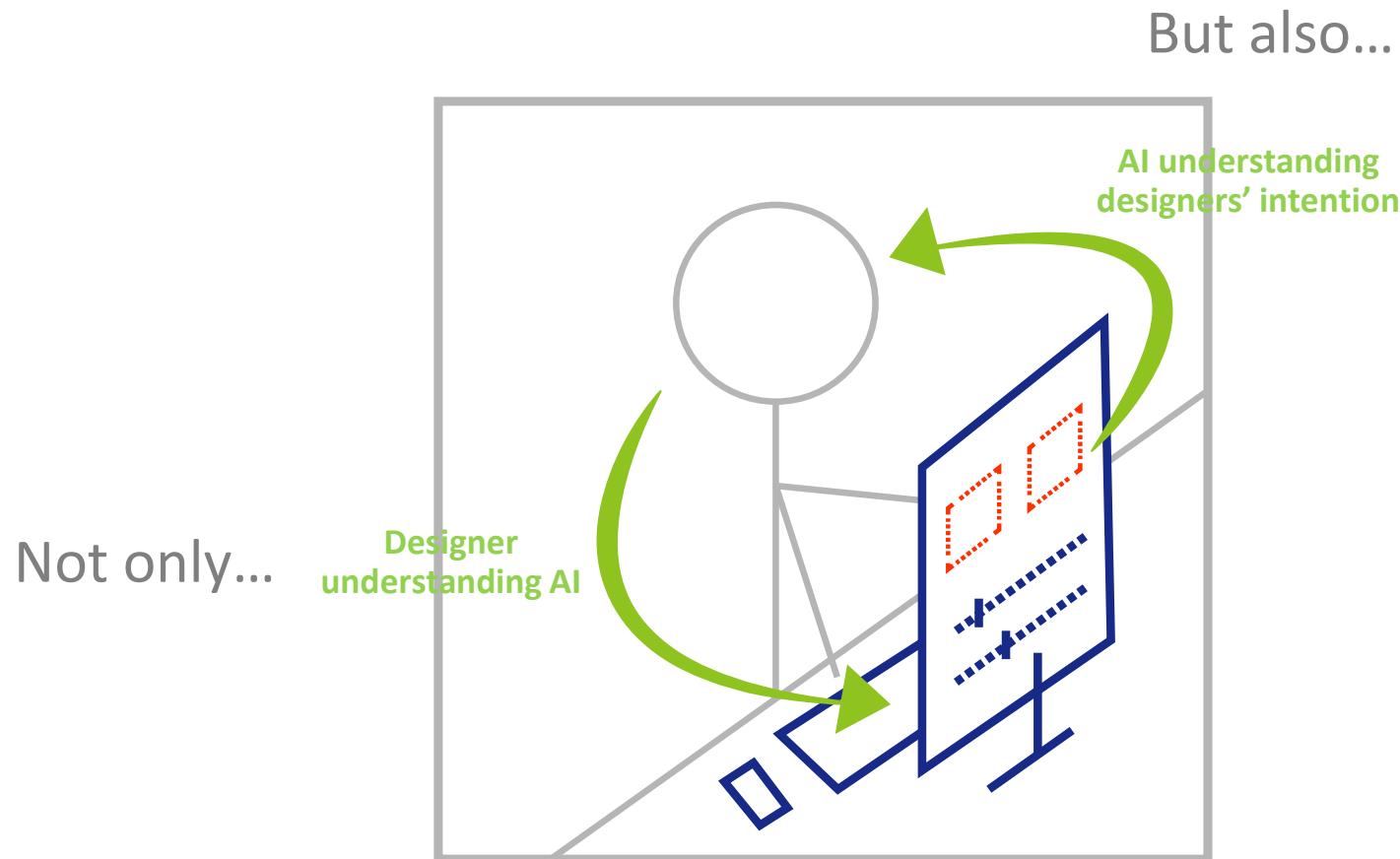
**Designer:** *What if I had AI as a collaborator?*

# Collaboration in both ways

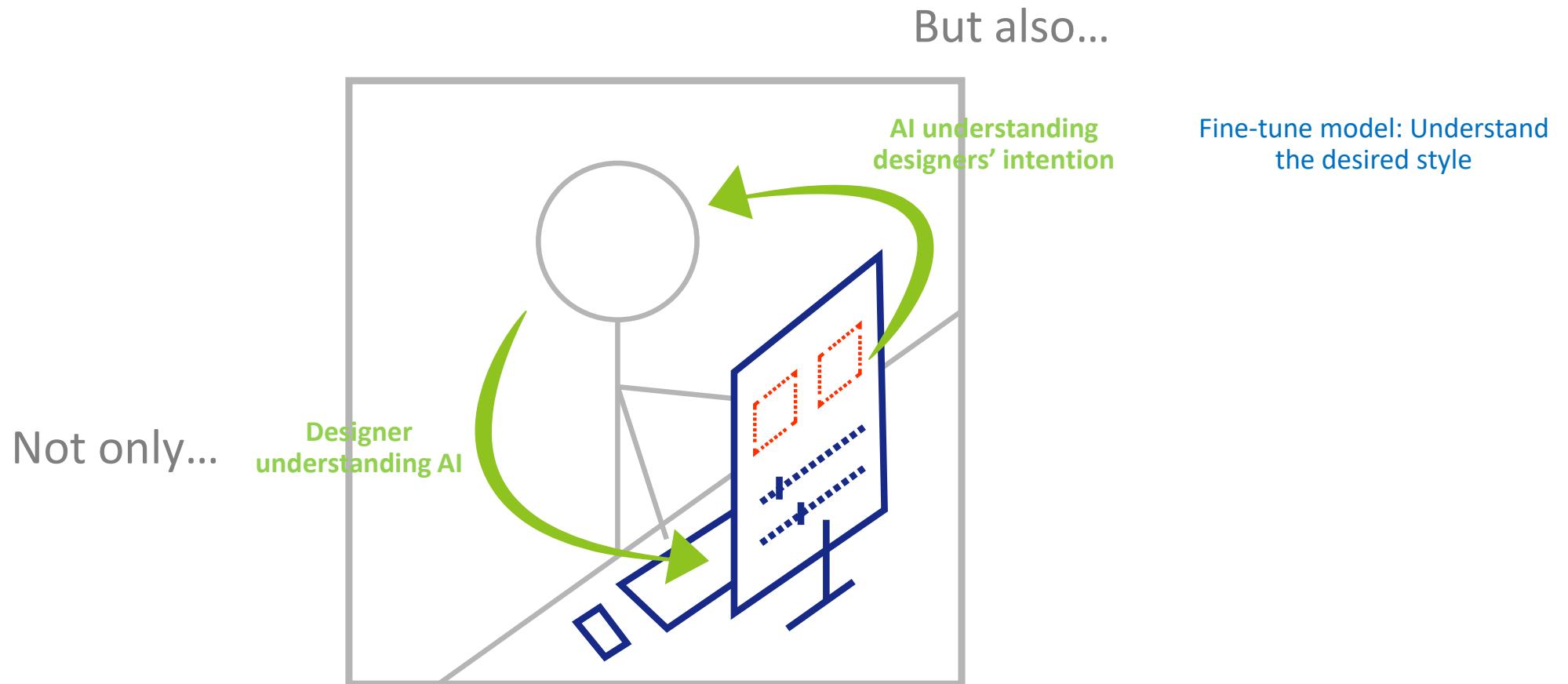
Not only...



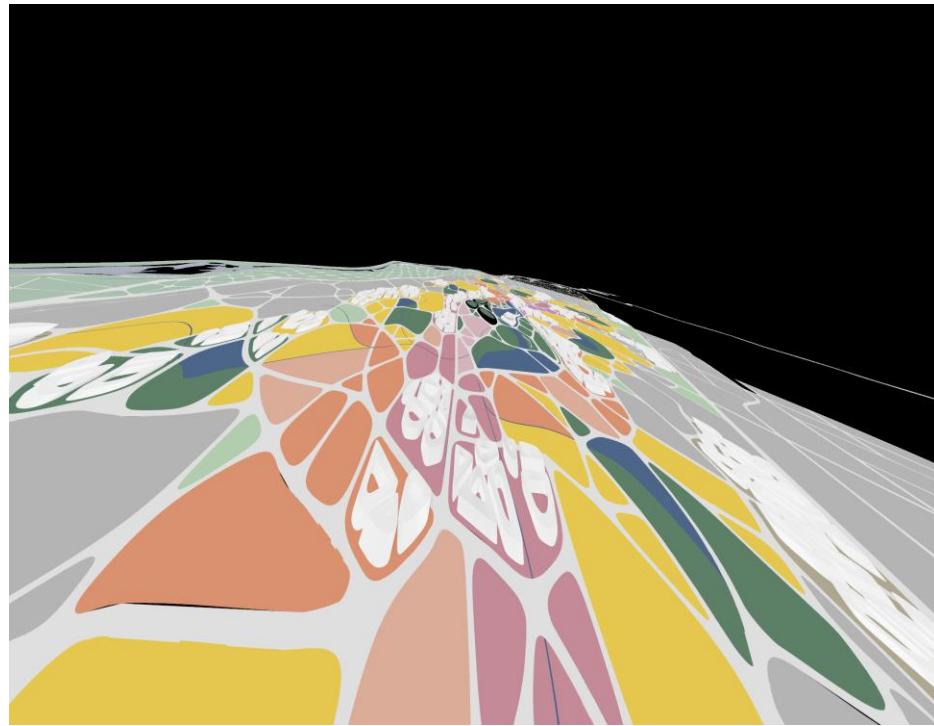
# Collaboration in both ways



# Collaboration in both ways



# Train a fine-tune model for specific style



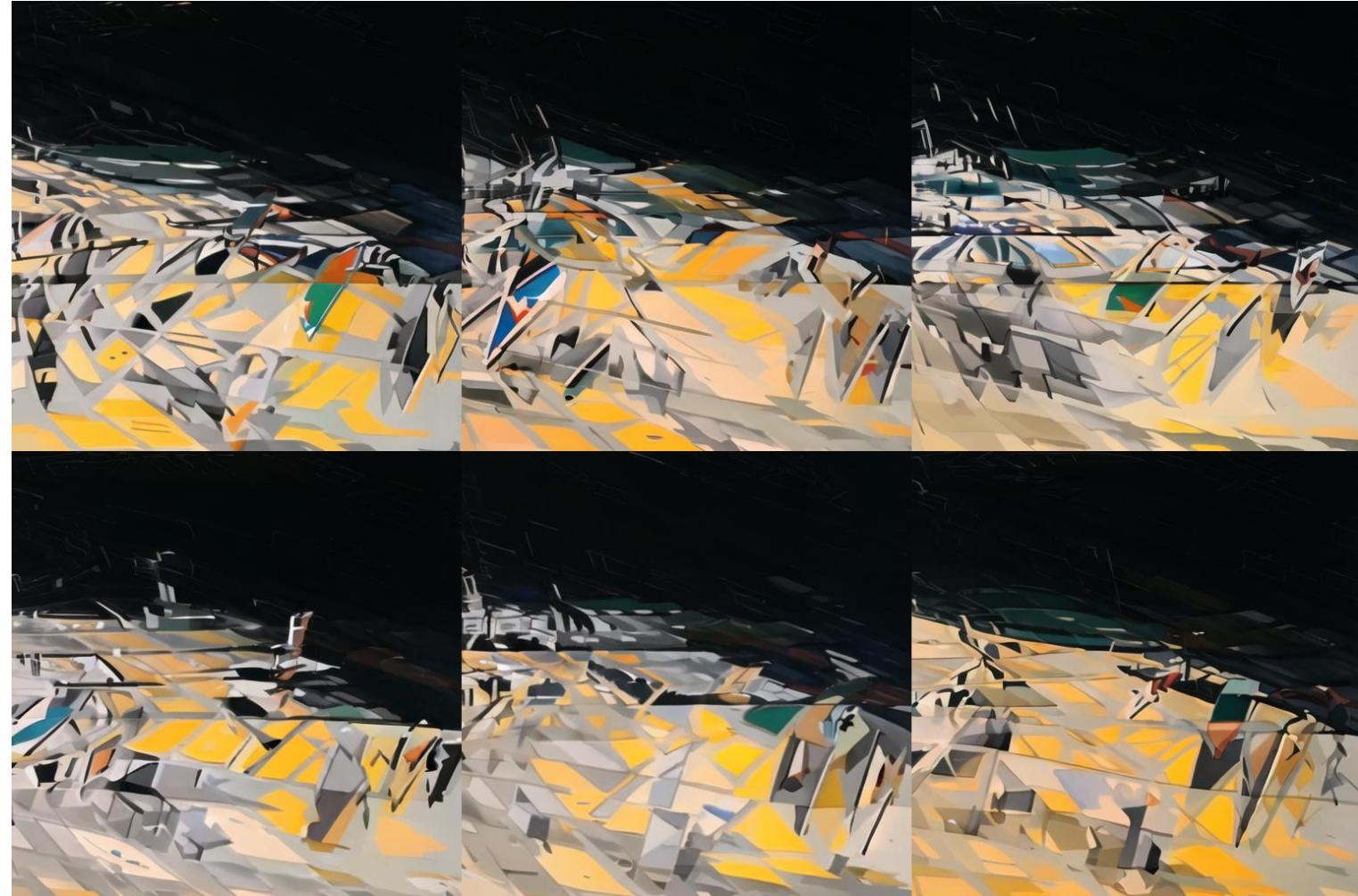
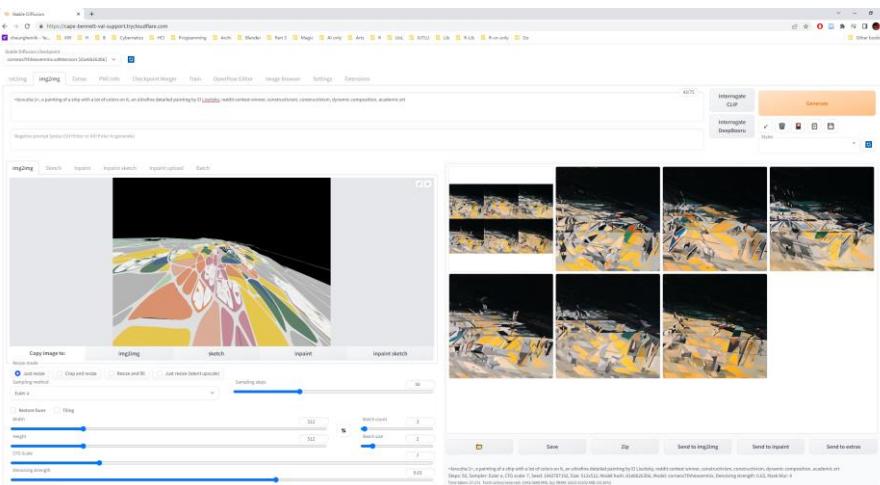
3D model screenshot



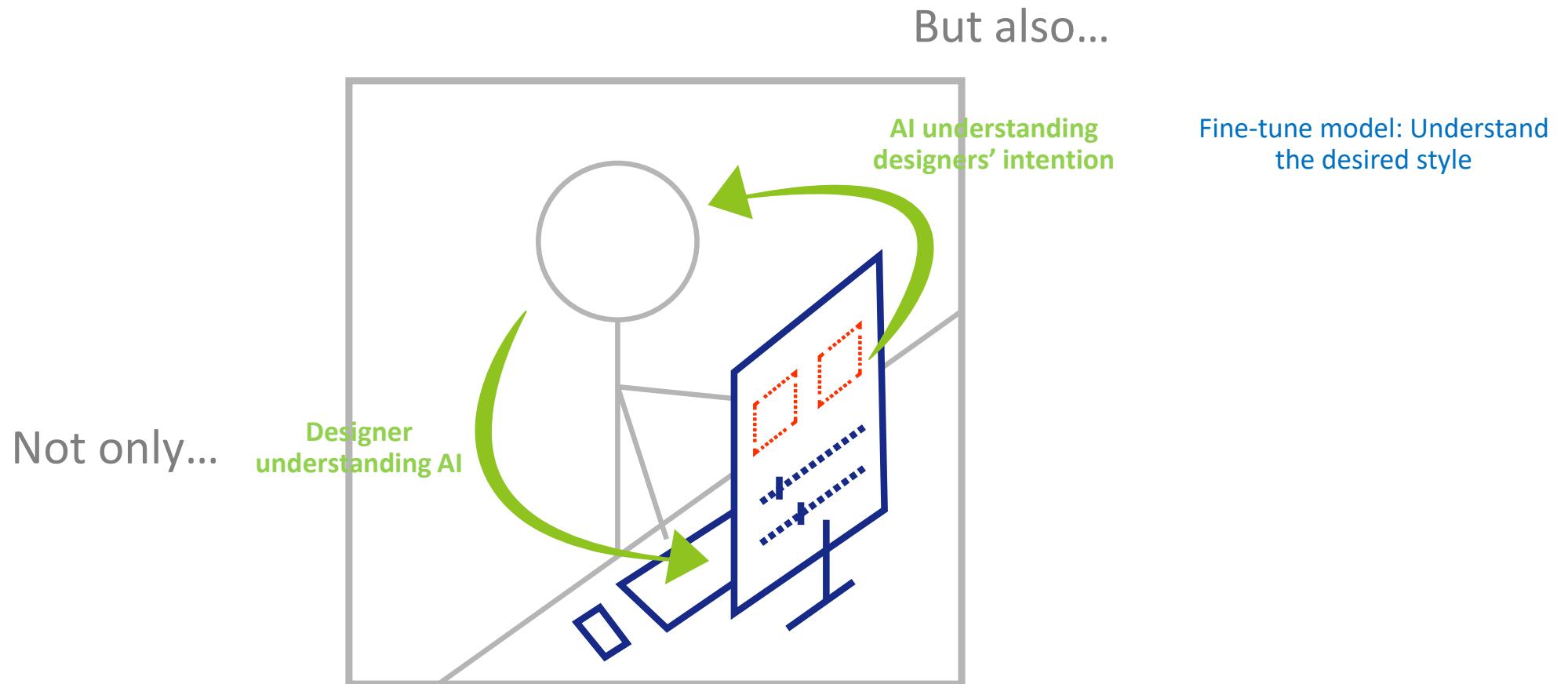
Style reference

# Initial test

- WebUI on Google Colab
- **Undesired results** (Similar to StyleTransfer)
- **Developable platform**, make use of more latest tools

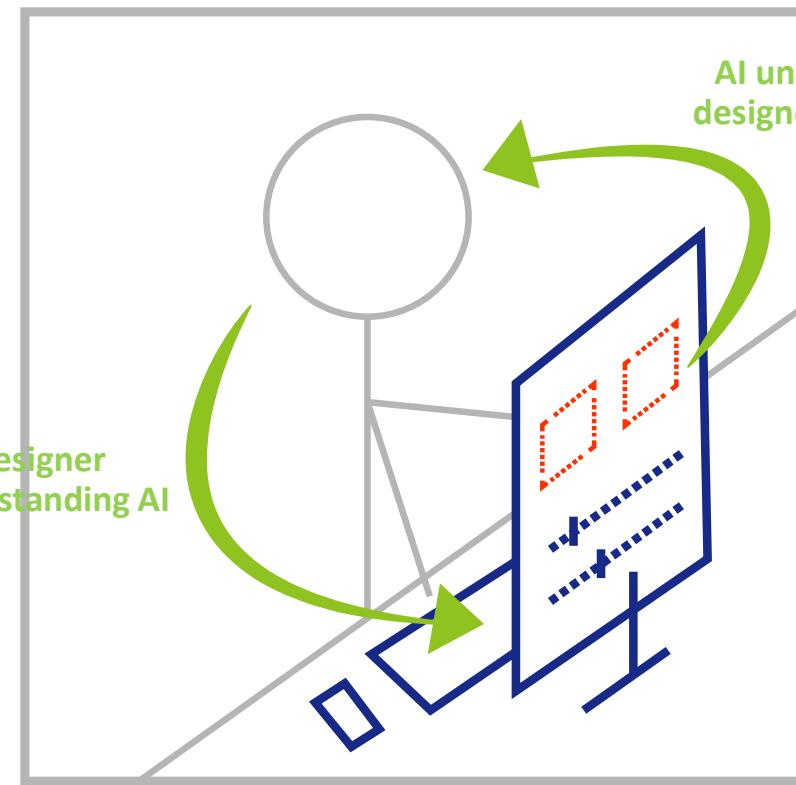


# Collaboration in both ways



# Collaboration in both ways

Not only...



But also...

Fine-tune model: Understand  
the desired style

+

**Understand the input image  
with the concept of “edges”**

[txt2img](#) [img2img](#) [Extras](#) [PNG Info](#) [Checkpoint Merger](#) [Train](#) [OpenPose Editor](#) [Image Browser](#) [Settings](#) [Extensions](#)<lora:zha:1>, a painting of a building with a sky background, an ultrafine detailed painting by Zaha Hadid, [behance](#), [deconstructivism](#), constructivism, orthogonal, dynamic composition

# Edge detection (using ControlNet)

Negative prompt (press Ctrl+Enter or Alt+Enter to clear)  
  

Sampling method

Euler a

Sampling steps

20

 Restore faces  Tiling  Hires. fix

Width

512

Height

512

CFG Scale

Batch count

Batch size

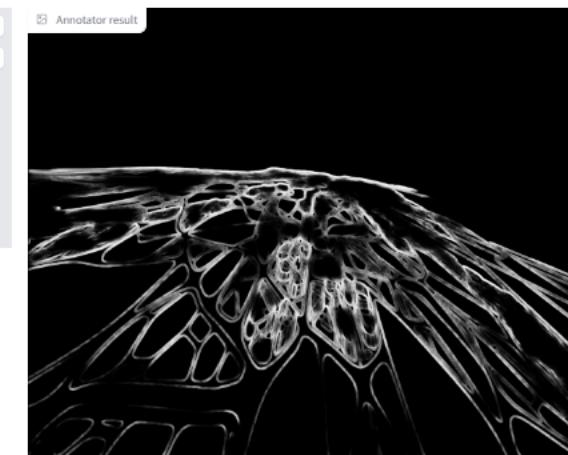
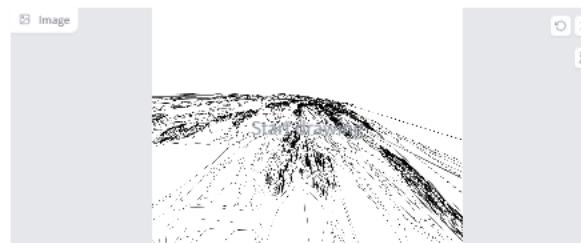
7

Seed

-1

Extra

ControlNet



Invert colors if your image has white background.

Change your brush width to make it thinner if you want to draw something.

 Enable Invert Input Color RGB to BGR Low VRAM Guess Mode

Preprocessor

hed

Model

control\_hed-fp16 [13fee50b]



Weight

1

0

1

Guidance Start (T) Guidance End (T)

txt2img img2img Extras PNG Info Checkpoint Merger Train OpenPose Editor Image Browser Settings Extensions

<lora:zha:1>, a painting of a building with a sky background, an ultrafine detailed painting by Zaha Hadid, [behance](#), [deconstructivism](#), constructivism, orthogonal, dynamic composition

39/75

Generate

# Edge detection (using ControlNet)

Negative prompt (press Ctrl+Enter or Alt+Enter to clear)

Sampling method

Euler a

 Restore faces    Tiling    Hires. fix

Width

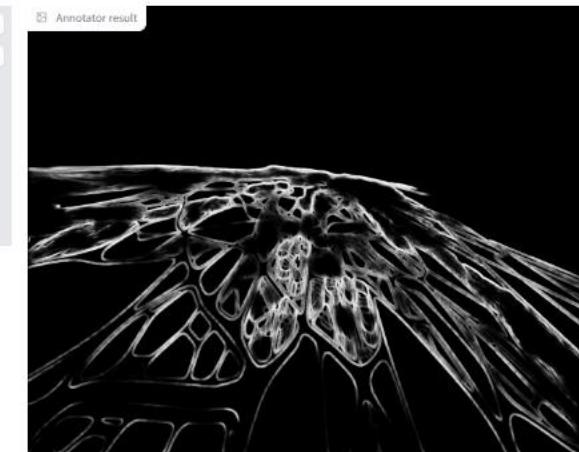
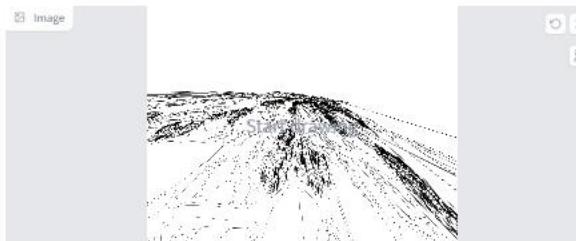
Height

CFG Scale

Seed

-1

ControlNet



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hed

Model

control\_hed-fp16 [13fee50b]

<lora:zha:1>, a painting of a building with a sky background, an ultrafine detailed painting by Zaha Hadid, [behance](#), [deconstructivism](#), constructivism, orthogonal, dynamic composition  
 Steps: 20, Sampler: Euler a, CFG scale: 7, Seed: 3712235901, Size: 512x512, Model hash: d1e6b263b6, Model: corneos7thheavenmix, ControlNet Enabled: True, ControlNet Module: hed, ControlNet Model: control\_hed-fp16 [13fee50b], ControlNet Weight: 1, ControlNet Guidance Start: 0, ControlNet Guidance End: 1  
 Time taken: 36.98s. Torch active/reserved: 9944/13572 MiB, Sys VRAM: 14905/15102 MiB (98.7%)

Weight

Guidance Start (T)

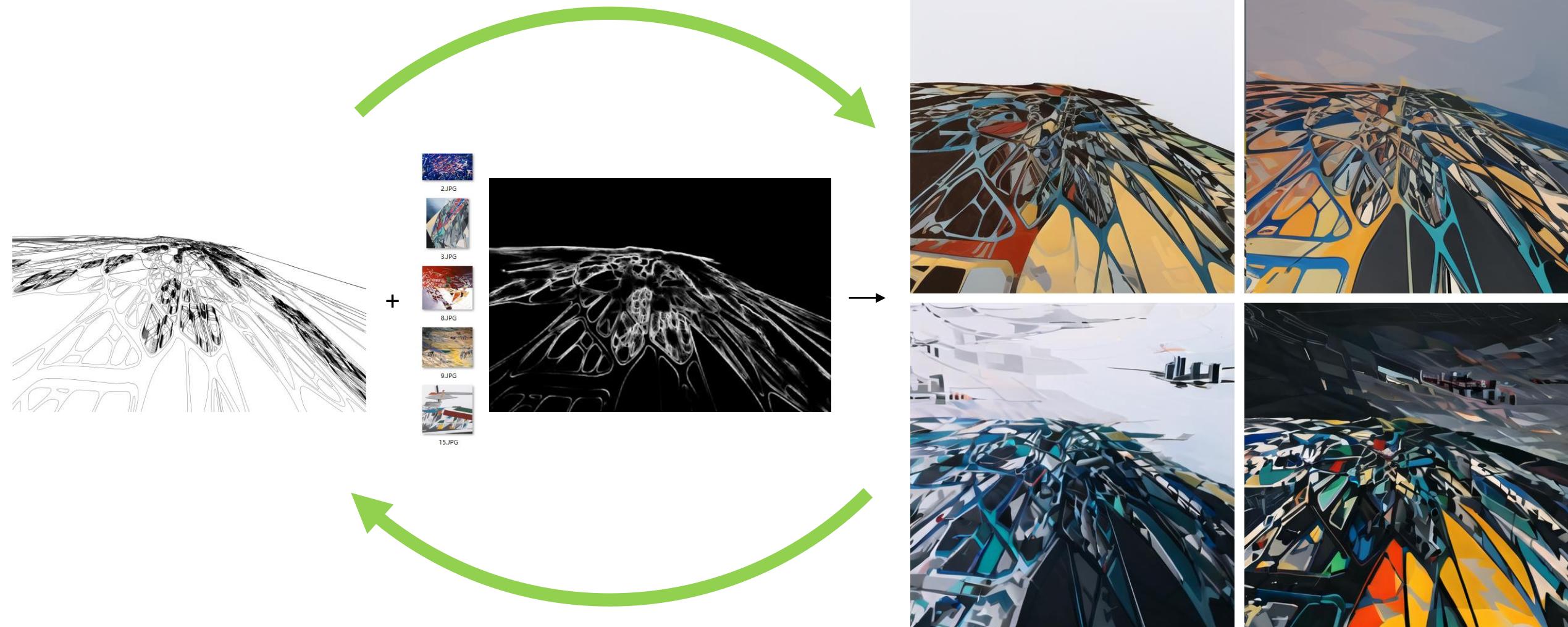
0

Guidance End (T)

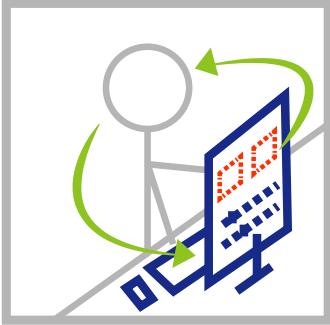
1



# [intuitive] & [collaborative] & [combined]

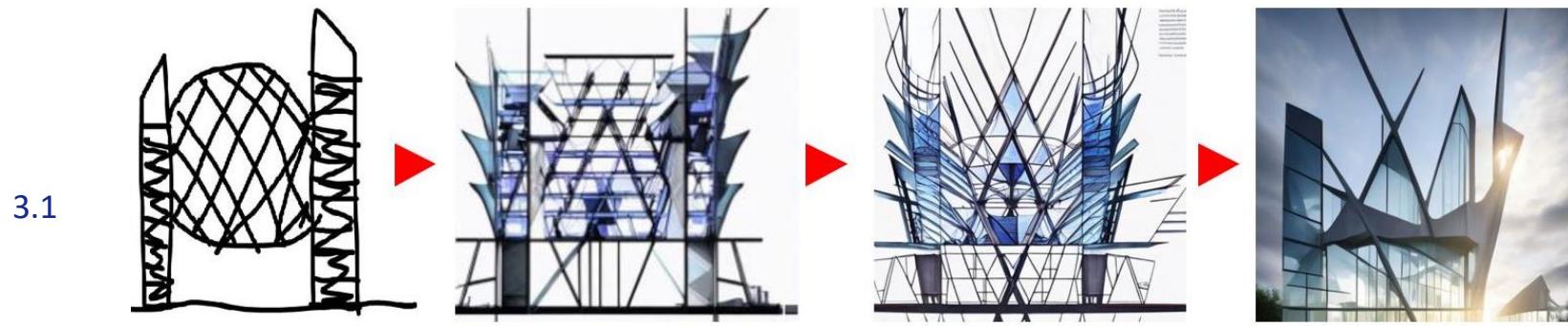


# Conclusion



**[Intuitive]** *[prompt engineering]*

Use designer's images, understandable parameters as inputs



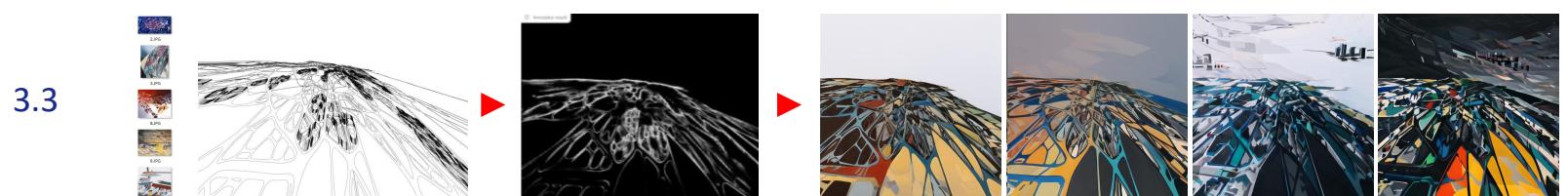
**[Collaborative]** *[design in seconds]*

Outputs variations are controllable for a meaningful design process



**[Combined]** *[fastest/HQ images]*

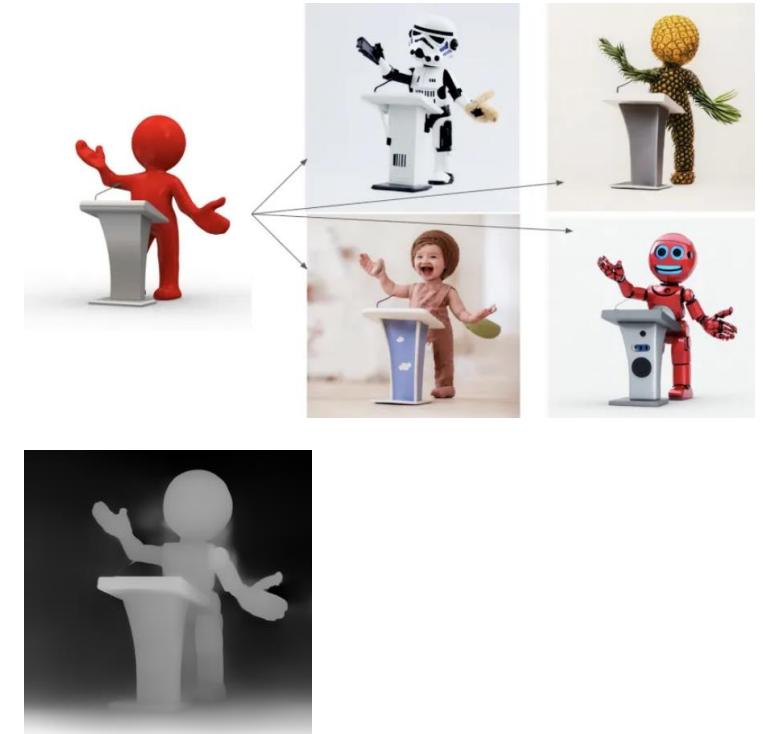
Select tools according to design needs



# Limitations and future works

**[intuitive]** Architectural design is not limited to 2D hand sketches

Photographs of 3D models as inputs with AI's understanding (image depth)



**[combinational]** Switches between tools

Streamlined application for architectural designers



**[collaborative]** Practice! (motivation of this research)

Workshop / design module – introduce the proposed framework for future architecture students

<https://creativedigest.substack.com/p/stable-diffusion-20-out-adding-a>

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Thank you!