# A Generative Adversarial Network for AI-Aided Chair Design

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# Motivations

Generated Prototype

Sketch

3D Model

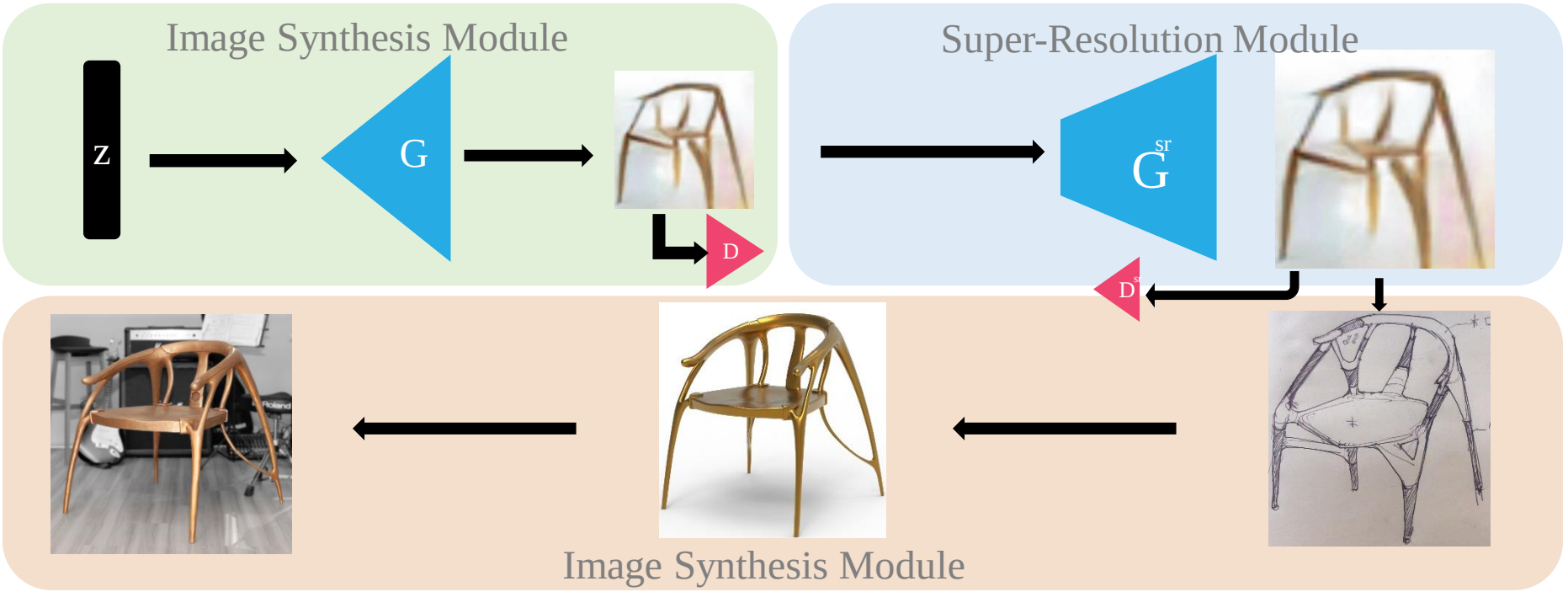
Real Life Chair

- Leveraging the power of artificial intelligence to improve chair design.
- Speeding up the designing process tremendously while maintaining the variety of shapes and textures.

# Contributions

1. We present a deep neural network for improving human design of chairs which consists of an image synthesis module and a super-resolution module.
2. We select one of the candidates as design prototype and create a real life chair based on it. To the best of our knowledge, this is the first physical chair created with the help of deep neural network, which bridges the gap between AI and design.

# Network Architecture



# Image Synthesis Module

Learn chair data distribution and sample from it.

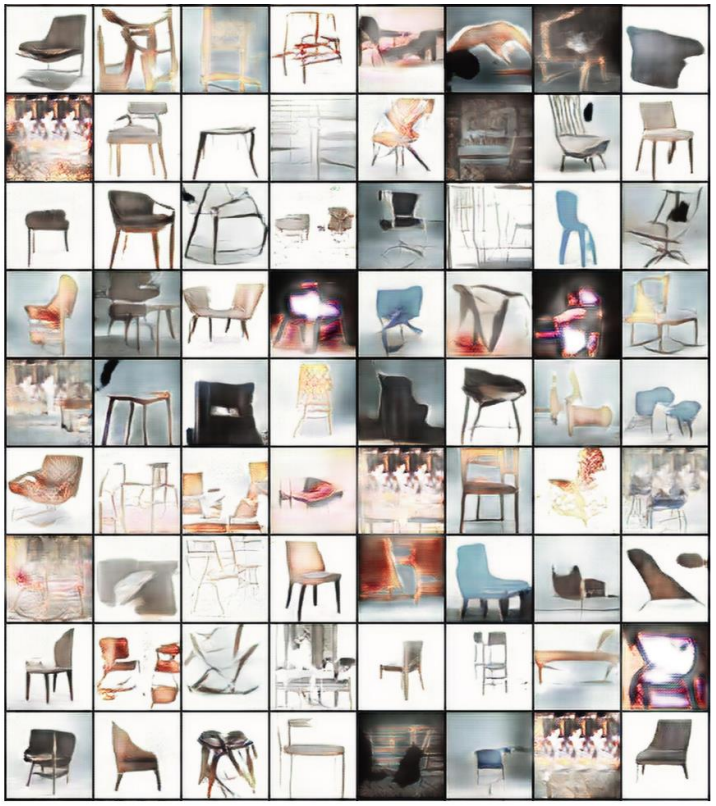
$$\mathcal{L}_{GAN}^{gen}(G,D) = \min_G \max_D E_{x\sim p_{chair}(x)}[\log D(x)] + E_{z\sim p_Z(z)}[\log(1-D(G(z)))]$$

Chair data distribution $x \sim p_{chair}(x)$

Random noise $z \sim p_Z(z)$

Generator $G$

Discriminator $D$



# Super-Resolution Module

## Adversarial Loss

$$\mathcal{L}^{sr}_{GAN}(G_{sr}, D_{sr}) = \min_{G_{sr}} \max_{D_{sr}} E_{y_{hr}\sim p_{train}(y_{hr})}[\log D_{sr}(y_{sr})] + E_{y_{lr}\sim p_{G_{sr}}(y_{lr})}[\log(1 - D_{sr}(G_{sr}(y_{lr})))]$$

$y_{hr}$ , $y_{lr}$ : Images from high resolution domain and corresponding low resolution domain.
$G_{sr}$ , $D_{sr}$ : Generator and discriminator of super-resolution module

## Perceptual Content Loss

$$\mathcal{L}^{sr}_{content/i,j}(G_{sr}) = \frac{1}{W_{i,j}H_{i,j}} \sum_{k=1}^{W_{i,j}} \sum_{l=1}^{H_{i,j}} \{\phi_{i,j}(y_{hr})_{k,l} - \phi_{i,j}[G_{sr}(y_{lr})]_{k,l}\}^2$$

$\phi_{ij}$: feature response of $i^{th}$ layer and $j^{th}$ filter
$W_{ij}, H_{ij}$: dimensions of the respective feature maps of VGG19 network

# AI Aided Chair Design and Realization

Generated Prototype

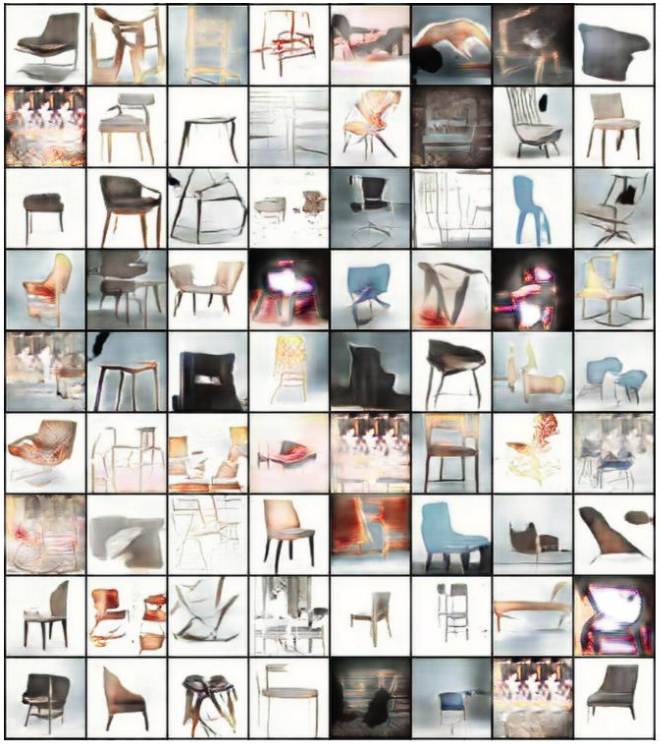
Sketch

3D Model

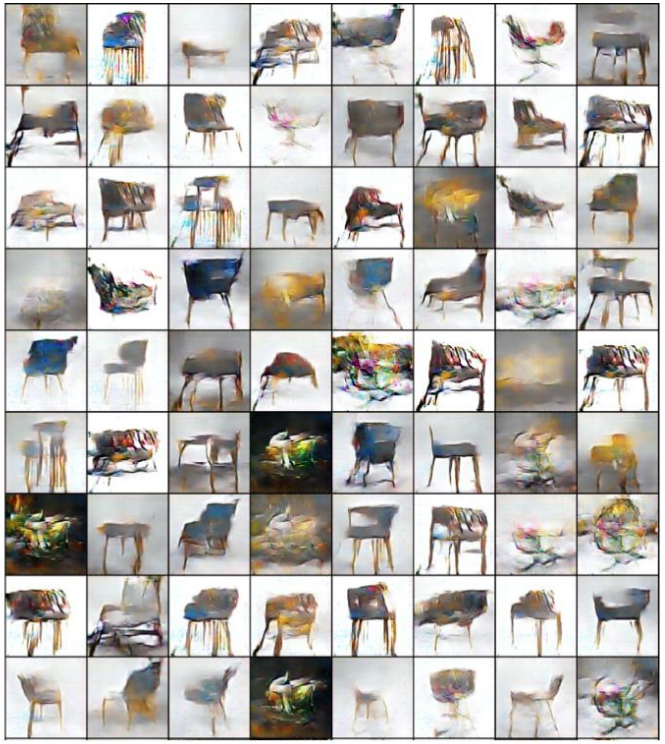
Real Life Chair

- Select a final chair prototype from 320K generated candidates
- Create 2D sketch and 3D model
- Real life chair

# Results



380K training data



1k training data

# Results

# Results

# Thank you !

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