Special Topics: MODERN METHODS

PHYS 453

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Modern Methods

- A very brief survey of some recent hot topics in ML
- No particular order

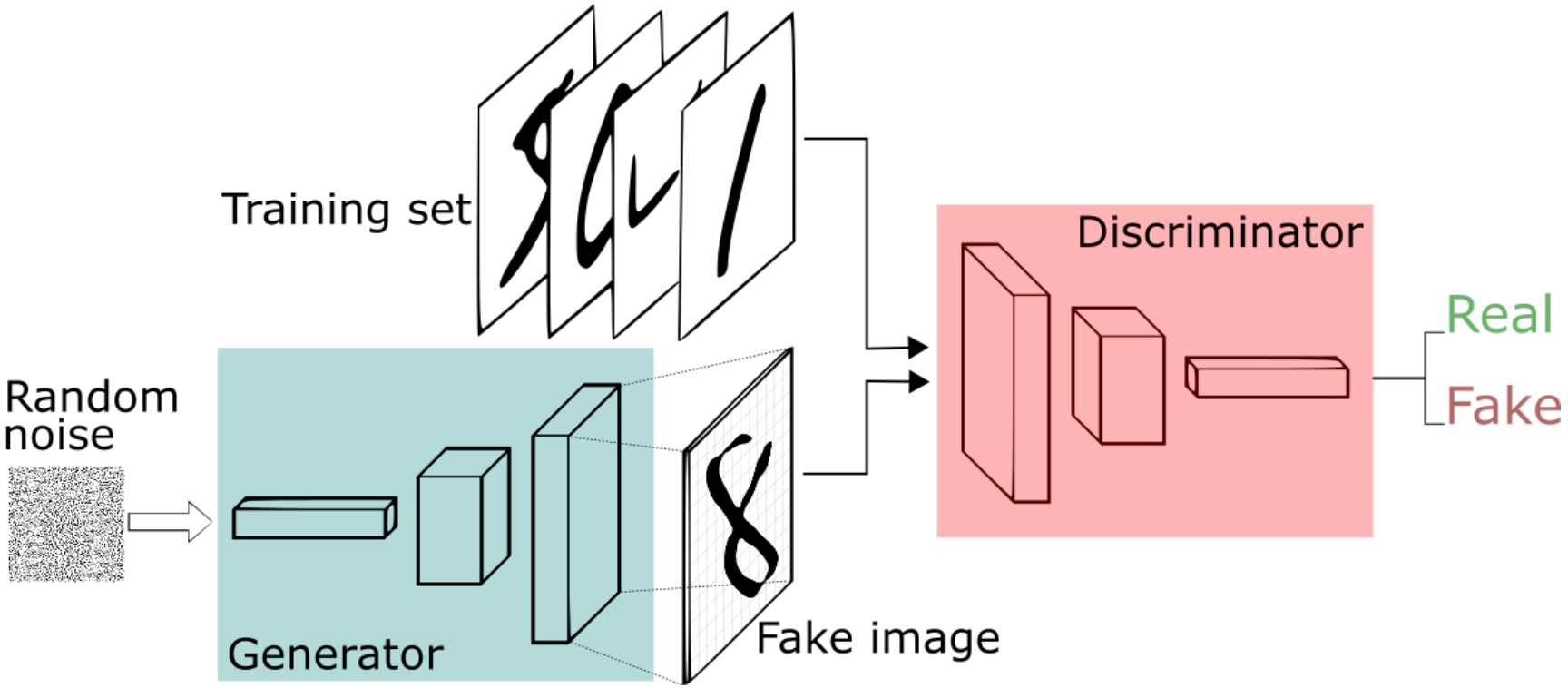
GANS

https://arxiv.org/abs/1710.10196

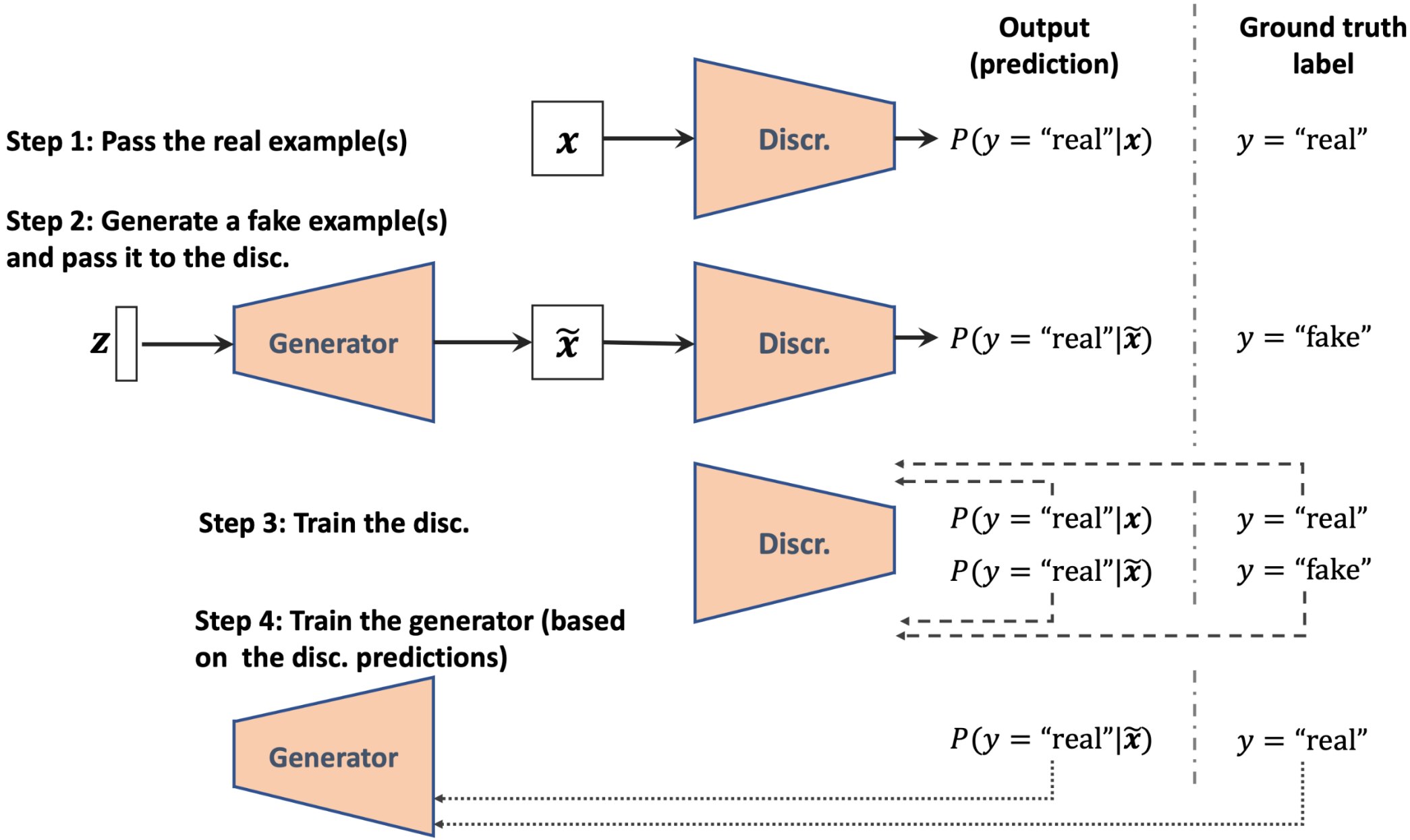
NONE OF THESE PEOPLE ARE REAL

Generative Adversarial Networks

- Very clever trick to generate realistic data
- Proposed in 2014 - https://arxiv.org/abs/1406.2661
- Create a generator and a discriminator that learn from each other and improve together



https://github.com/rasbt/machine-learning-book/blob/main/ch17/ch17_part1.ipynb



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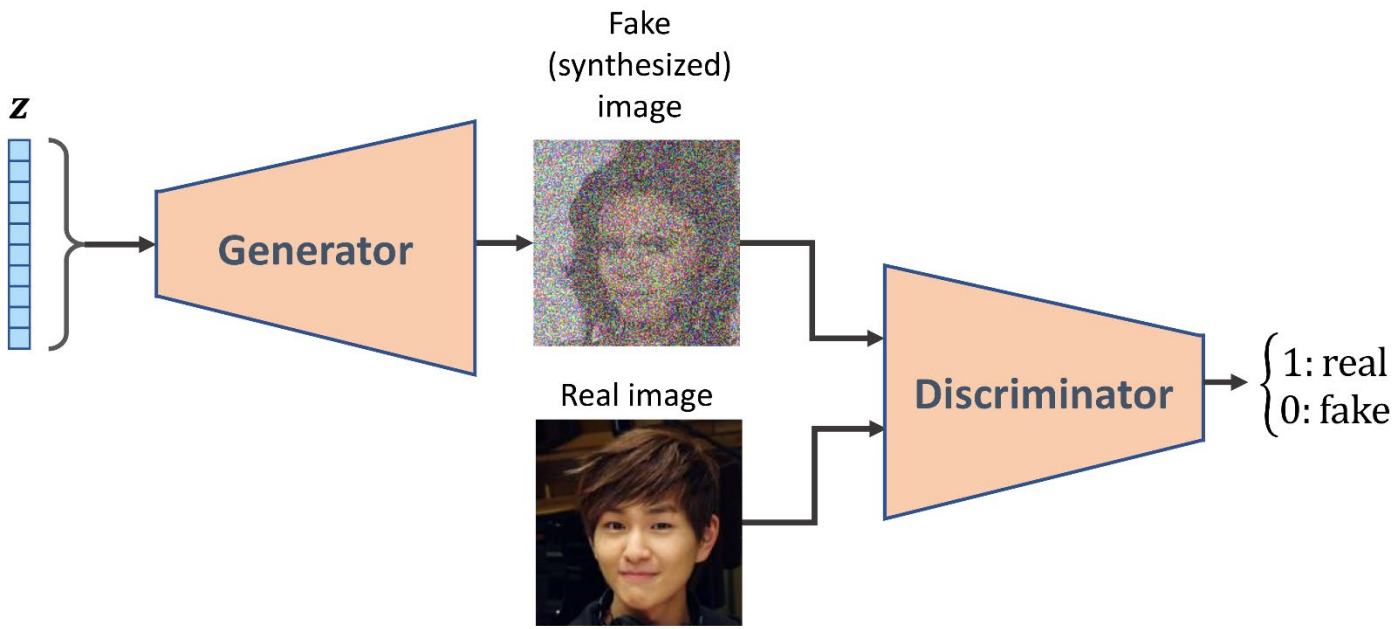
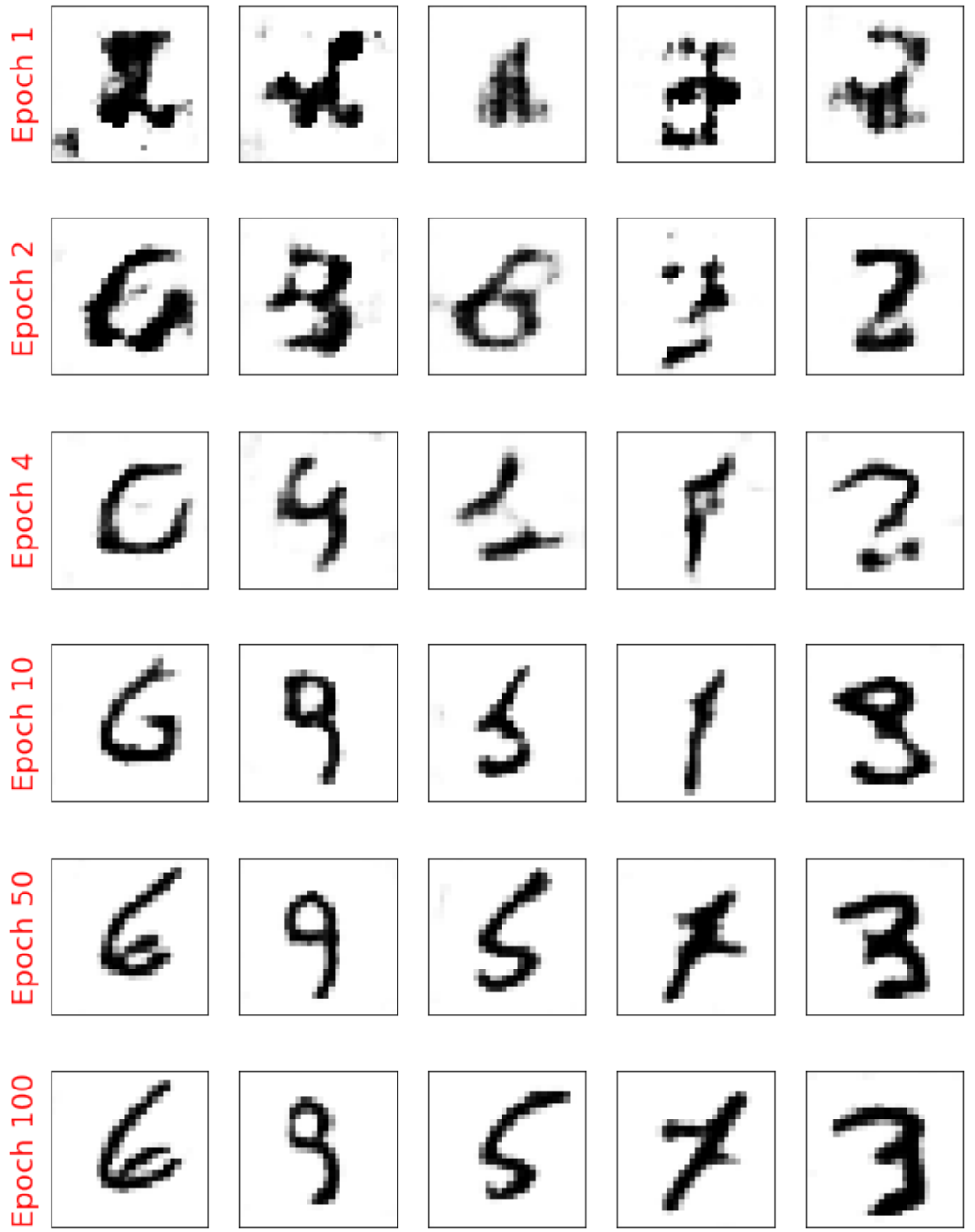




Generative Adversarial Networks

Resources

- https://arxiv.org/abs/1406.2661
- https://en.wikipedia.org/wiki/Generative_adversarial_network
- https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/
- https://github.com/rasbt/machine-learning-book/blob/main/ch17/ch17_part1.ipynb

Stable Diffusion

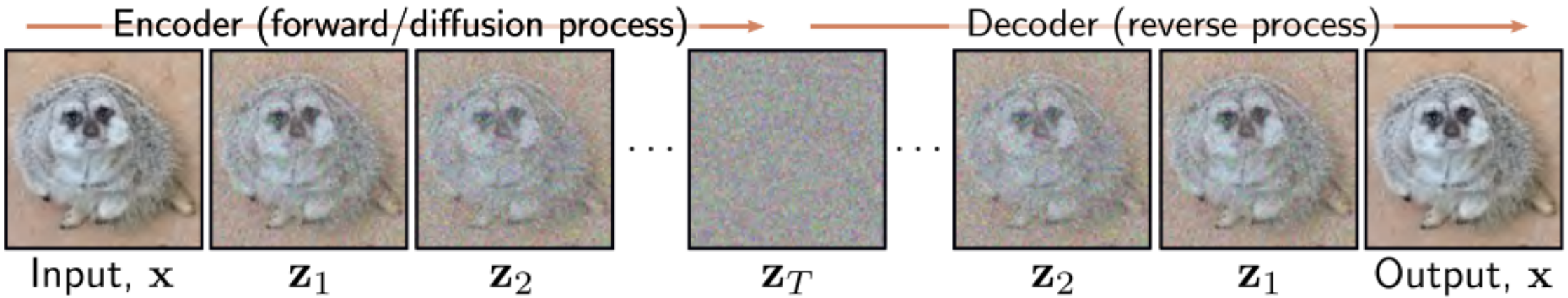


Figure 18.1 Diffusion models. The encoder (forward, or diffusion process) maps the input $\mathbf{x}$ through a series of latent variables $\mathbf{z}_1 \ldots \mathbf{z}_T$. This process is pre-specified and gradually mixes the data with noise until only noise remains. The decoder (reverse process) is learned and passes the data back through the latent variables, removing noise at each stage. After training, new examples are generated by sampling noise vectors $\mathbf{z}_T$ and passing them through the decoder.

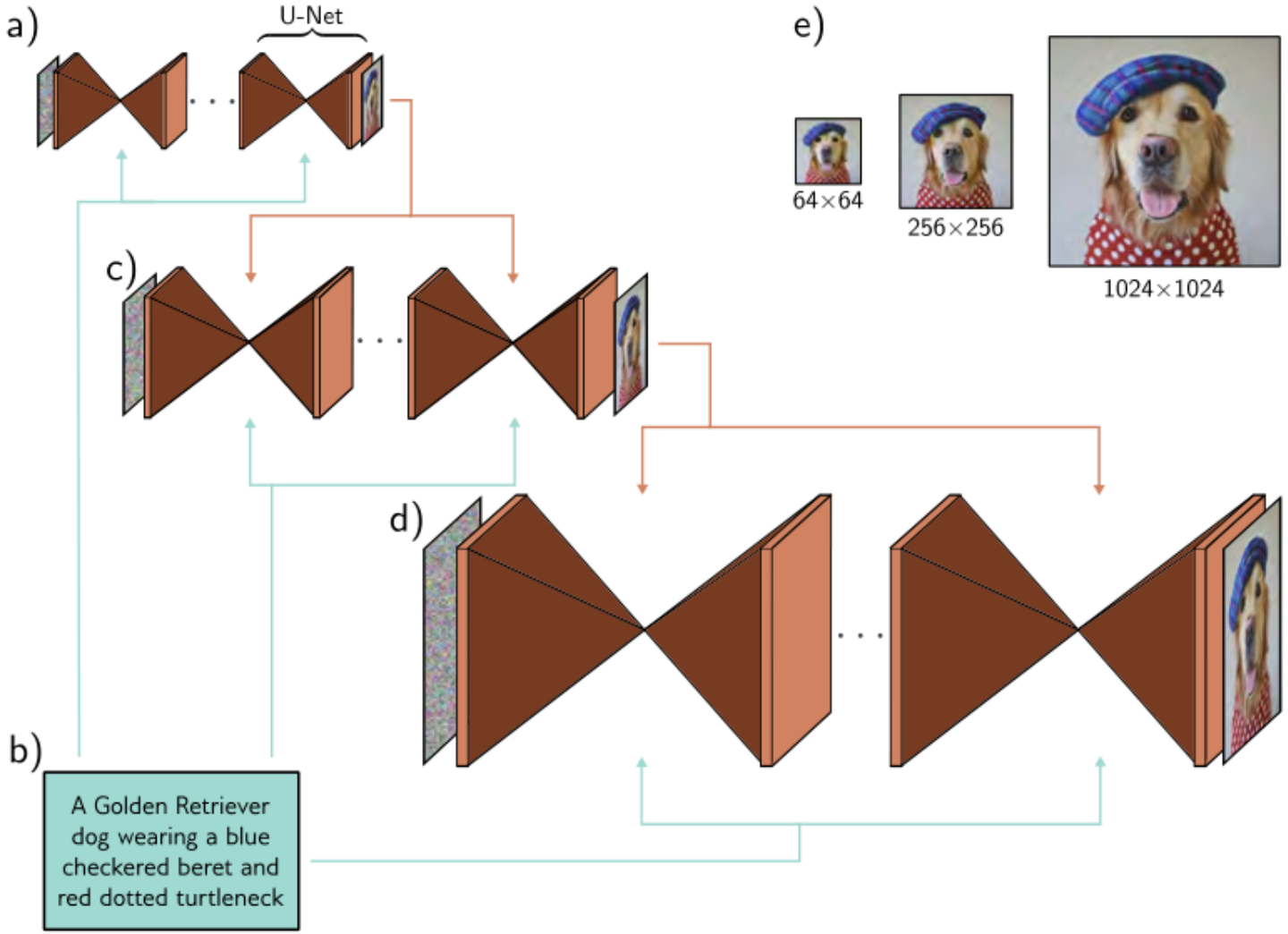


Figure 18.11 Cascaded conditional generation based on a text prompt. a) A diffusion model consisting of a series of U-Nets is used to generate a 64×64 image. b) This generation is conditioned on a sentence embedding computed by a language model. c) A higher resolution 256×256 image is generated and conditioned on the smaller image *and* the text encoding. d) This is repeated to create a 1024×1024 image. e) Final image sequence. Adapted from Saharia et al. (2022b).

DEEP NEURAL NETWORKS

https://scikit-learn.org/stable/modules/neural_networks_supervised.html

1.17. Neural network models (supervised)

Warning: This implementation is not intended for large-scale applications. In particular, scikit-learn offers no GPU support. For much faster, GPU-based implementations, as well as frameworks offering much more flexibility to build deep learning architectures, see Related Projects.

What to use instead:

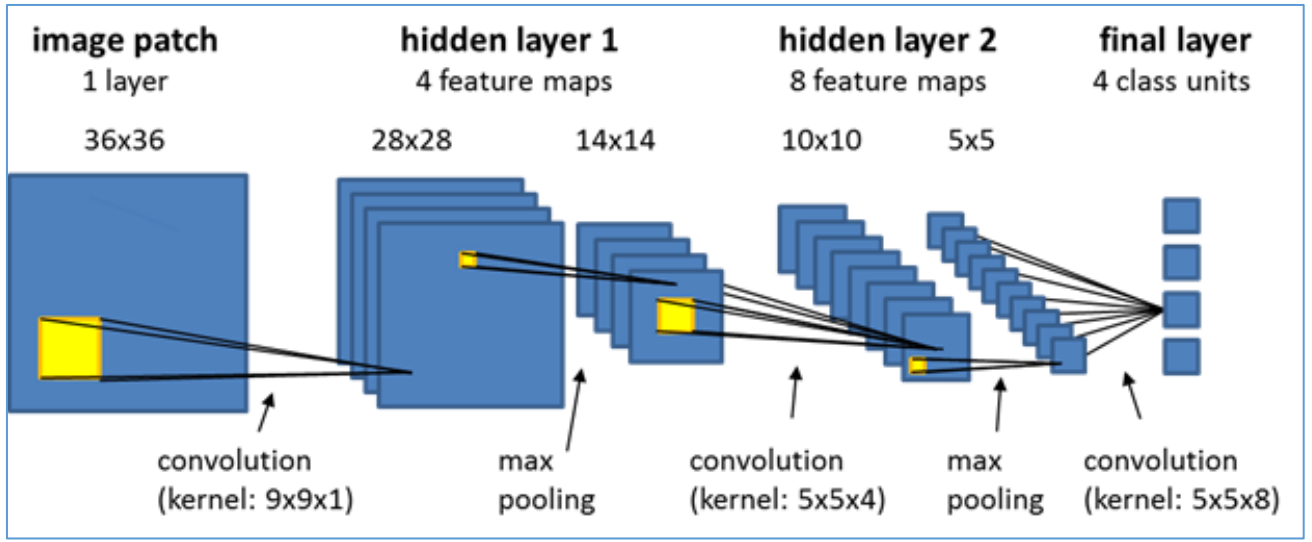
- https://pytorch.org/ optionally with https://github.com/skorch-dev/skorch
- https://www.tensorflow.org/ optionally with https://keras.io/

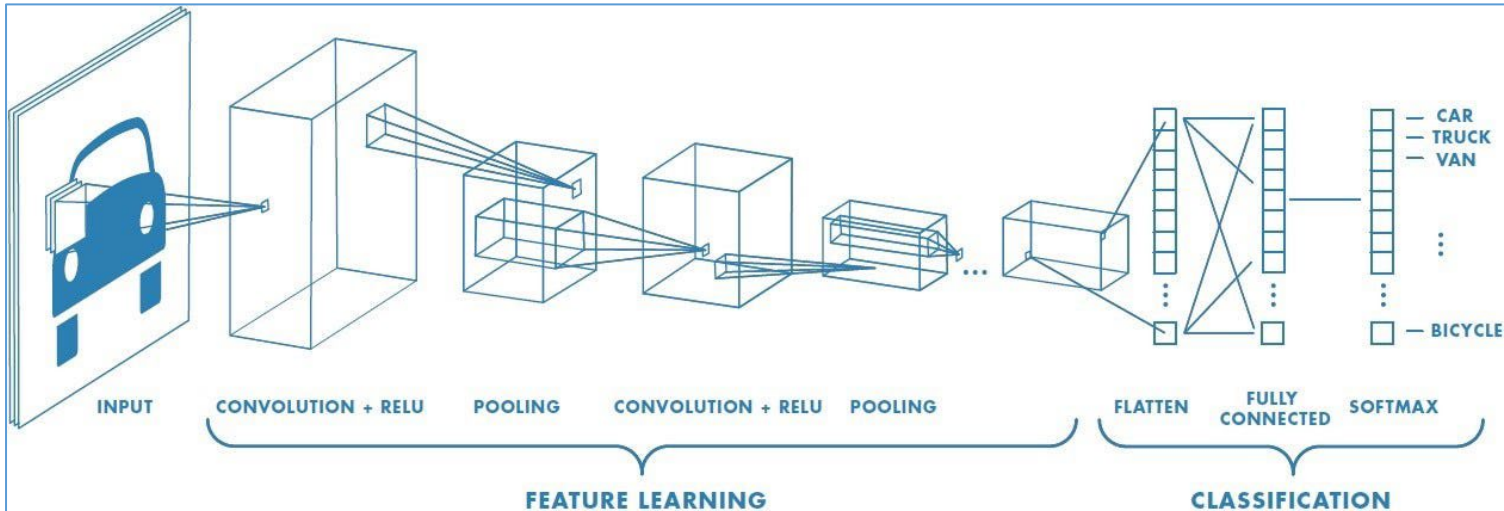
Advantages

- Designed to run on GPU farms
- Flexible deep NNs with ever-growing list of tools

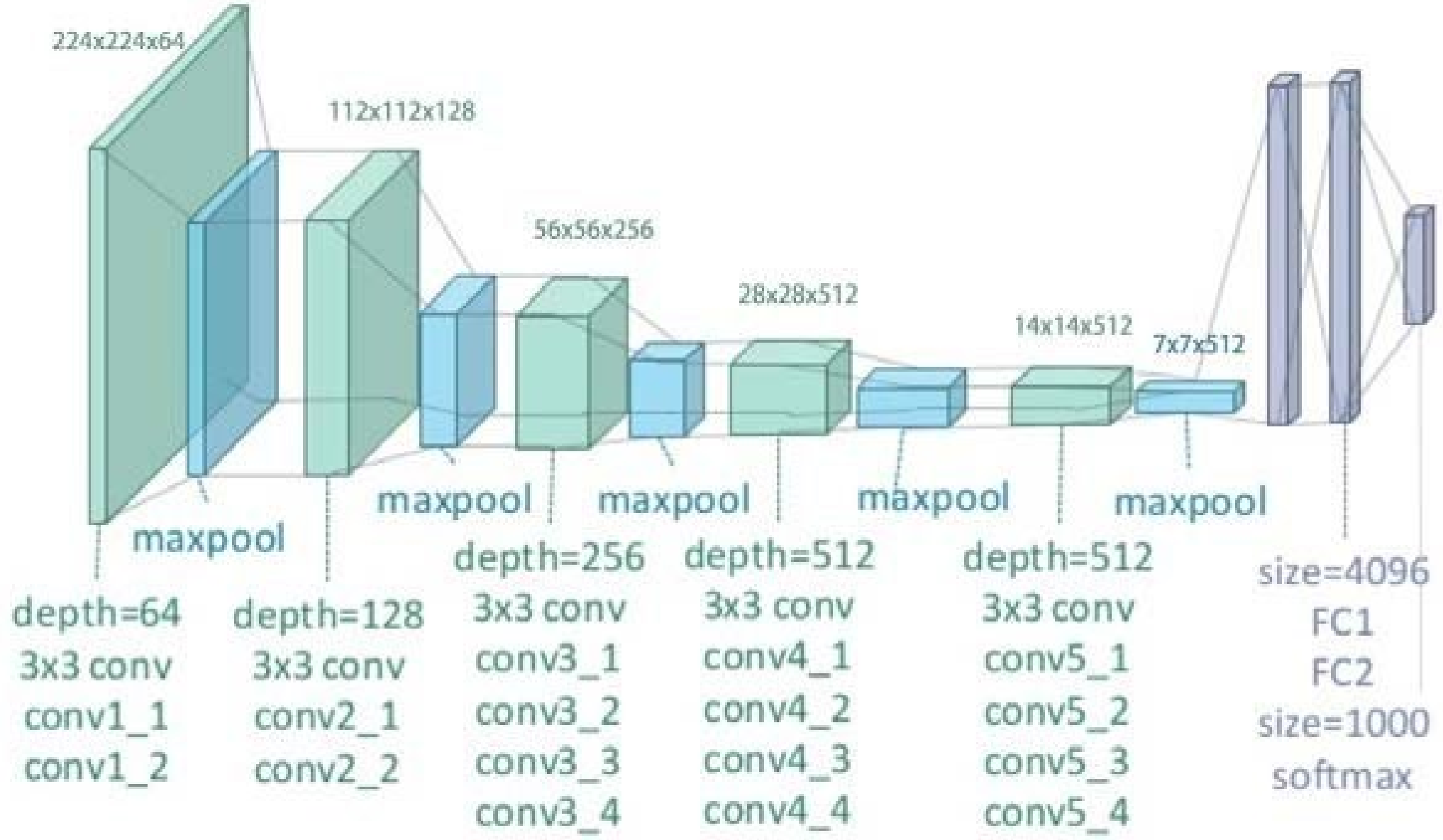
Example: CNN

- Convolution: imagine a sliding window that moves across pixels
- Main application is computer vision, need model to match symmetries of our problem. For a picture of a bird, the bird can be anywhere in the picture, so a convolution gives a direct way to handle images
- Pooling: reduce dimension by combining inputs from previous layer





https://colab.research.google.com/github/tensorflow/models/blob/master/research/nst_blogpost/4_Neural_Style_Transfer_with_Eager_Execution.ipynb



Deep Convolutional GAN

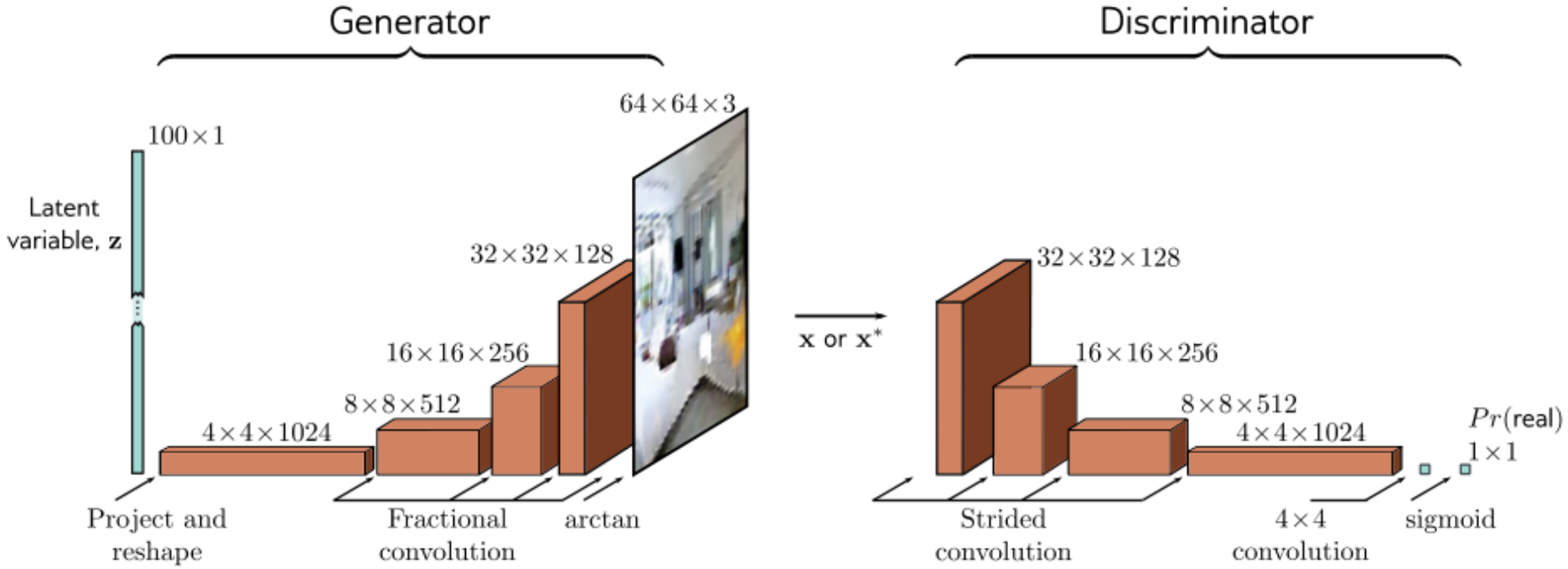
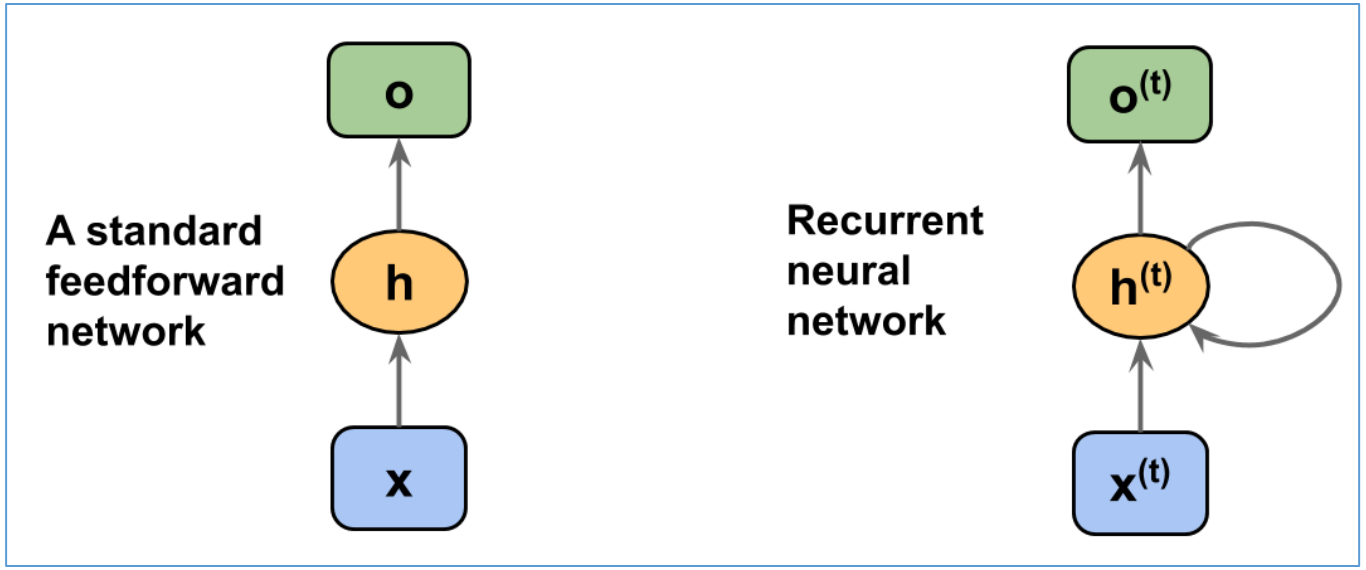
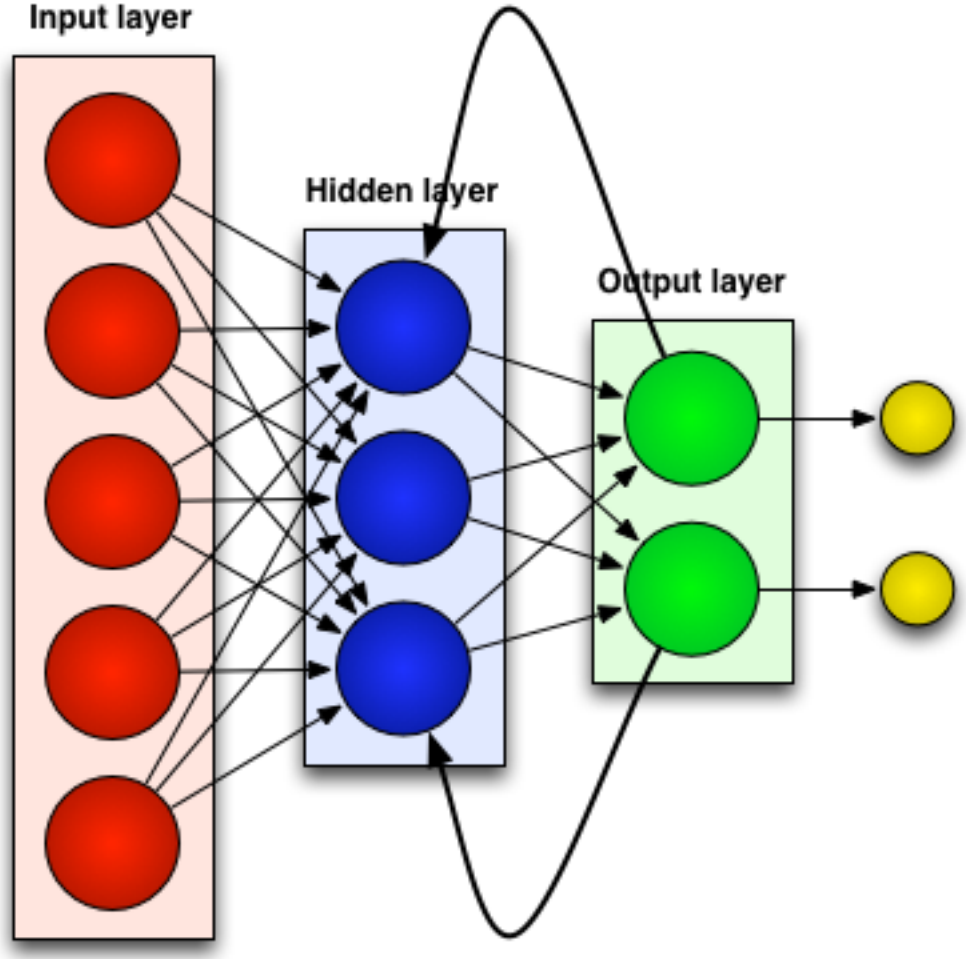


Figure 15.3 DCGAN architecture. In the generator, a 100D latent variable $\mathbf{z}$ is drawn from a uniform distribution and mapped by a linear transformation to a 4×4 representation with 1024 channels. This is then passed through a series of convolutional layers that gradually upsample the representation and decrease the number of channels. At the end is an arctan function that maps the 64×64×3 representation to a fixed range so that it can represent an image. The discriminator consists of a standard convolutional net that classifies the input as either a real example or a generated sample.

Recurrent Neural Network

- Adds limited “short term memory” to NN
- Allows for context in classifiers
- https://en.wikipedia.org/wiki/Recurrent_neural_network





Deep Learning

Resources

- https://en.wikipedia.org/wiki/Deep_learning
- https://keras.io/
- https://github.com/skorch-dev/skorch

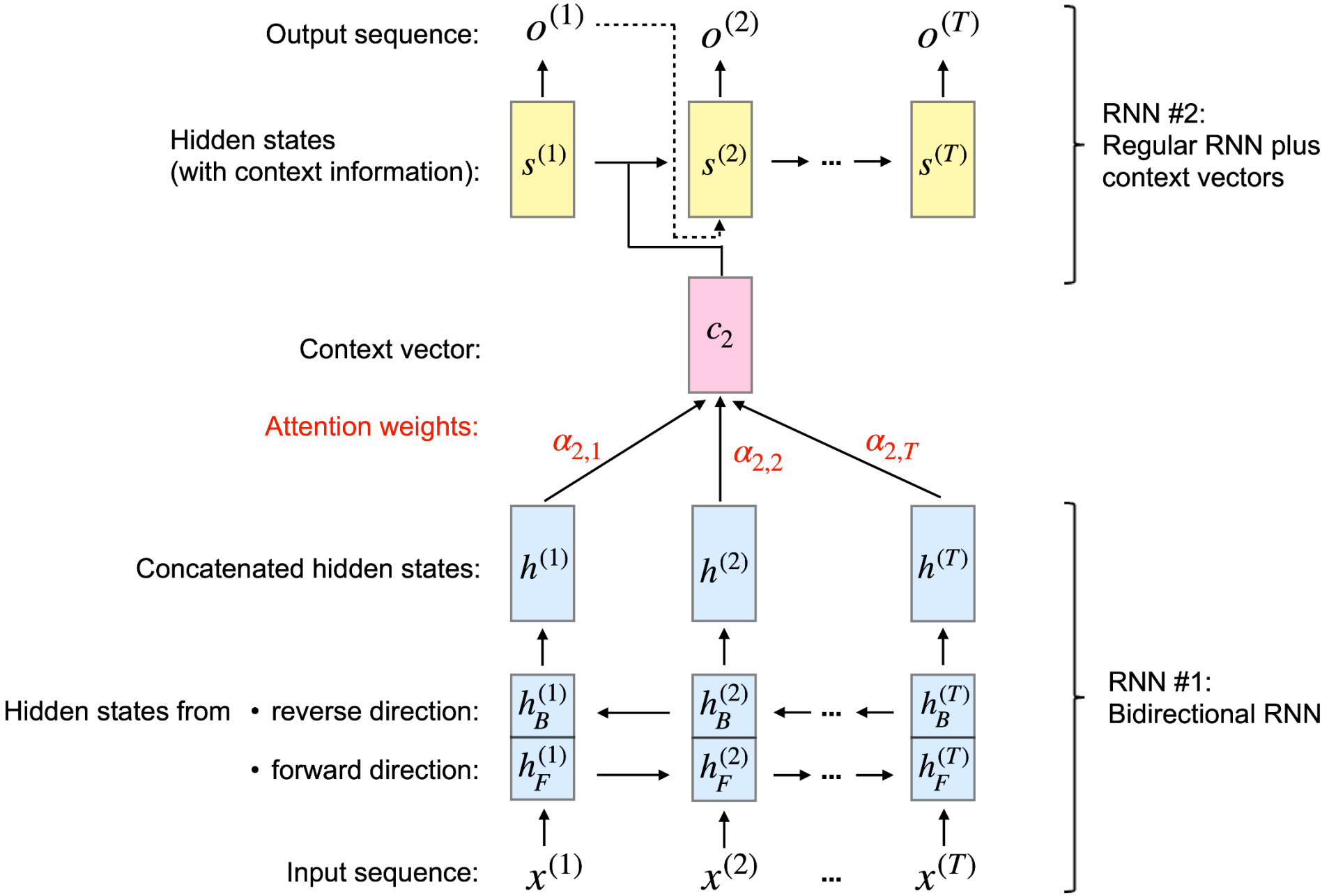
Suggestion

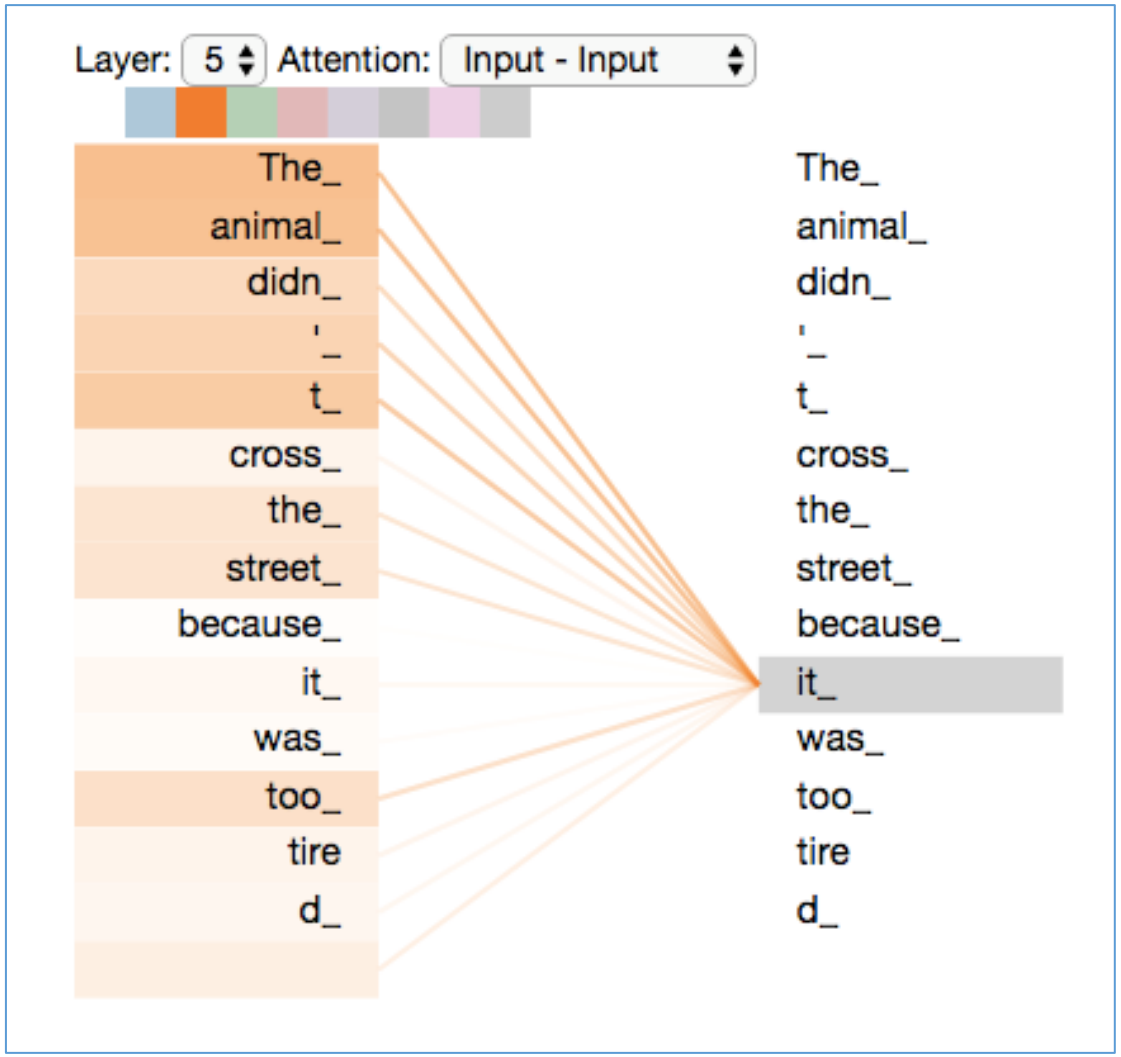
If you want to continue learning about machine learning, playing with pytorch or keras is the next step

Large Language Models

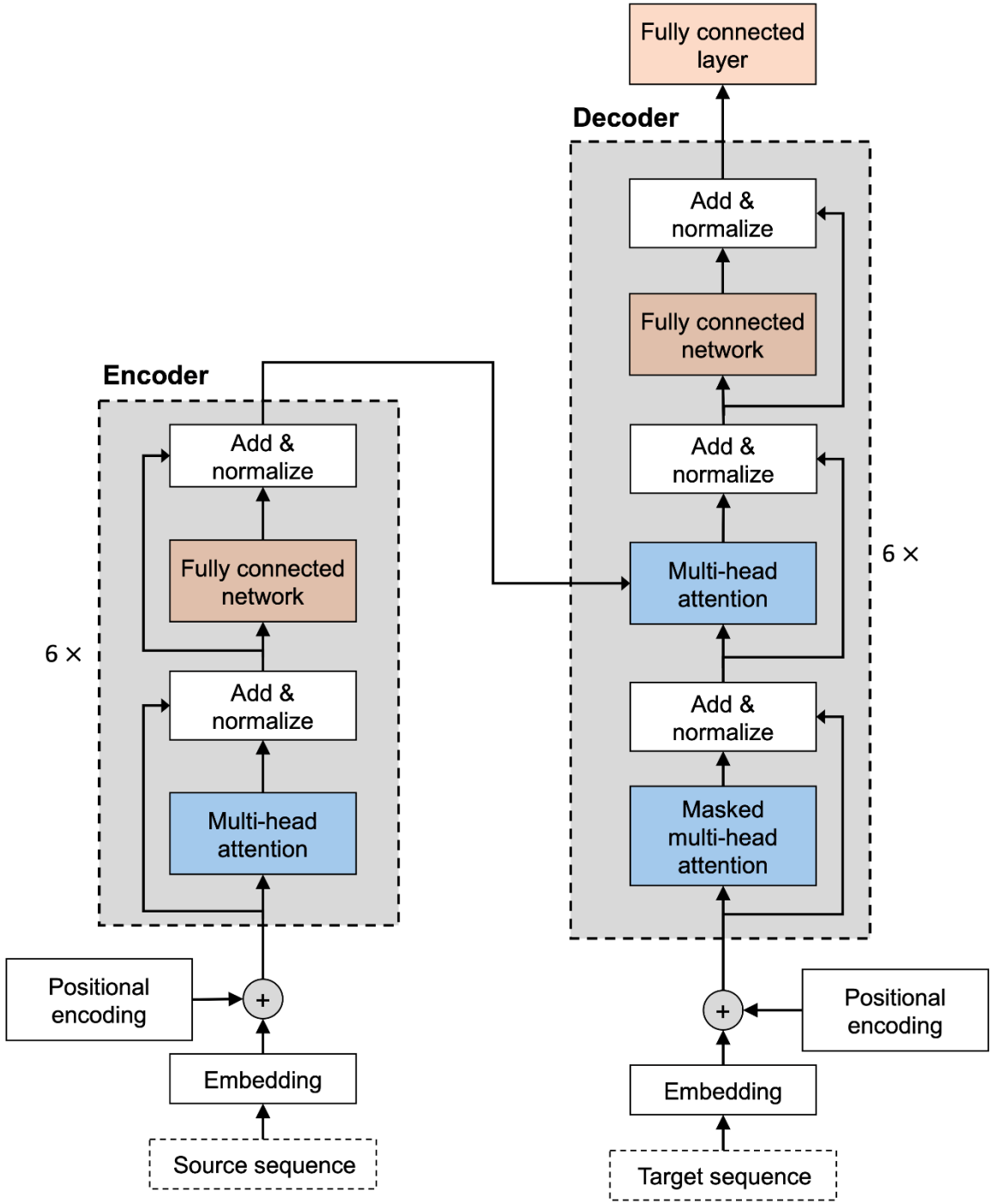
Such as Chat-GPT

https://github.com/rasbt/machine-learning-book/blob/main/ch16/ch16-part1-self-attention.ipynb





http://jalammar.github.io/illustrated-transformer/



LLM

- https://en.wikipedia.org/wiki/Large_language_model
- http://jalammar.github.io/illustrated-transformer/
- https://sebastianraschka.com/blog/2023/llm-reading-list.html