Text to image

- 60-90 min: Non-technical
  - Try out different models
  - Prompting
  - Bias, limitations and controversy
- 150-180 min: Understand how some of the models work behind the scenes
  - Diffusion
    - Conditioned models
  - Stable Diffusion
    - CLIP
    - U-Net
  - Textual Inversion
  - InstructPix2Pix

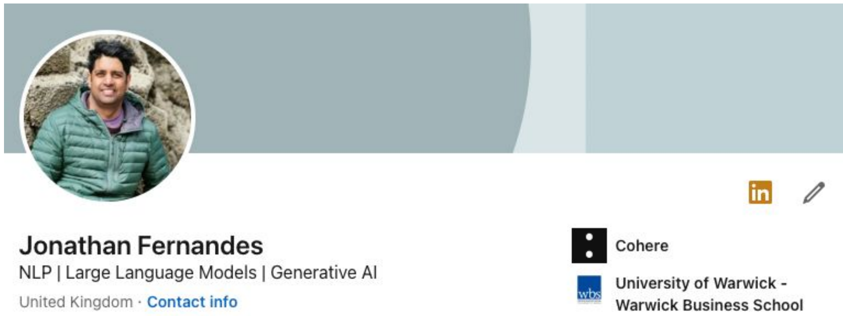
Live Course

Fundamentals of Large Language Models: A hands-on approach

With Jonathan Fernandes

5pm BST May 31

Next iteration of this course will include the latest AI generation



What is diffusion?

Text to image - try it out (Colab notebook)

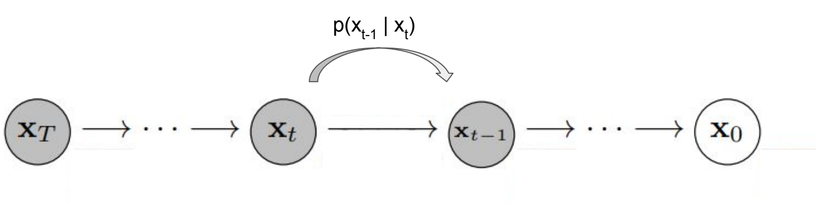
- Start with pipeline. Show the components of the pipeline like Edan Meyer
- 2015 paper chap from STanford (images with gas is very nice)
- Using words only to edit your video. You don't need to have graphic editing skills.
- You can imagine a movie / ad and have it come out. Human creativity at a new level.
- Diffusion process is agnostic (audio, video). Anything that you can add noise to will work.
- Lady Gaga lyrics in the style of Iron Maiden.
- Video / 3-D.
- Human movement - text conditioned. SOmeone picking up a box.

What is diffusion?

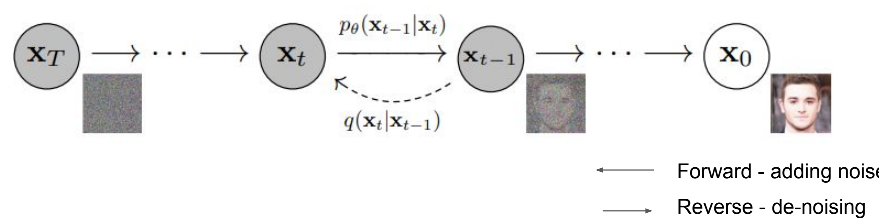
What if we could reverse this process?

Markov chains

A Markov chain is a mathematical system that experiences transitions from one state to another according to certain probabilistic rules. The probability of transitioning to any particular state is dependent solely on the current state and time elapsed.



Diffusion model



Source: Denoising Diffusion Probabilistic Models (Ho et al)

3 key components

- Pipelines - high-level wrappers that make it easy to use the functions.

3 key components

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- Models - UNet

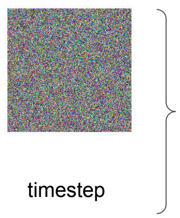
3 key components

- Pipelines - high-level wrappers that make it easy to use the functions.
- Models - UNet

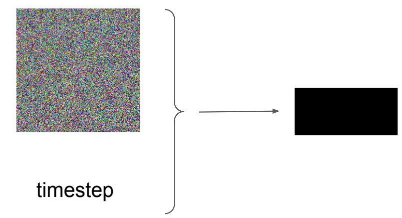
- Schedulers - the method for iteratively adding noise to an image
  - Why different schedulers?

Colab notebook - diffusion

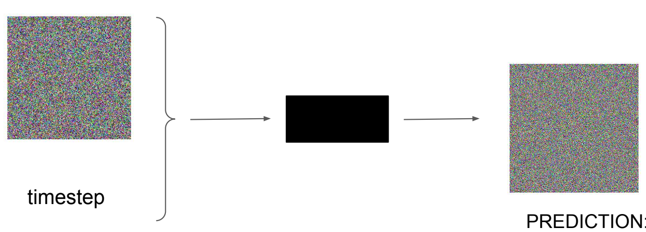
Diffusion models (inference)



Diffusion models (inference)



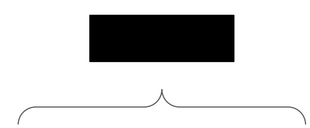
Diffusion models (inference)



PREDICTION:

- Slightly less noisy image OR
- Difference between slightly less noisy image and input image OR
- …

Diffusion models (inference)



UNet2DModel

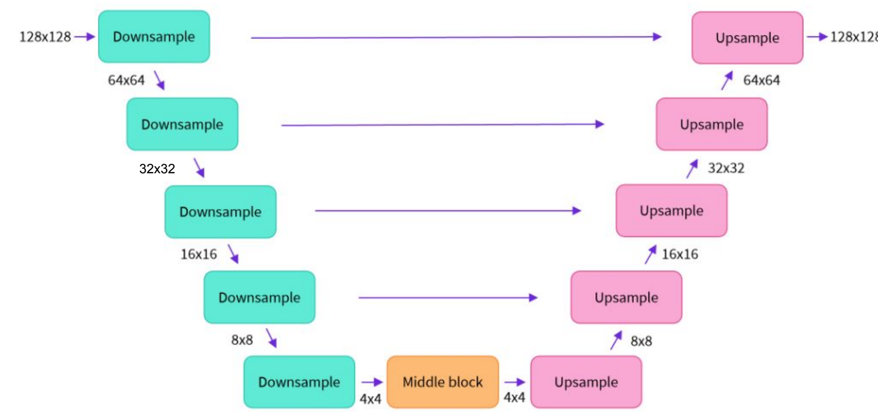
- Trainable weights

Scheduler

- No Trainable weights
- Contain step() methods to compute slightly less noisy image

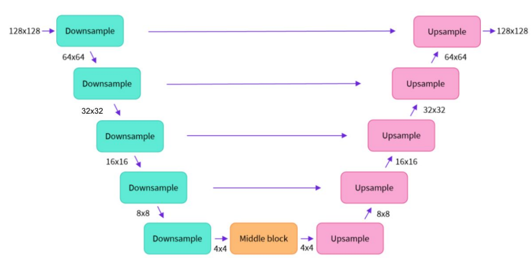
U-Net model

U-Net model



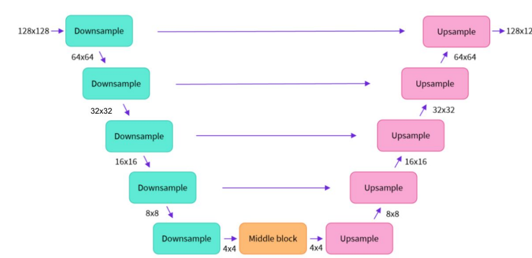
U-Net

- Predicts images of the same size as the input



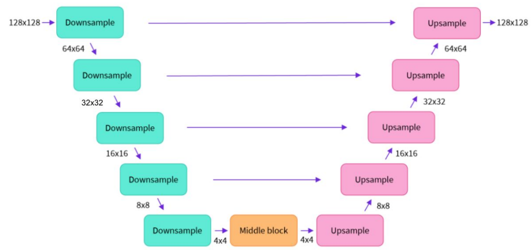
U-Net

- Predicts images of the same size as the input
- Has the same number of downsample blocks as upsample blocks



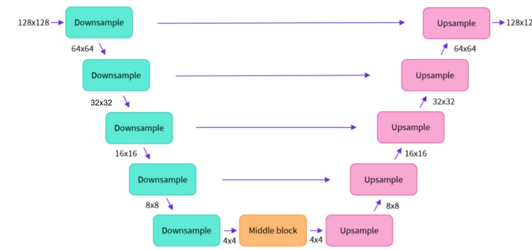
U-Net

- Predicts images of the same size as the input
- Has the same number of downsample blocks as upsample blocks
- Downsample and Upsample are several blocks of ResNet layers



U-Net

- Predicts images of the same size as the input
- Has the same number of downsample blocks as upsample blocks
- Downsample and Upsample are several blocks of ResNet layers
- Downsample - halve the image sizes
- Upsample - double the image sizes



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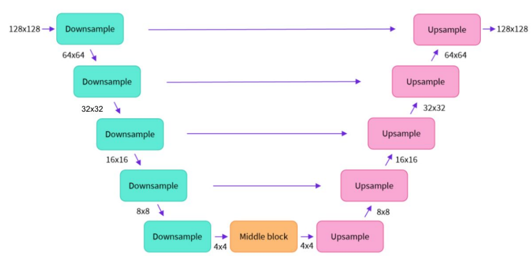
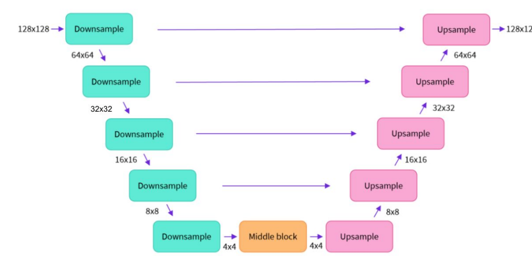


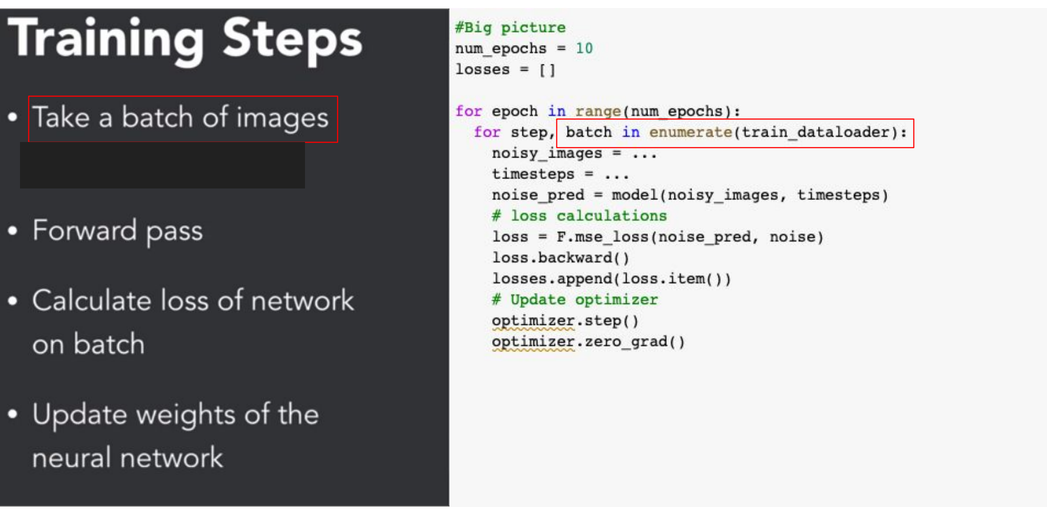
U-Net

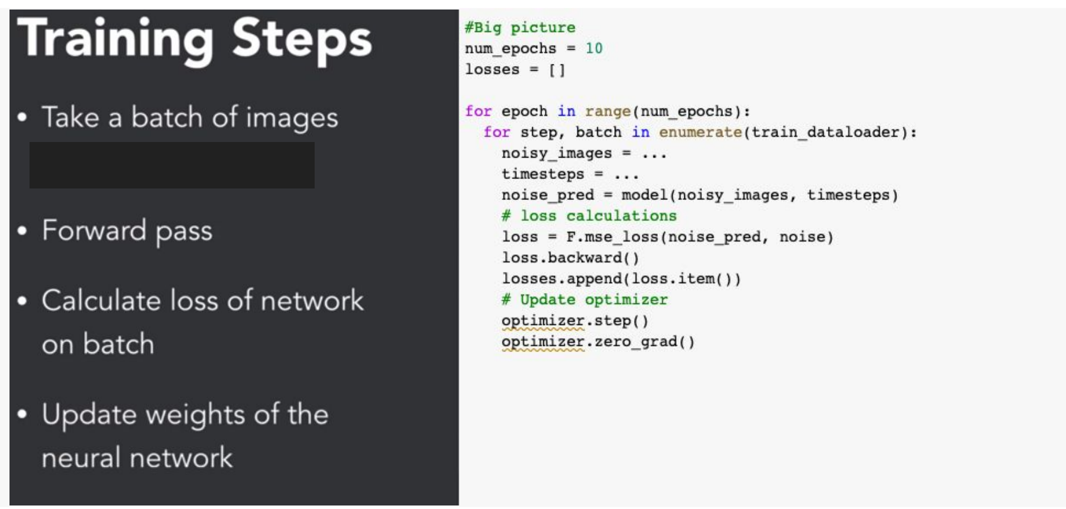
- Predicts images of the same size as the input
- Has the same number of downsample blocks as upsample blocks
- Downsample and Upsample are several blocks of ResNet layers
- Downsample - halve the image sizes
- Upsample - double the image sizes
- Skip connects - connect downsample to corresponding upsample
- What is the purpose of the “middle block”?
- What is the purpose of skip connections?

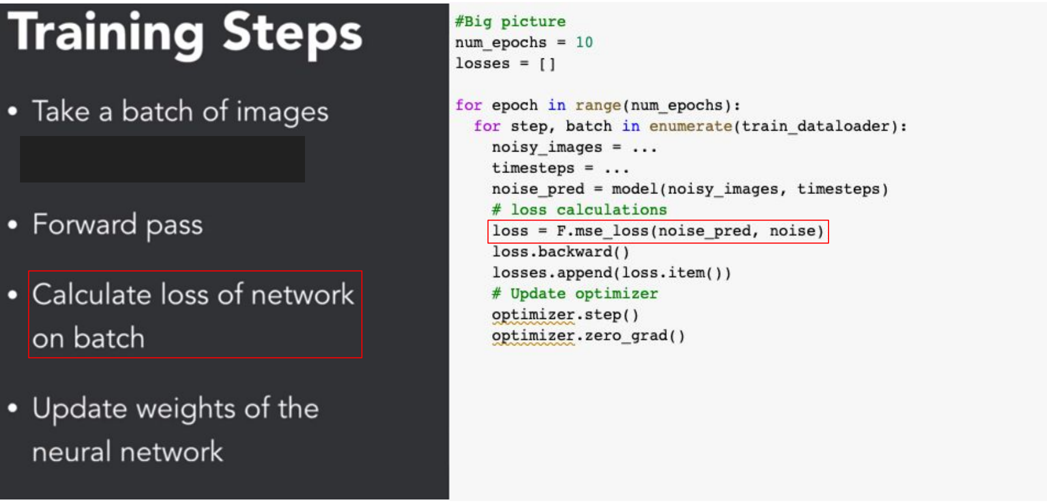


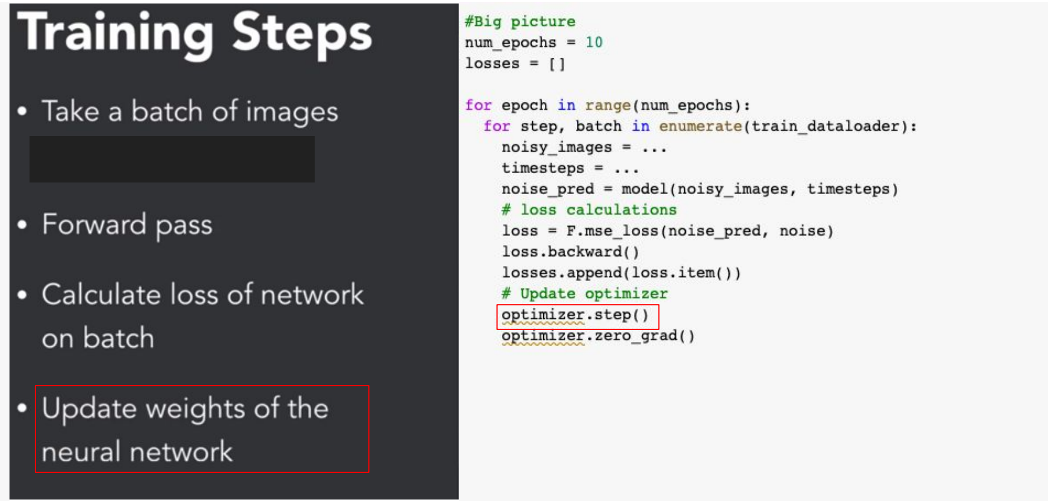
Go to colab

Train a model









Training a diffusion model

Load a batch of training images

Training a diffusion model

Load a batch of training images

Add a random amount of noise

Training a diffusion model

Load a batch of training images

Add a random amount of noise

Input to model : noisy version of inputs

Training a diffusion model

Load a batch of training images

Add a random amount of noise

Input to model : noisy version of inputs

Use the loss to determine how well the model does at de-noising the inputs

Training a diffusion model

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Use the loss to determine how well the model does at de-noising the inputs

Update the model weights

Training a diffusion model

Load a batch of training images

Add a random amount of noise

Input to model : noisy version of inputs

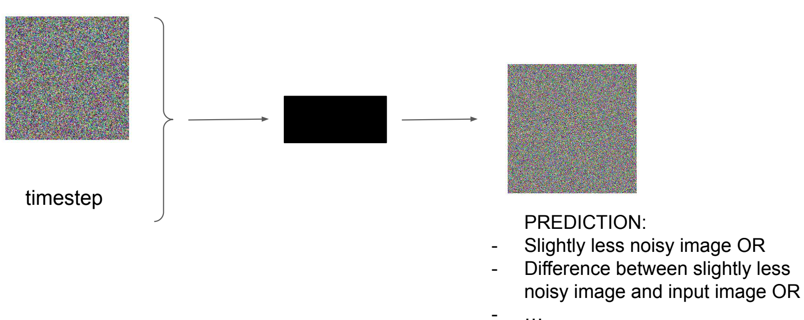
Use the loss to determine how well the model does at de-noising the inputs

Update the model weights

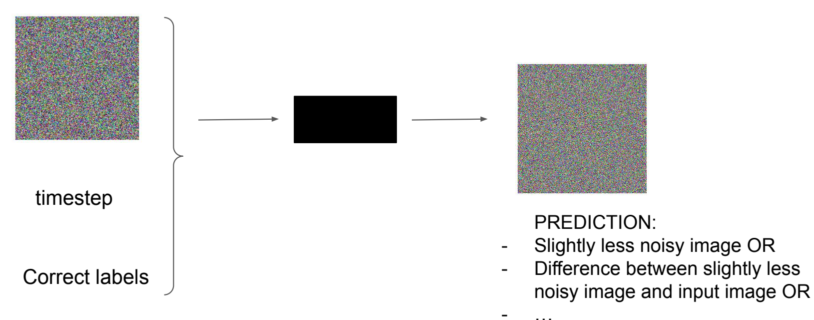
Train a model (colab notebook)

Conditioned models

Diffusion models (training)

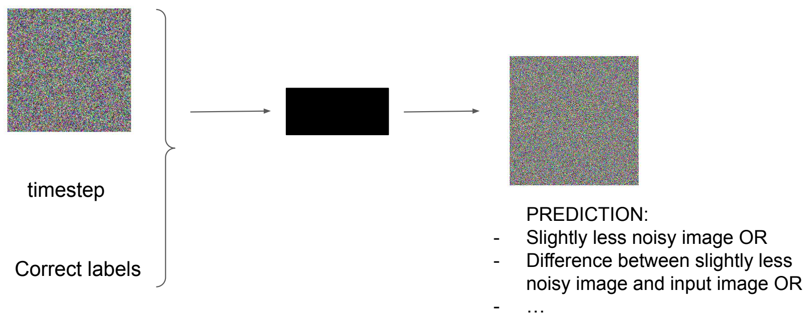


Conditioned Diffusion models (training)



Conditioned Diffusion models (inference)

Inference: We pass the labels we want and the model should generate images that match.



Conditioned models

- Add additional channels in the input to the Unet
- Add cross-attention layers that can attend to a sequence passed.
    - Conditioning is text
    - Stable Diffusion uses this

Add additional channels in the input to the Unet

- UNet2DModel with additional input channels

Add additional channels in the input to the Unet

- UNet2DModel with additional input channels
- Map class labels (expected output == conditioned) to a learned vector e.g. an embedding layer

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- Submit this as input to UNet2DModel as before, with timestep.

Conditioned models - adding additional channels (colab notebook)

Add additional channels in the input to the Unet

- UNet2DModel with additional input channels
- Map class labels to a learned vector (embedding layer)
- Add this information as extra channels for the Unet input
- Submit this as input to UNet2DModel as before, with timestep.

REVIEW: This is what we have done in the notebook

Stable Diffusion

What makes this different to other text to image solutions?

- DALL-E
- DALLE-2
- Imagen

Can run on commodity hardware

Model and training details

Model

Text encoder - CLIP ViT-L/14

UNet = 860M parameter model

Autoencoder - downsampling factor of 8.

The model was pretrained on 256x256 images and then finetuned on 512x512 images.

Training time

- Hardware Type: A100 PCIe 40GB
- Hours used: 150000

Training data

The core dataset was trained on LAION-Aesthetics, a soon to be released subset of LAION 5B.

LAION-Aesthetics was created with a new CLIP-based model that filtered LAION-5B based on how “beautiful” an image was, building on ratings from the alpha testers of Stable Diffusion.

Cost

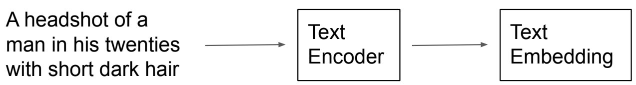
Controversy

- Image regurgitation
- Copying artist styles
  - Getty Images
  - Shutterstock

Applications

https://www.reddit.com/r/StableDiffusion/comments/wyduk1/show_rstablediffusion_integrating_sd_in_photoshop/

What components do we need?



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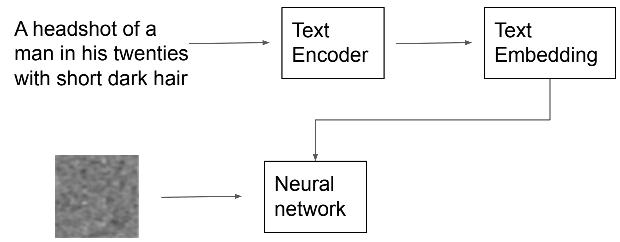

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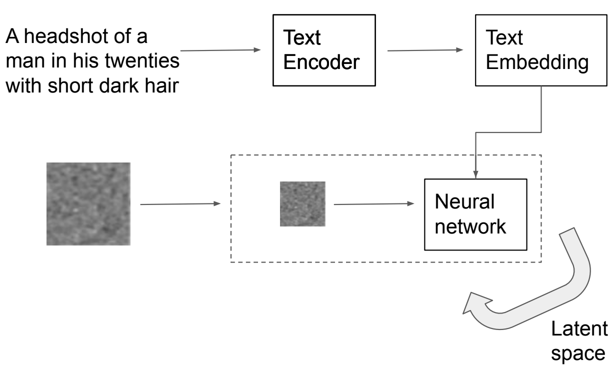

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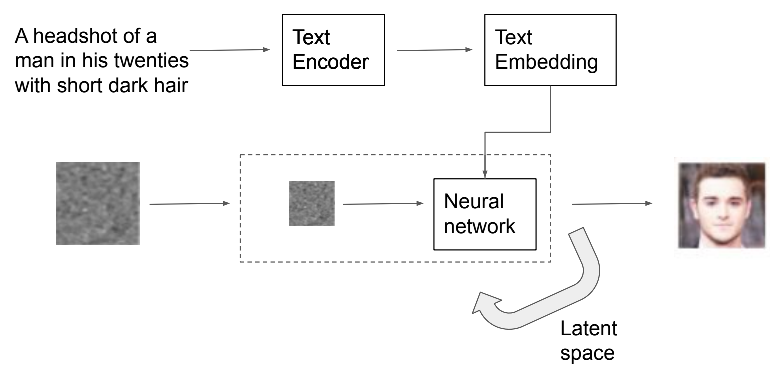


The key difference between latent and standard diffusion is that latent diffusion model is trained to generate latent (compressed) representations of the images

What 3 components do we need for latent diffusion?

- A text encoder (CLIP's Text Encoder)

What 3 components do we need for latent diffusion?

- A text encoder - CLIP's Text Encoder
- Neural network - UNet

U-Net

+ Time encoding

U-Net

+ Time encoding + Text encoding = Conditioned Image

What 3 components do we need for stable diffusion?

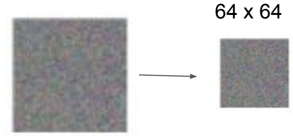
- A text encoder - CLIP's Text Encoder
- Neural network - UNet
- Autoencoder

Autoencoder

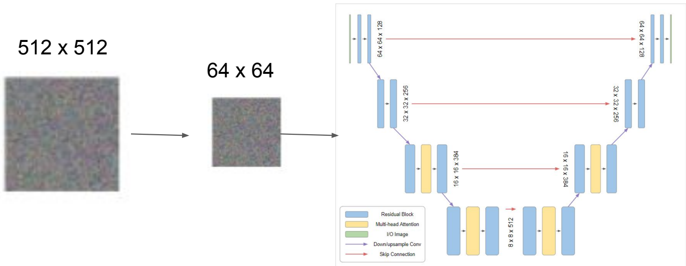
Autoencoder

512 x 512

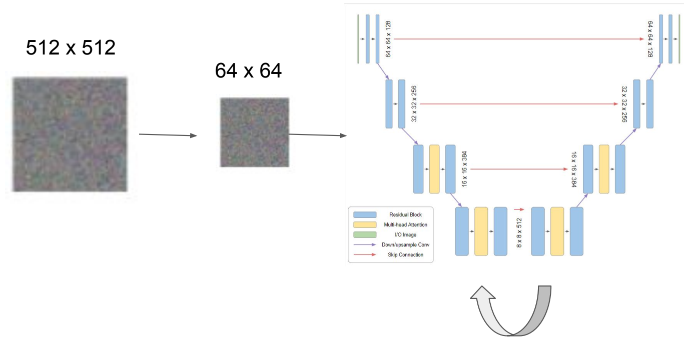
64 x 64



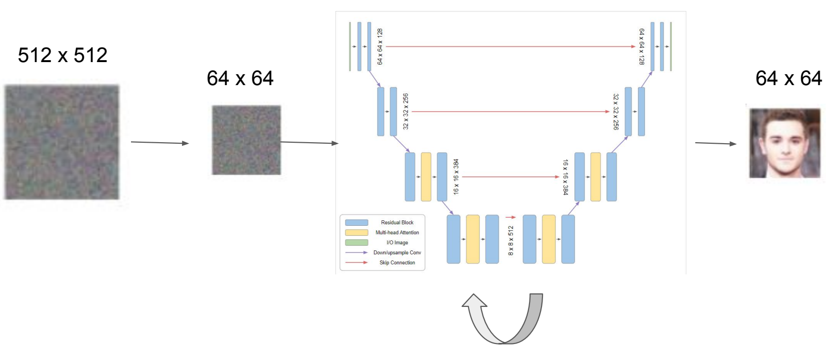
Autoencoder



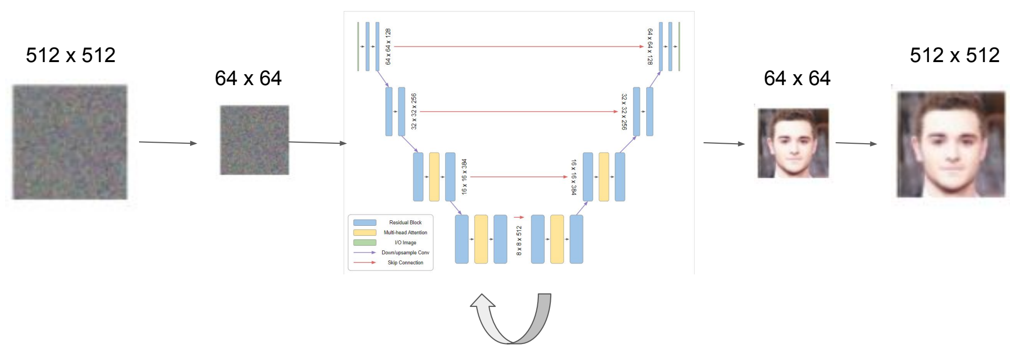
Autoencoder



Autoencoder



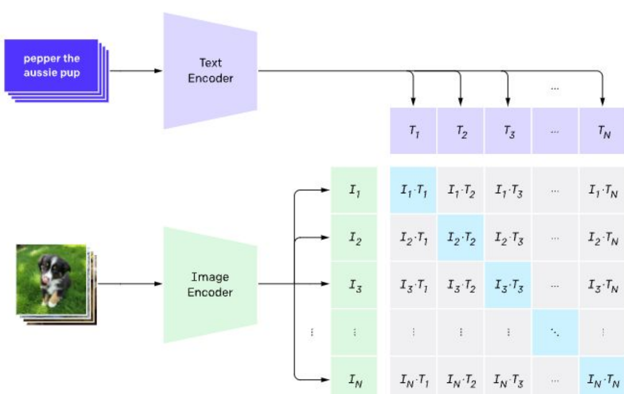
Autoencoder



Colab notebook - autoencoder

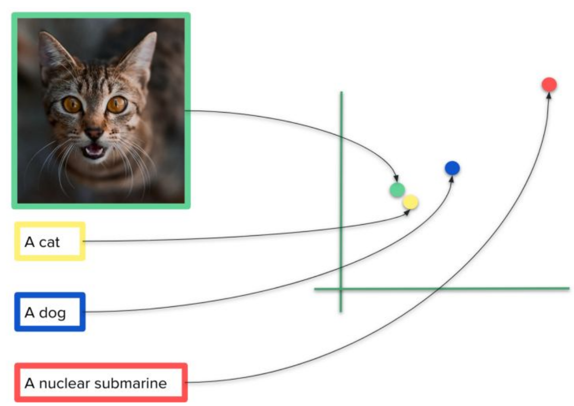
Text encoder - CLIP

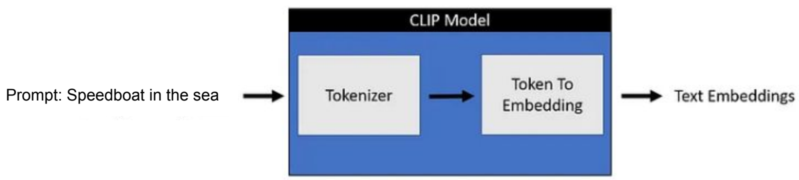
CLIP - Contrastive pre-training



Source: https://openai.com/blog/clip/

CLIP



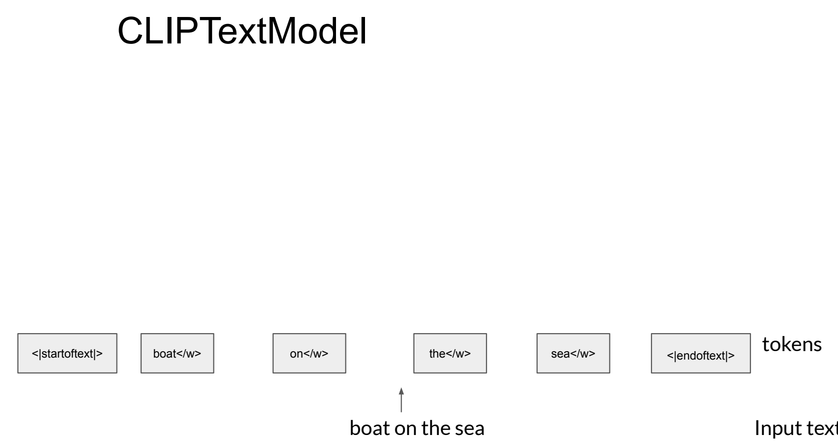


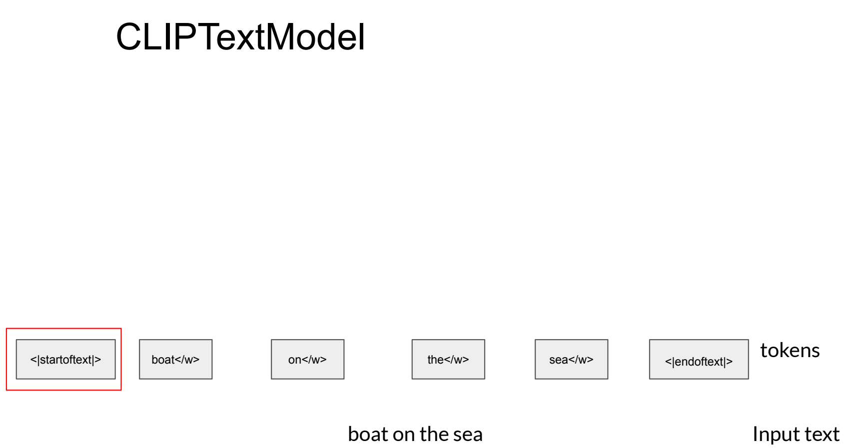
Colab - CLIP Model

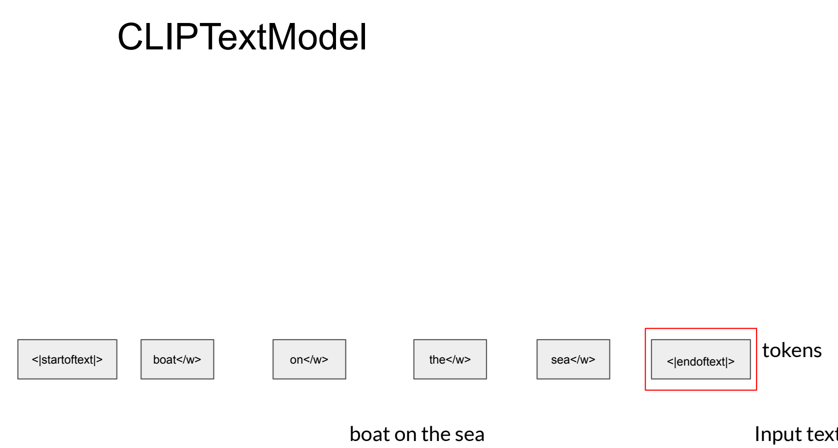
Colab - tokenizers

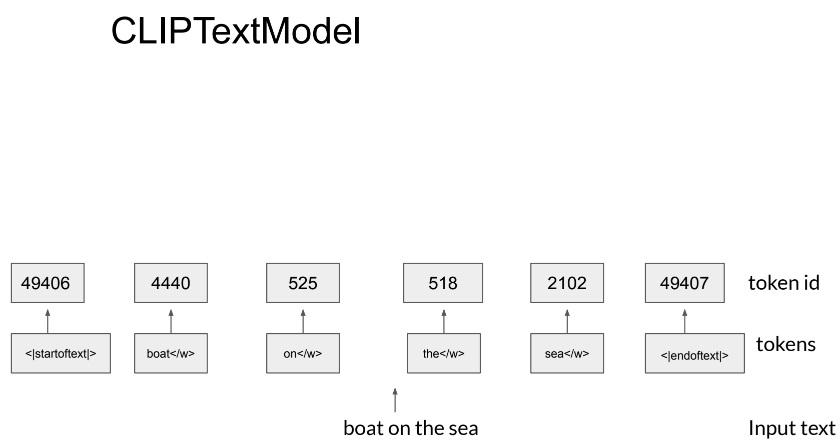
Text encoders

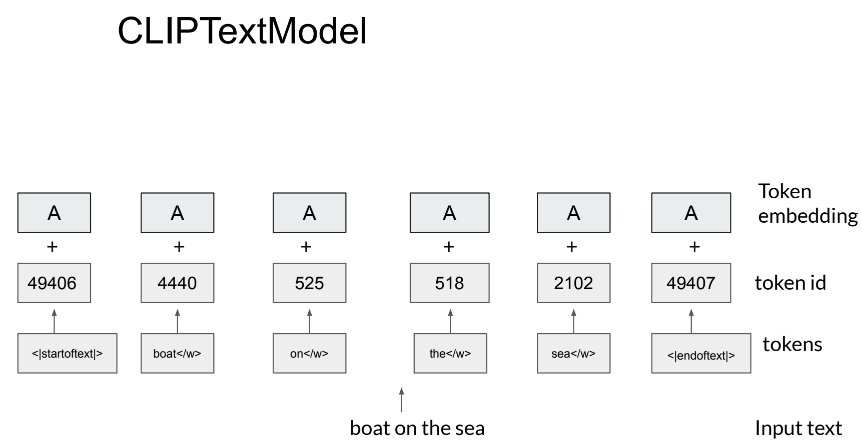
boat on the sea








CLIPTextModel
49406
4440
525
518
2102
49407
token id
<|startoftext|>
boat</w>
on</w>
the</w>
sea</w>
<|endoftext|>
tokens
boat on the sea
Input text


CLIPTextModel
A
Token embedding
49406
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boat</w>
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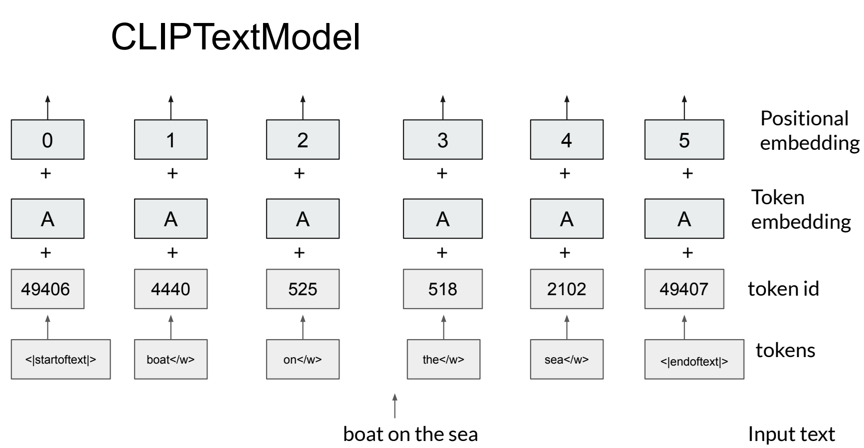
CLIPTextModel
0
1
2
3
4
5
Positional embedding
A
Token embedding
49406
4440
525
518
2102
49407
token id
<|startoftext|>
boat</w>
on</w>
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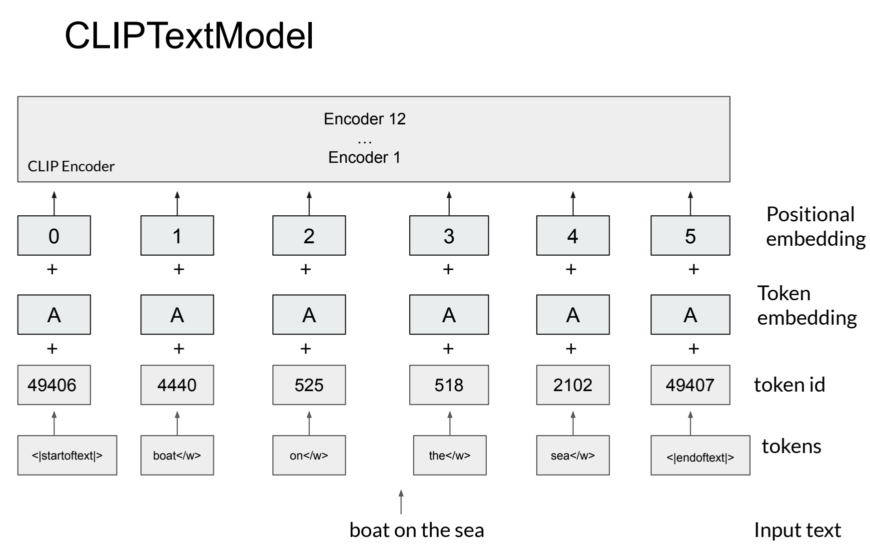
CLIPTextModel
Encoder 12
...
Encoder 1
CLIP Encoder
0
1
2
3
4
5
Positional embedding
A
Token embedding
49406
4440
525
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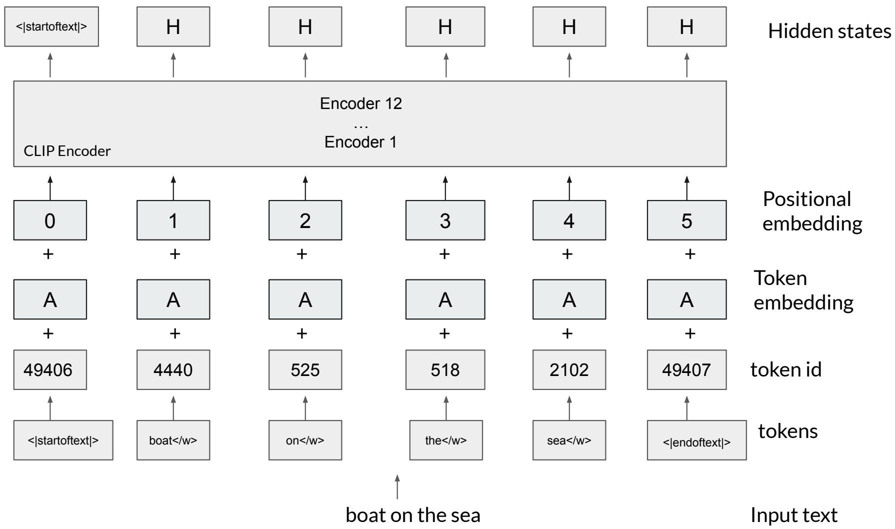
CLIPTextModel

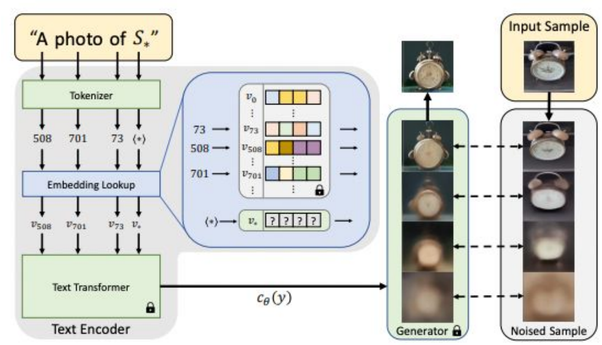


Colab - text encoders

Textual Inversion

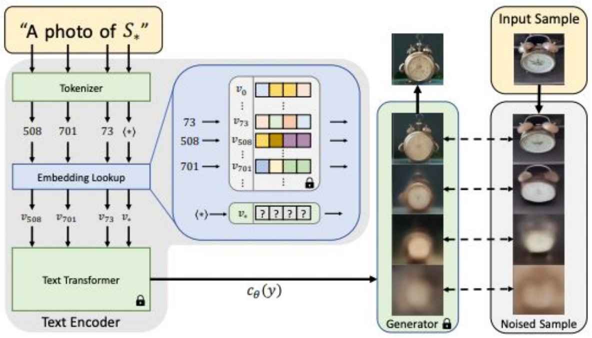
Textual Inversion

- Capture concepts from a small number of example images to control text-to-image pipelines



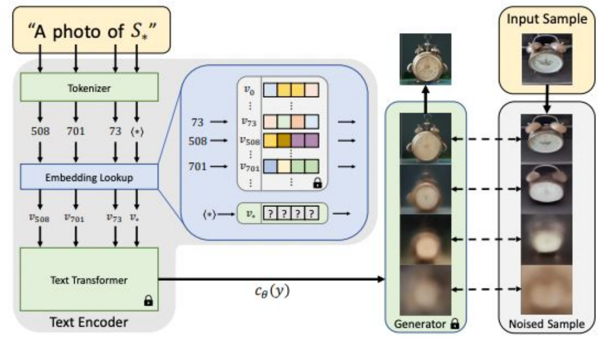
Textual Inversion

- A prompt containing the placeholder word is first converted to tokens



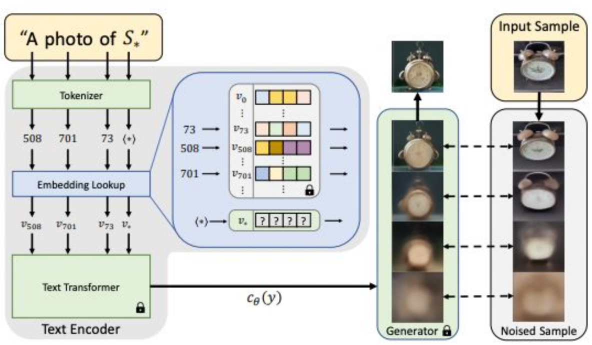
Textual Inversion

- The tokens are converted to embeddings



Textual Inversion

- Finally, the embedding vectors are transformed into a single conditioning code cθ(y) which guides the generative model.



InstructPix2Pix

InstructPix2Pix

- https://huggingface.co/spaces/timbrooks/instruct-pix2pix
-

“A photograph of a girl riding a horse”

“A photograph of a girl riding a dragon”

Different images generated

With Prompt-to-Prompt
"A photograph of a girl riding a horse"

With Prompt-to-Prompt
"A photograph of a girl riding a dragon"

Training Data Generation

Training Data Generation

	Input LAION caption	Edit instruction	Edited caption
Human-written (700 edits)	*Yefim Volkov, Misty Morning*	*make it afternoon*	*Yefim Volkov, Misty Afternoon*
	girl with horse at sunset	*change the background to a city*	*girl with horse at sunset in front of city*
	painting-of-forest-and-pond	*Without the water.*	*painting-of-forest*
	...	...	...

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	painting-of-forest-and-pond	*Without the water.*	*painting-of-forest*
	...	...	...

Fine-tune GPT-3 to generate a large dataset of text triplets

Training Data Generation

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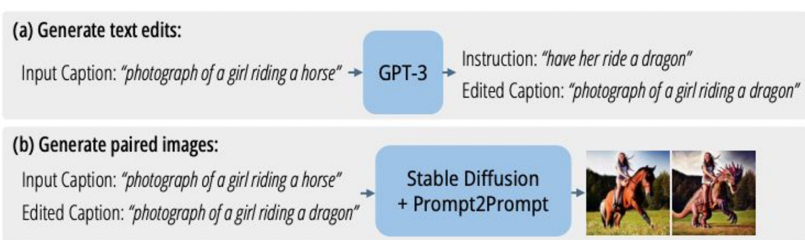
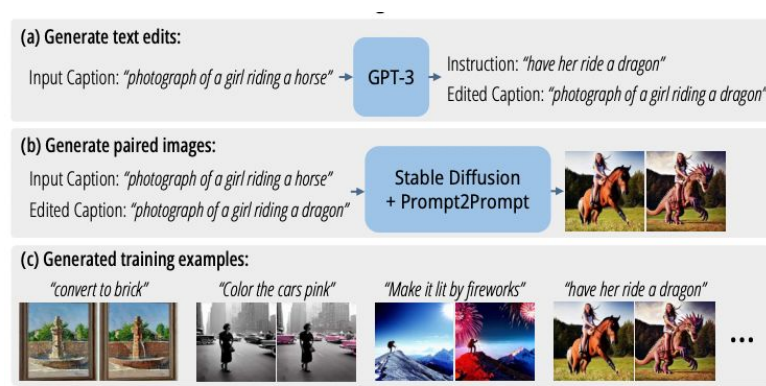
	girl with horse at sunset	*change the background to a city*	*girl with horse at sunset in front of city*
	painting-of-forest-and-pond	*Without the water.*	*painting-of-forest*
	...	...	...
GPT-3 generated (>450,000 edits)	*Alex Hill, Original oil painting on canvas, Moonlight Bay*	*in the style of a coloring book*	*Alex Hill, Original coloring book illustration, Moonlight Bay*
	The great elf city of Rivendell, sitting atop a waterfall as cascades of water spill around it	*Add a giant red dragon*	*The great elf city of Rivendell, sitting atop a waterfall as cascades of water spill around it with a giant red dragon flying overhead*
	Kate Hudson arriving at the Golden Globes 2015	*make her look like a zombie*	*Zombie Kate Hudson arriving at the Golden Globes 2015*
	...	...	...

Training Data Generation



Training Data Generation



What have we looked at?

- Non-technical
  - Try out different models
  - Prompting
  - Bias, limitations and controversy
- 180 min: Understand how some of the models work behind the scenes
  - Diffusion
    - Conditioned models
  - CLIP
  - U-Net
  - Stable Diffusion
  - Textual Inversion
  - InstructPix2Pix

What have we looked at?

- We've tried out different models
- We've looked at prompting and prompting guides to improve
- Looked at Bias, limitations and controversy with AI generation.
- Diffusion
  - Conditioned models
- Stable Diffusion
  - CLIP
  - U-Net
- Textual Inversion
- InstructPix2Pix

Next iteration of this course will include the latest AI generation

- 60-90 min: Non-technical
  - Try out different models
  - Prompting
  - Bias, limitations and controversy
- 150-180 min: Understand how some of the models work behind the scenes
  - Diffusion
    - Conditioned models
  - Stable Diffusion
    - CLIP
    - U-Net
  - Textual Inversion
  - InstructPix2Pix

Live Course

Fundamentals of Large Language Models: A hands-on approach

With Jonathan Fernandes

5pm BST May 31

END