Zero-Shot Text-to-Image Generation for Housing Floor Plans

By

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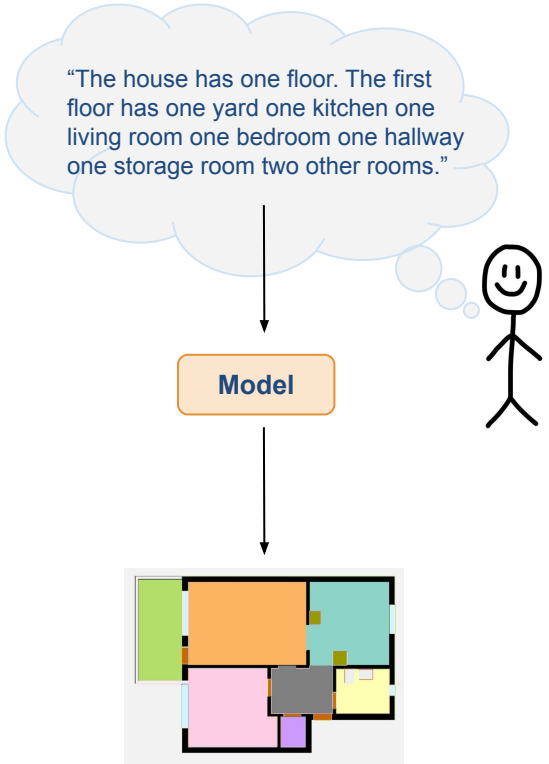
Goal

Floor plans help you envision a space and understand how it will look when construction or renovations are complete.

Interior designers, pro builders, and real estate agents can use these floor plans when they are looking to design or sell a new home or property.

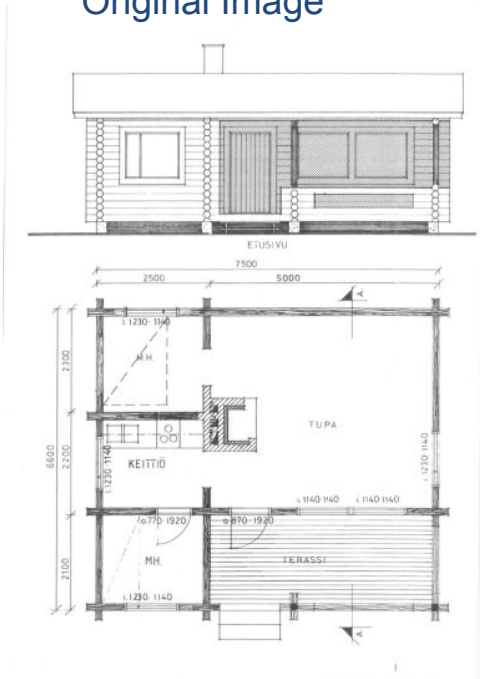
Such users can just enter the text description of floor plan and our model should gives out the image representing the text entered.



Data Collection

Source : [CubiCasa Dataset]
Data Size : 5k housing floor plan images
Data Format : Floor plan Images in SVG format

Original Image



Original SVG

```
!cat /content/cubicasa5k/{instance_dir}/model.svg

<?xml version="1.0"?>
<svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink" height="1369.6700439453125" ve
            <g class="BoundaryPolygon" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)">
                <polygon points="0.00,0.00 215.40,0.00 215.40,60.00 0.00,60.00 "/>
            </g>
            <g class="Direction" fill-opacity="0.9" style="display: none;">
                <polygon points="114.91,55.20 114.91,44.58 111.90,44.58 111.90,55.20 108.10,55.20 113.40,60.00 11
            </g>
            <g class="Name" fill-opacity="0.9" style="display: none;">
                <text transform="translate(3 12)" font-size="12" font-family="Verdana, Sans-Serif">CB</text>
            </g>
            <desc>Width:60 Height:90 Depth:60 Elevation:0</desc>
        </g><g class="FixedFurniture DoubleSink" transform="matrix(1,0,0,1,221.0756,897.0606)" style="fill-opacit
            <g class="InnerPolygonLeft" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)">
                <polygon points="5.00,9.90 36.00,9.90 36.00,47.59 5.00,47.59 "/>
            </g>
            <g class="InnerPolygonRight" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)">
                <polygon points="39.23,10.00 69.85,10.00 69.85,47.68 39.23,47.68 "/>
            </g>
            <g class="OuterDrain" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)" stroke-width="0.8">
                <circle cx="21.170965431359104" cy="28.174781972274896" r="3.5"/>
                <circle cx="53.94834845960544" cy="28.174781972274896" r="3.5"/>
            </g>
            <g class="InnerDrain" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)" stroke-width="0.8">
                <circle cx="21.170965431359104" cy="28.174781972274896" r="2"/>
                <circle cx="53.94834845960544" cy="28.174781972274896" r="2"/>
            </g>
            <g class="Faucet" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)">
                <polygon points="34.39,4.25 40.39,4.25 40.39,18.25 34.39,18.25 "/>
            </g>
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                <polygon points="39.24,47.42 39.24,36.80 36.23,36.80 36.23,47.42 32.42,47.42 37.73,52.72 43.03,47
            </g>
            <g class="Name" fill-opacity="0.9" style="display: none;">
                <text transform="translate(3 12)" font-size="12" font-family="Verdana, Sans-Serif">DSINK</text>
            </g>
         <desc>Width:70 Height:90 Depth:60 Elevation:0</desc>
        </g><g class="FixedFurniture ElectricalAppliance IntegratedStove" transform="matrix(1,0,0,1,329.5773,897.
            <g class="BoundaryPolygon" fill="rgb(255, 255, 255)" stroke="rgb(0, 0, 0)">
```
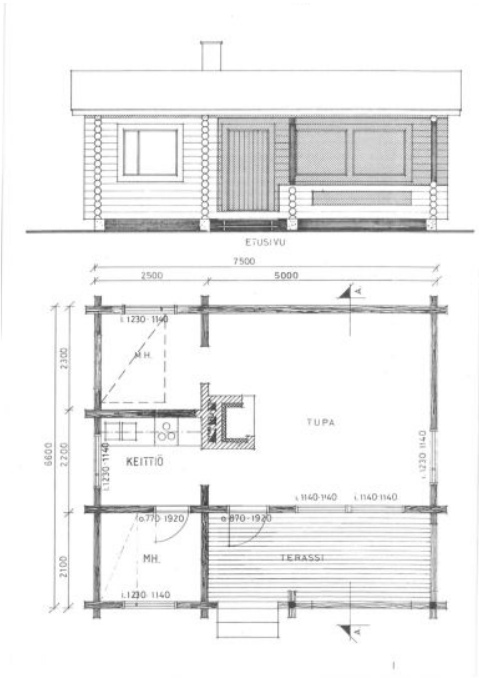
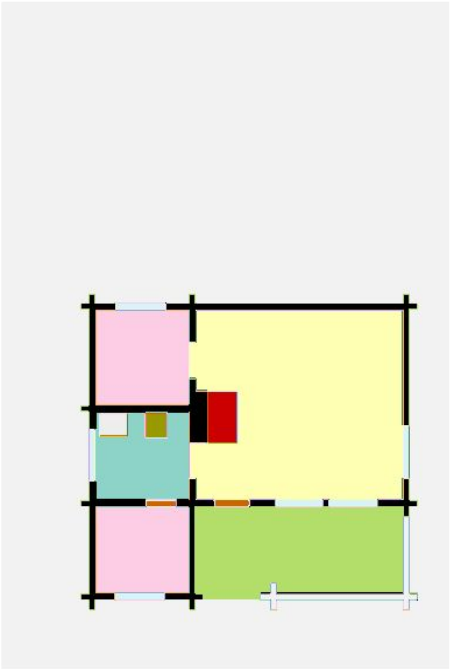

Image Pre-processing

Original Image



Generated annotated image



Text Generation

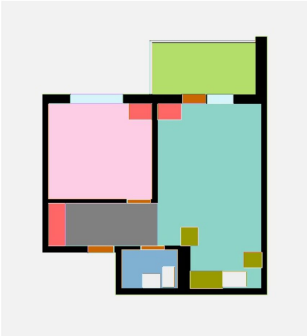
- Original dataset did not provide natural text descriptions
- We parsed the SVG to generate the text descriptions
- Example
  - “The house has one floor. The first floor has one yard one kitchen two bedrooms one other room.”

Generated annotated image

Dataset Filtration

- We used only houses with one story to simplify the problem

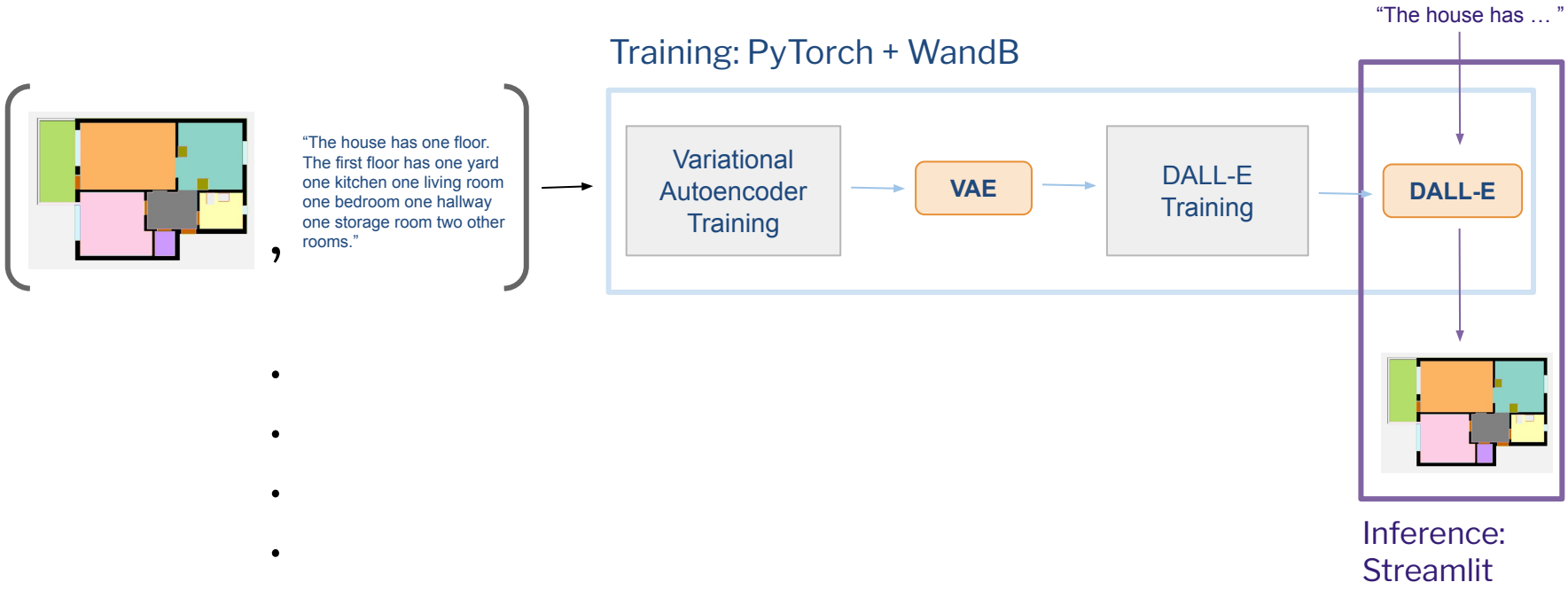
1 floor



2 floors

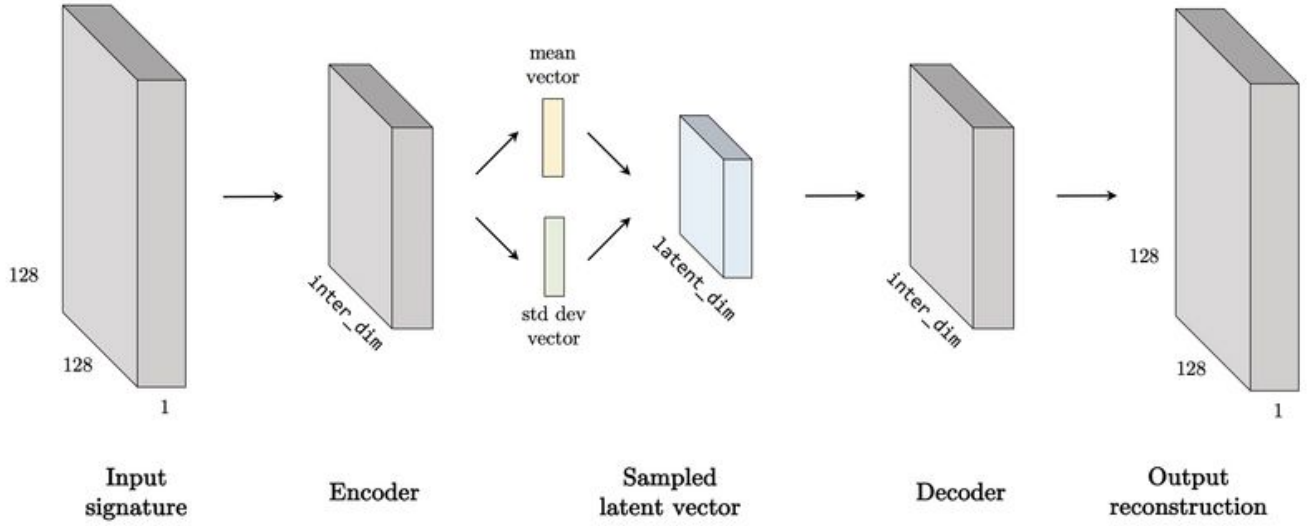
3 floors

Model Architecture



What is VAE

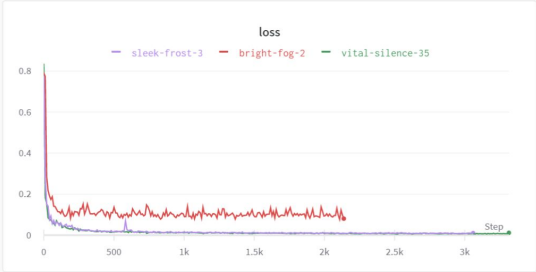
A variational autoencoder is an architecture composed of both an encoder and a decoder and that is trained to minimize the reconstruction error between the encoded-decoded data and the initial data.

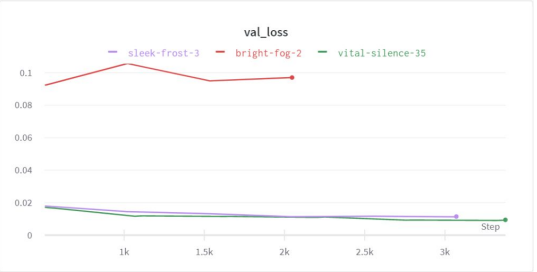


System diagram of VAE architecture (source: https://www.researchgate.net)

VAE Training

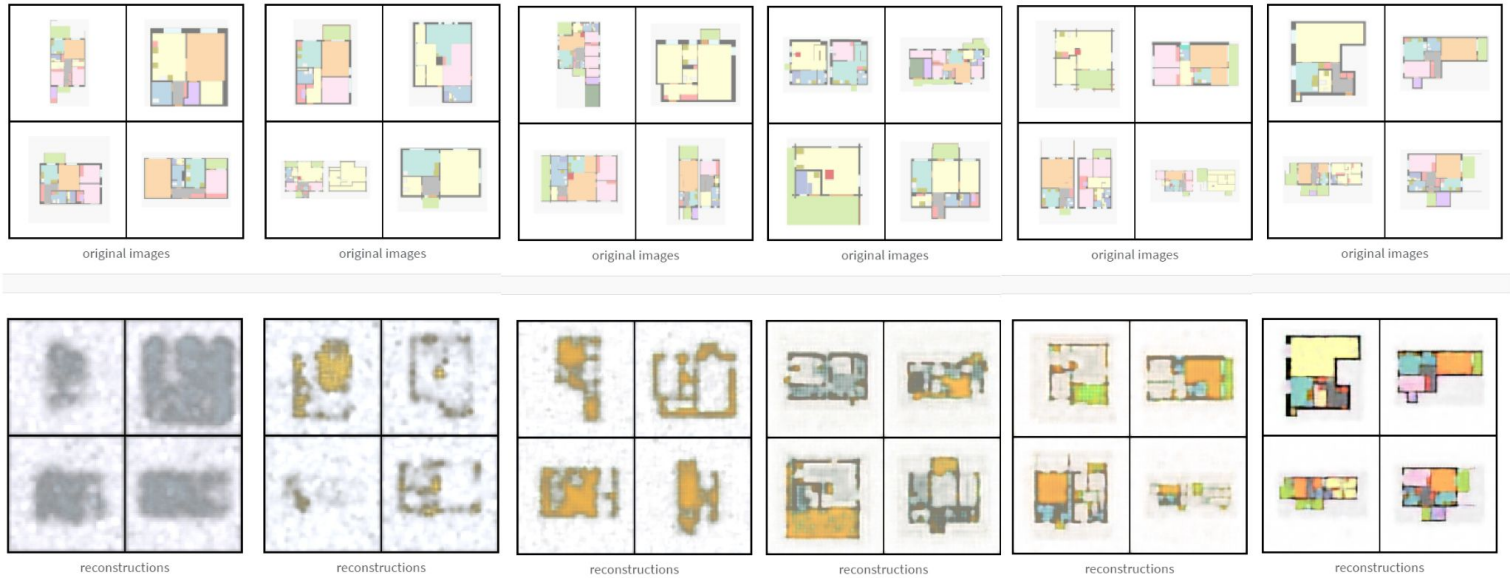
- Train/test: 90/10 split
- Resize images to 128 px
- Image augmentations
  - *sweeping resize*
- Epochs: 6
- Batch size: 6
- Learning rate: 1e-3
- # layers: 3
- Embedding # dimensions: 512
- Loss function: reconstruction loss and KL divergence loss





Experiments	Training Loss	Validation Loss
6 epochs, 512 dim	0.012	0.009
5 epochs, 512 dim	0.010	0.012
4 epochs, 256 dim	0.081	0.107

VAE Results


original images
original images
original images
original images
original images
original images
reconstructions
reconstructions
reconstructions
reconstructions
reconstructions
reconstructions
epoch 0, iter 10
epoch 0, iter 200
epoch 1, iter 100
epoch 2, iter 100
epoch 4, iter 60
epoch 5, iter 50

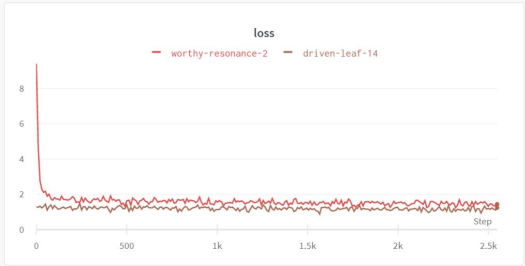
What is DALL-E

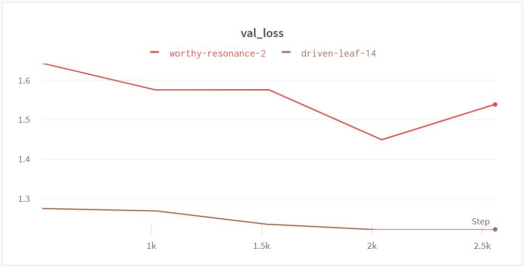
DALL-E is an extension of GPT-3 by creating images from text descriptions for a wide range of concepts expressible in natural language.

DALL-E is an autoregressive transformer decoder model. It accepts concatenated encoded text tokens with the encoded image embeddings to train the transformer auto-regressively. The training minimizes cross-entropy loss for a combination of the text and image representations.

DALL-E Training

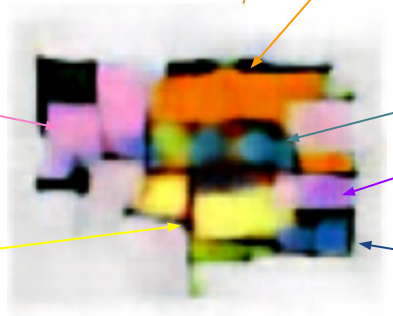
- Resize images to 128 px
- Train/test: 90/10 split
- Image augmentations
  - *sweeping resize*
- Epochs: 5
- Batch size: 4
- Learning rate: 1e-3
- Seq length: 256 tokens
- # heads: 4
- Embedding # dimensions: 512
- Loss function: cross-entropy weighted ⅞ image loss + ⅛ text loss





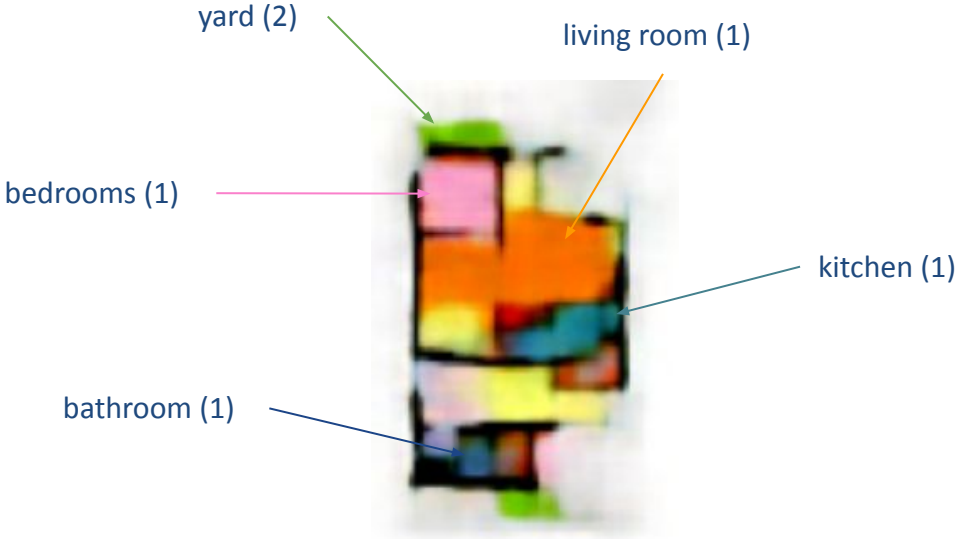
Experiments	Training Loss	Validation Loss
5 epochs, 512 dim	1.244	1.252
4 epochs, 256 dim	1.443	1.572

Example 1



the house has one floor. the first floor has one yard one kitchen one living room five bedrooms two bathrooms three hallways one storage room four other rooms.

Example 2



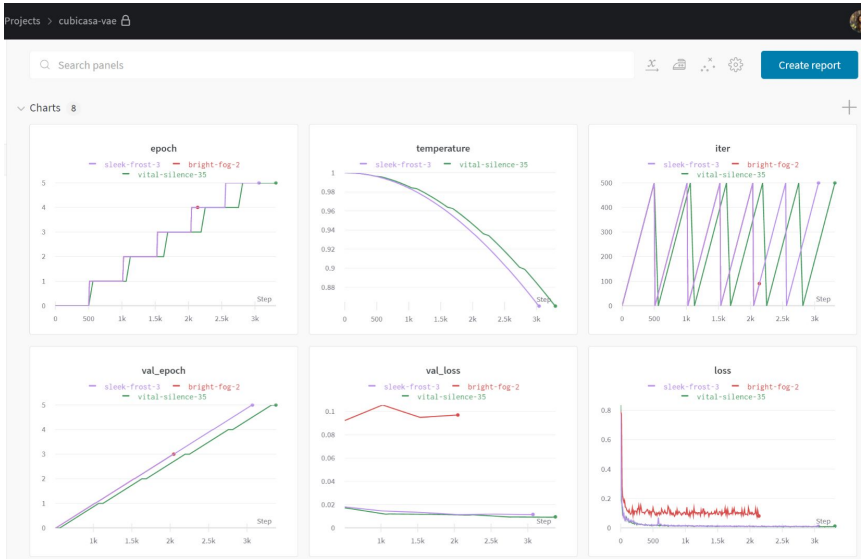
the house has one floor . the first floor has one yard one kitchen one living room one bedroom one bathroom .

Example 3

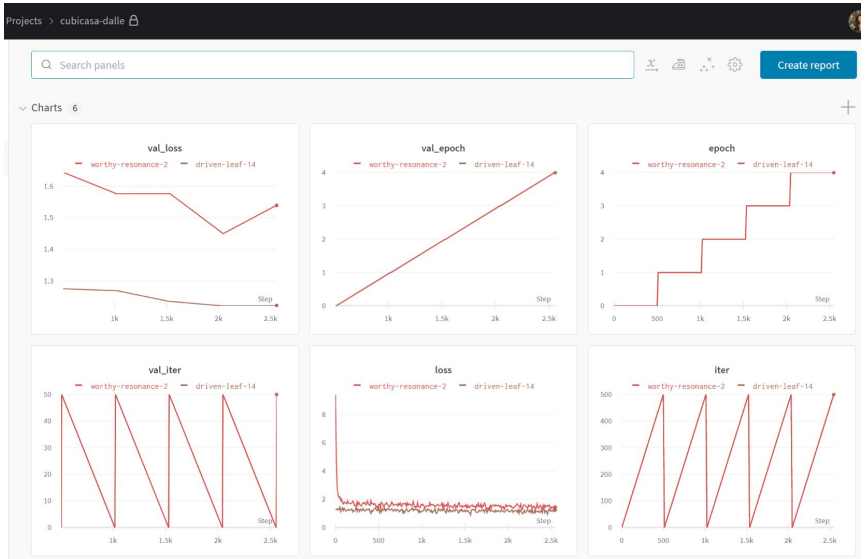
the house has one floor . the first floor has three yards one kitchen one living room three bedrooms two bathrooms one hallway one storage room three other rooms .

MLOps - WandB

VAE Training Pipeline Runs

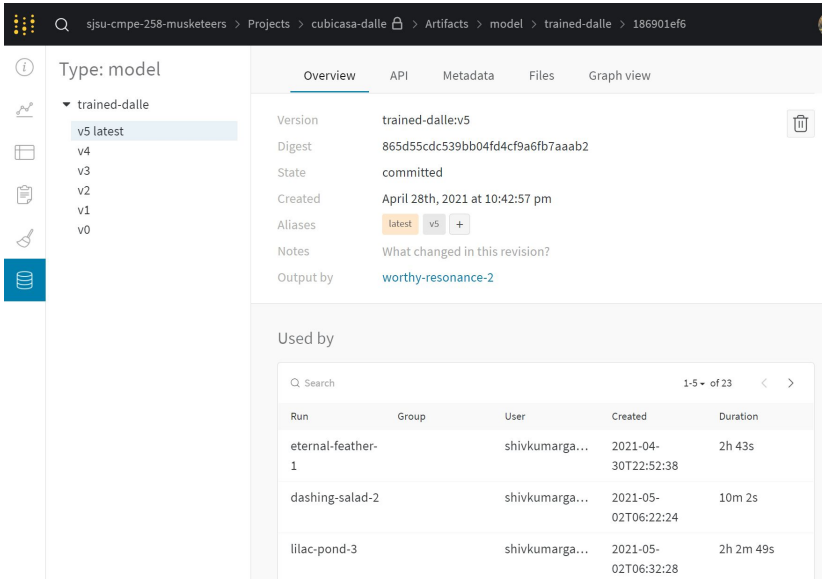


DALL-E Training Pipeline Runs

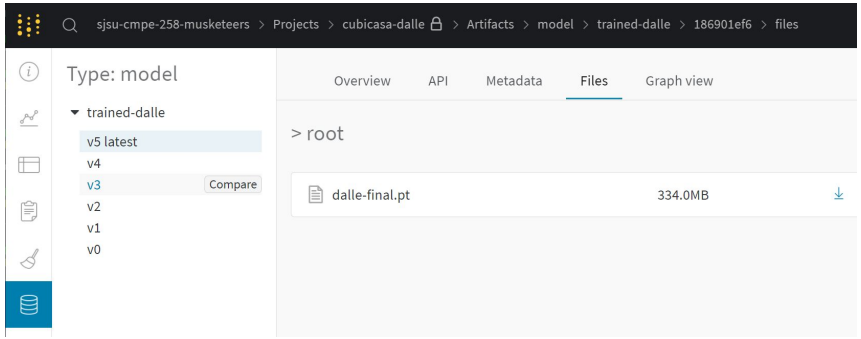


MLOps - WandB

Model Tracking/Logging

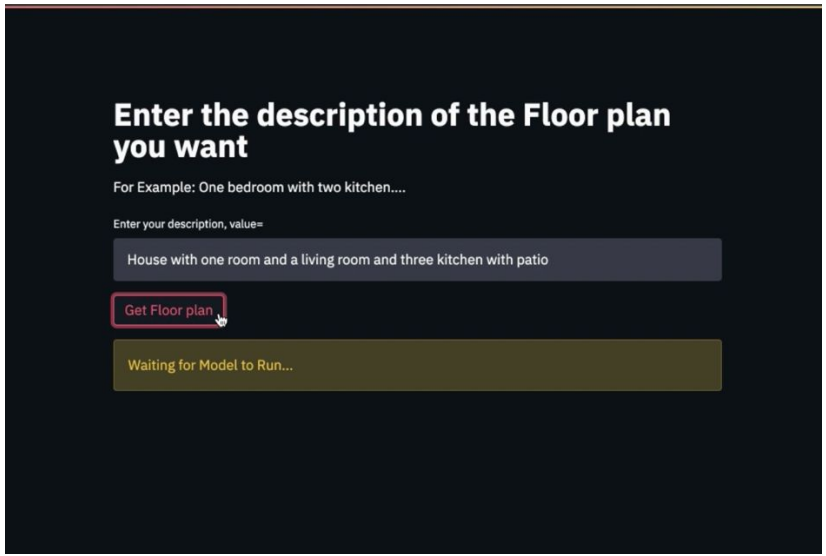


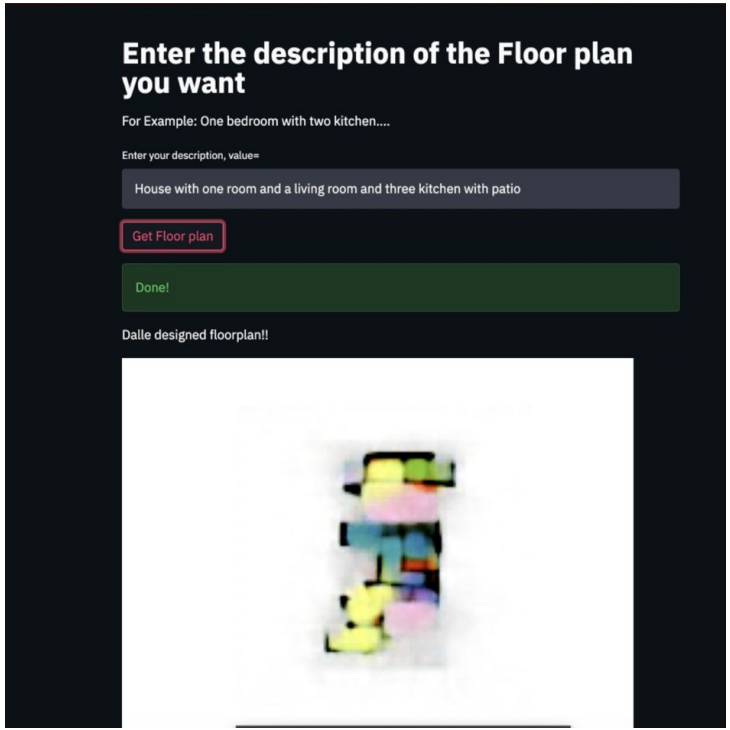
Model Versioning/Repository



Demo in Streamlit

The inference can be viewed on providing text description of floor plan like below and get the annotated floor plan image as result





Technical Difficulty

- Difficulty parsing original noisy SVGs to generate sentences
- Difficulty coloring in vector graphics for custom colored image
- Experimented with StackGAN, but ran into many problems with it
- Finding appropriate problem scope
  - *changed our dataset from original larger scope*
  - *restricted type of images to single story homes*
- RAM/memory usage
  - *paying for Colab Pro helped*

Lesson Learnt

- Generative tasks require a lot of data and computing resources
- We needed to keep our scope small for what type of images to generate

Teamwork

- Slack was used as the medium of communication across the team.
- We followed agile methodology for project management and its execution. We met as a team every wednesday at 9PM.
- The version control system used was git and the project was pushed to GitHub to be stored.
- Team communication played an important role in development of the project.

Code and Version Control

Packages : dalle-pytorch, pytorch, matplotlib, wandb, PIL, streamlit
Input : housing floor plan images, floorplan text description
Output : generated floor plan image from given text description
DL Model : Variational autoencoders (VAE), DALL-E

Tools Used : Google Colab Pro, Weights and Biases (WandB)
Google Colab : Floor Plan Generation Training
Version Ctrl : GitHub

MLOps: Weights and Biases (WandB)

Q & A

Thank You