# DeepRob

Lecture 21
Unsupervised Learning
University of Michigan | Department of Robotics

# Recall: Videos

## The temporal dimension

**Raw video**: Long, high FPS

**Training**: Train model to classify short **clips** with low FPS

**Testing**: Run model on different clips, average predictions

# Supervised Learning

**Data**: (x, y)

x is data, y is label

**Goal**: Learn a *function* to map x -> y

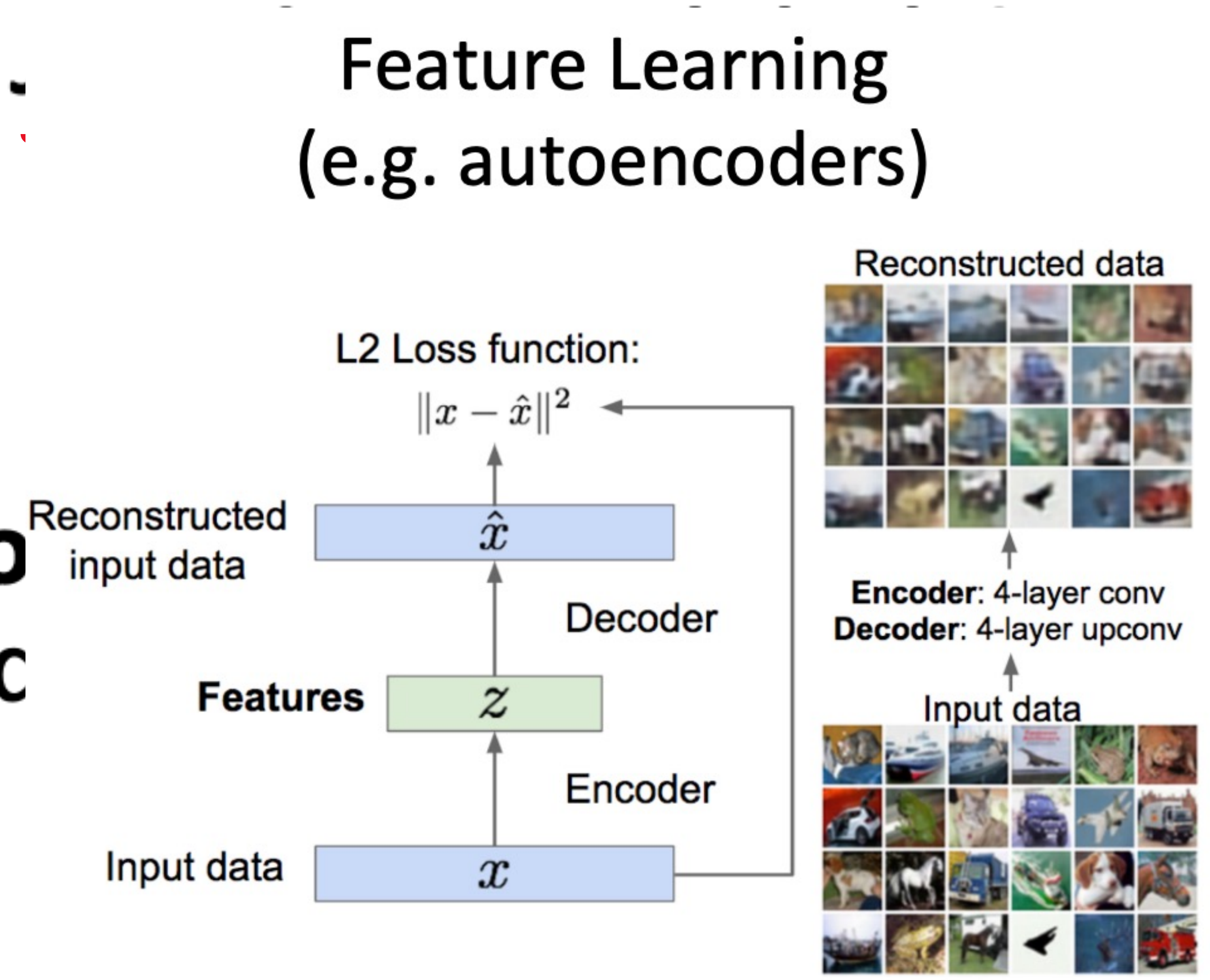
```
batch_size = 64
X_batch = data_dict['X_val'][:batch_size]
y_batch = data_dict['y_val'][:batch_size]

# Compute the loss and its gradient at W.
# YOUR_TURN: implement the gradient part of 'svm_loss_naive' function in "linear_classifier.py"
_, grad = svm_loss_naive(W, X_batch, y_batch, reg=0.0)
```

# Unsupervised Learning

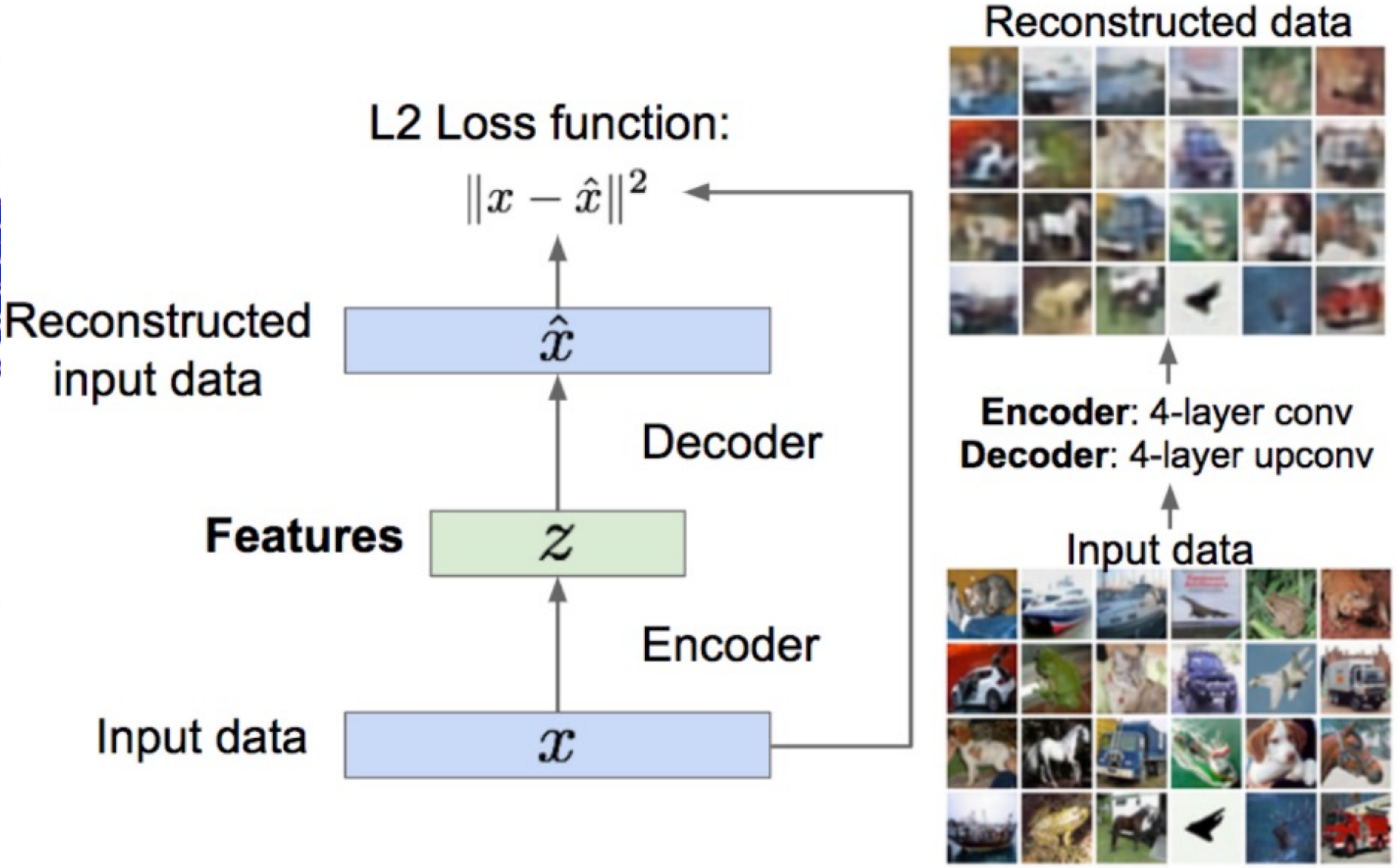
**Data**: x

Go

hic

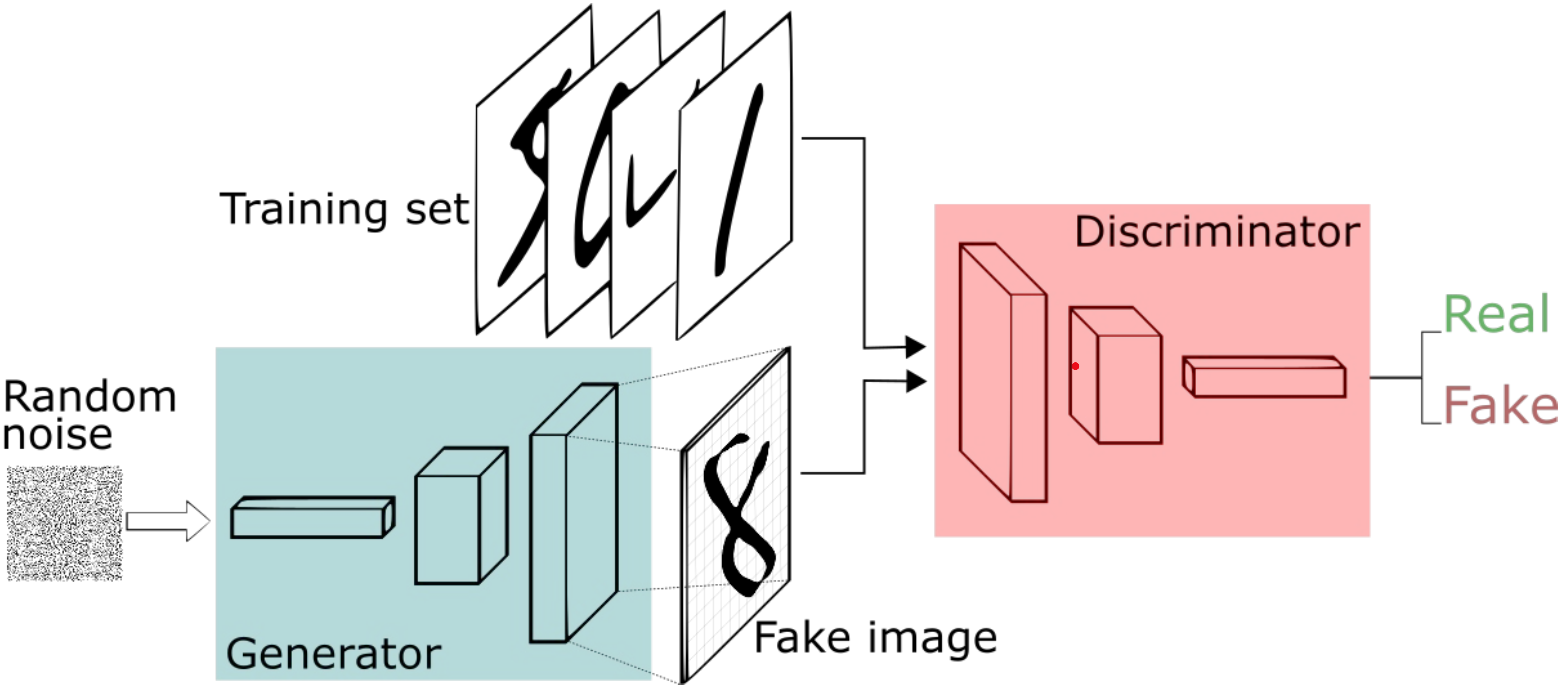



## Feature Learning
## (e.g. autoencoders)



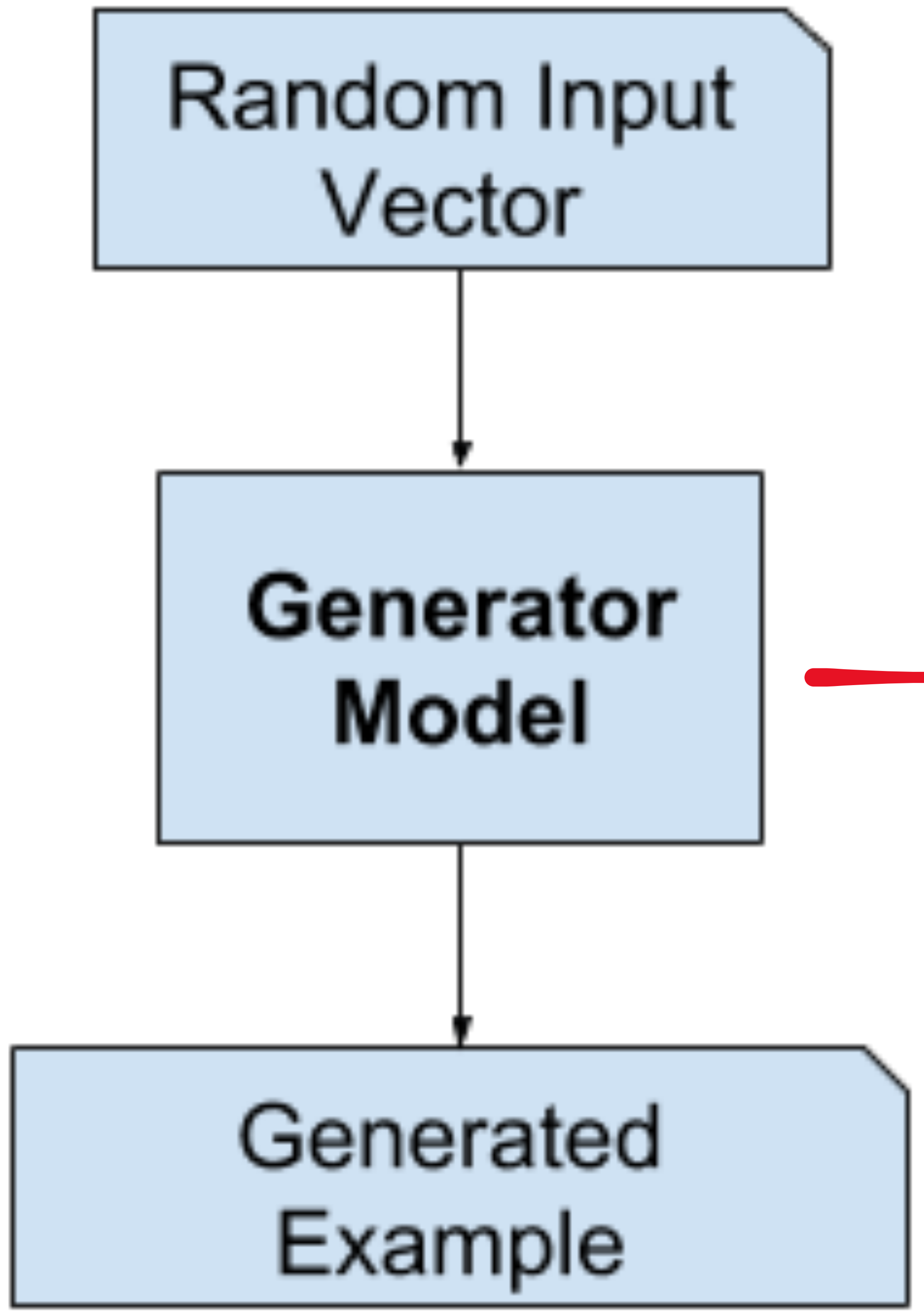
# Discriminative vs Generative

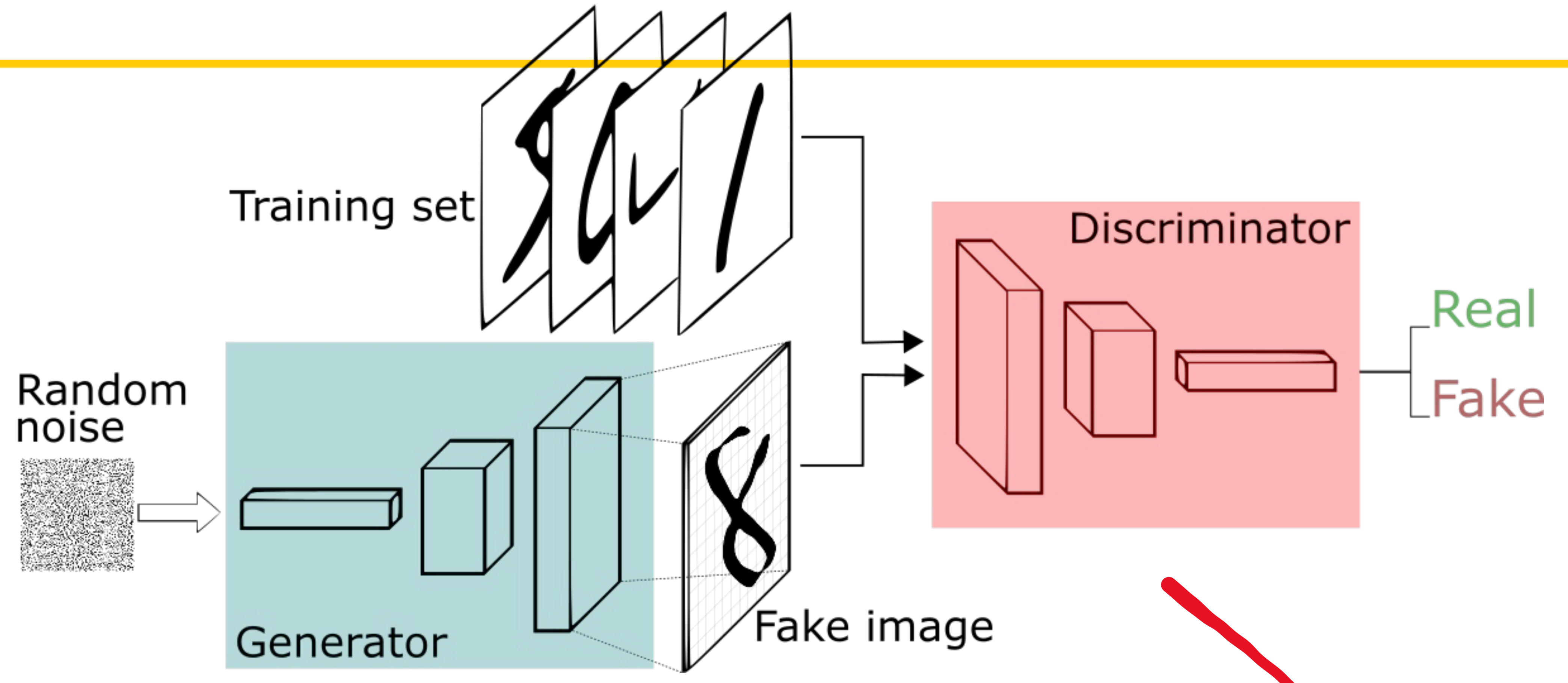
$$\min_{G} \max_{D} \left(E_{x\sim p_{data}}[\log D(x)] + E_{z\sim p(z)}\left[\log\left(1 - D(G(z))\right)\right]\right)$$

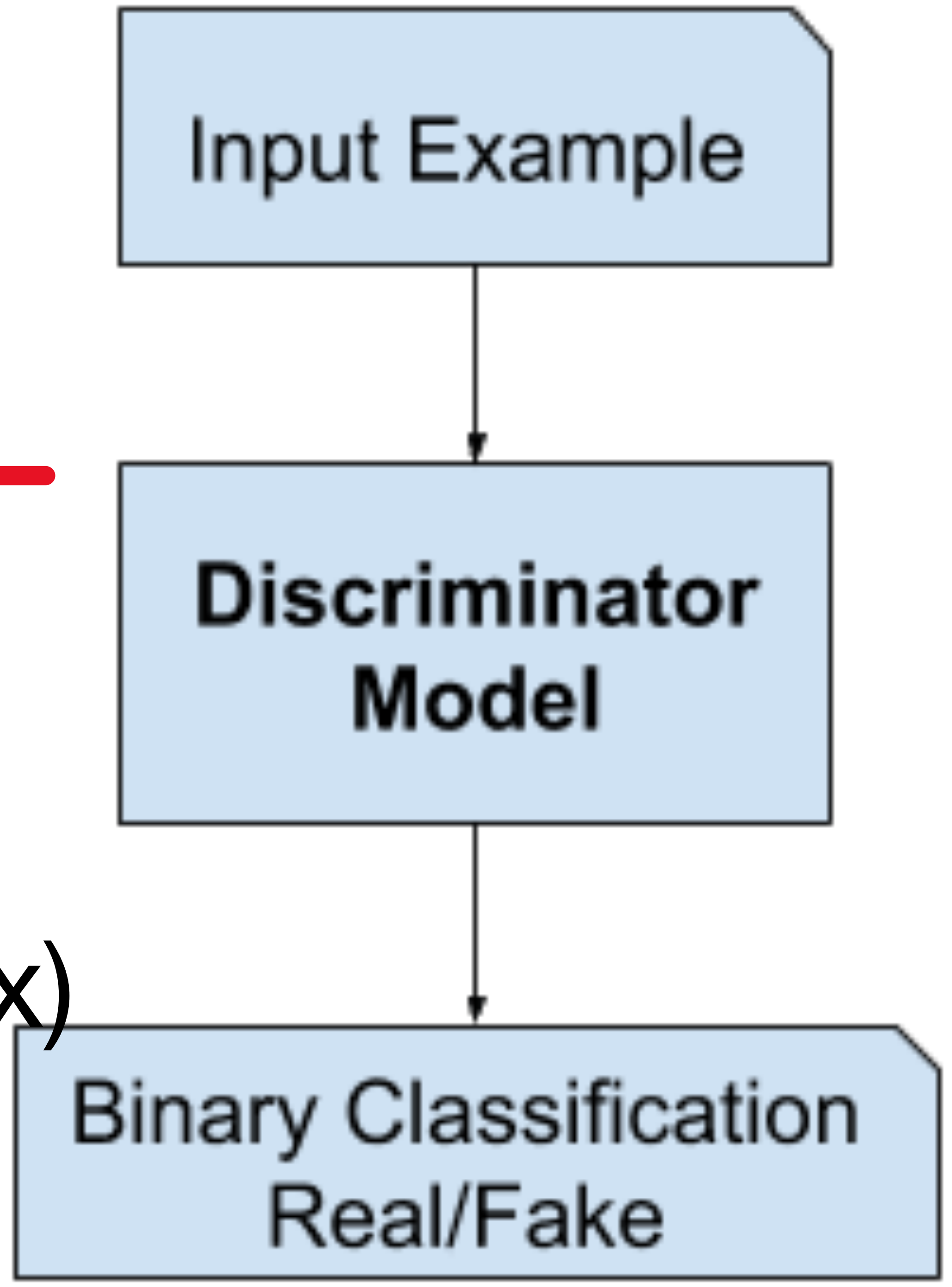



https://sthalles.github.io/intro-to-gans/

# Discriminative vs Generative




Learn a probability distribution p(x)

Learn a probability distribution p(y|x)

https://sthalles.github.io/intro-to-gans/

# Discriminative vs Generative

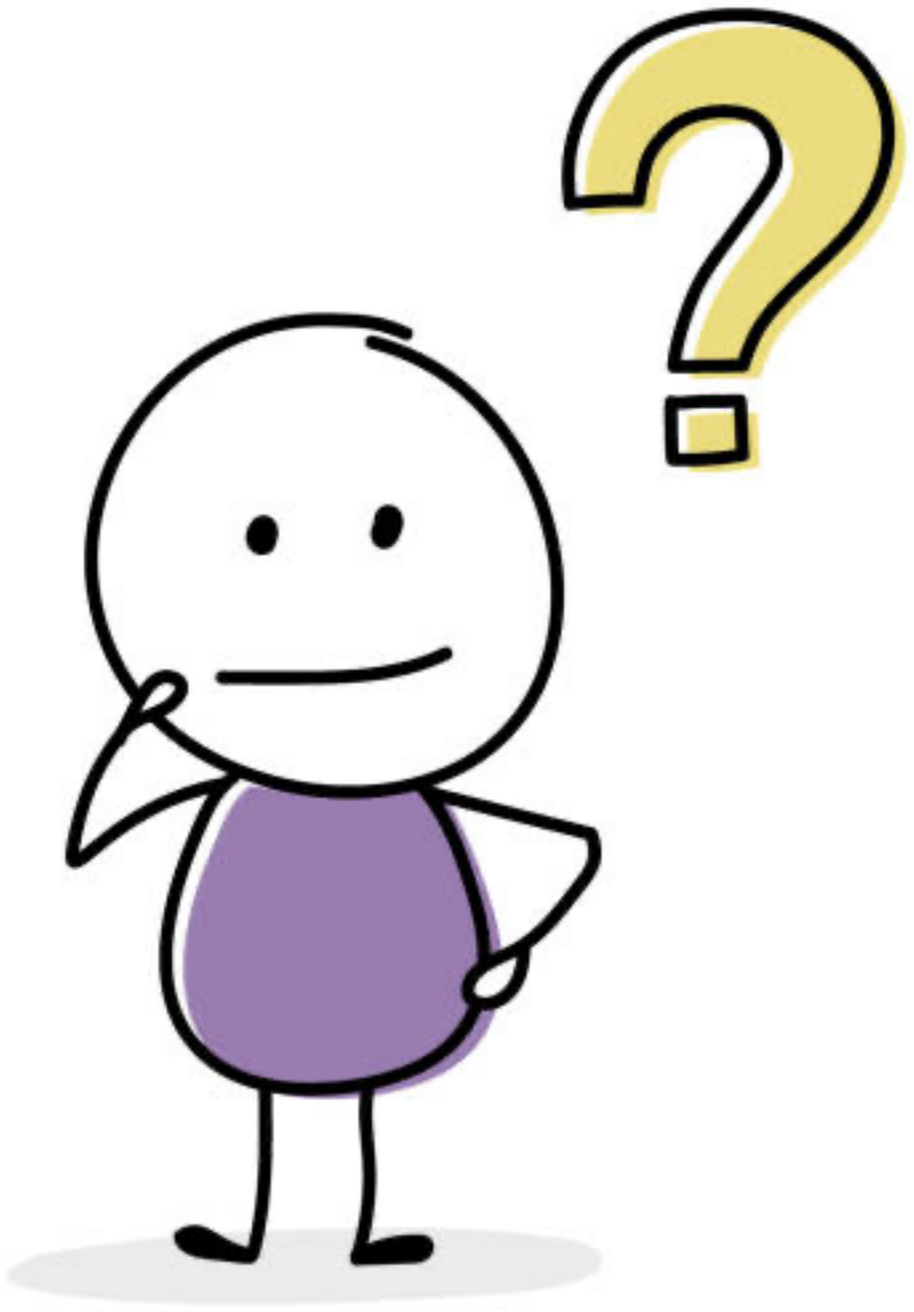
**Conditional Generative Model:** Learn $p(x|y)$

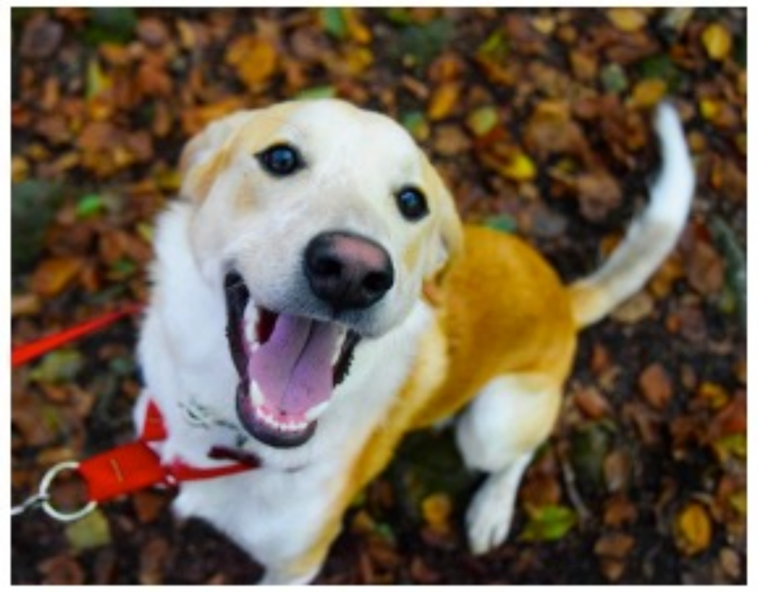
Bayes' rule

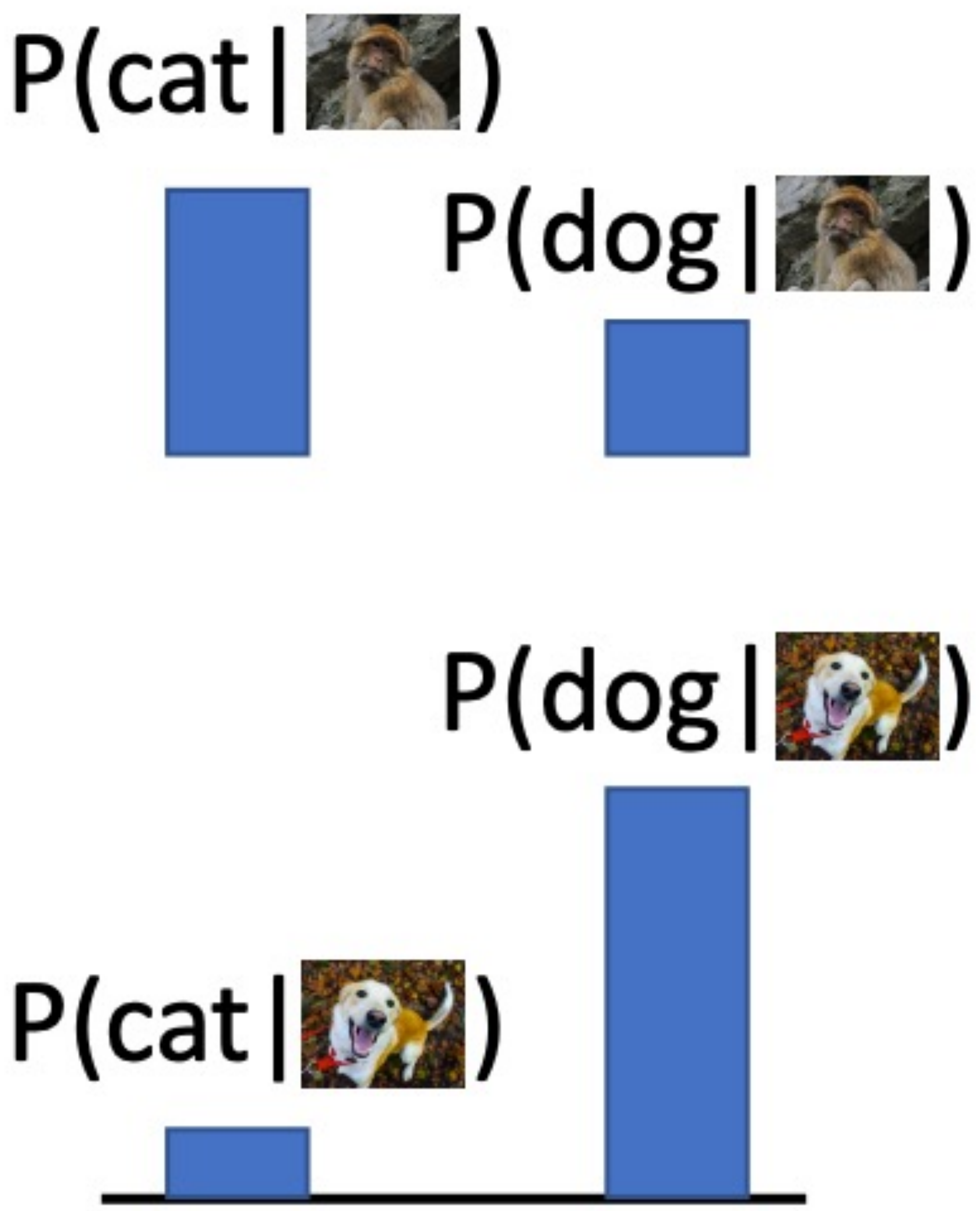
$$\underbrace{\boxed{P(x \mid y)}}_{\text{Conditional Generative Model}} = \frac{\overbrace{\boxed{P(y \mid x)}}^{\text{Discriminative Model}}}{\underbrace{\boxed{P(y)}}_{\text{Prior over labels}}} \overbrace{\boxed{P(x)}}^{\text{(Unconditional) Generative Model}}$$

We can build a conditional generative model from other components!

# Discriminative or Generative?







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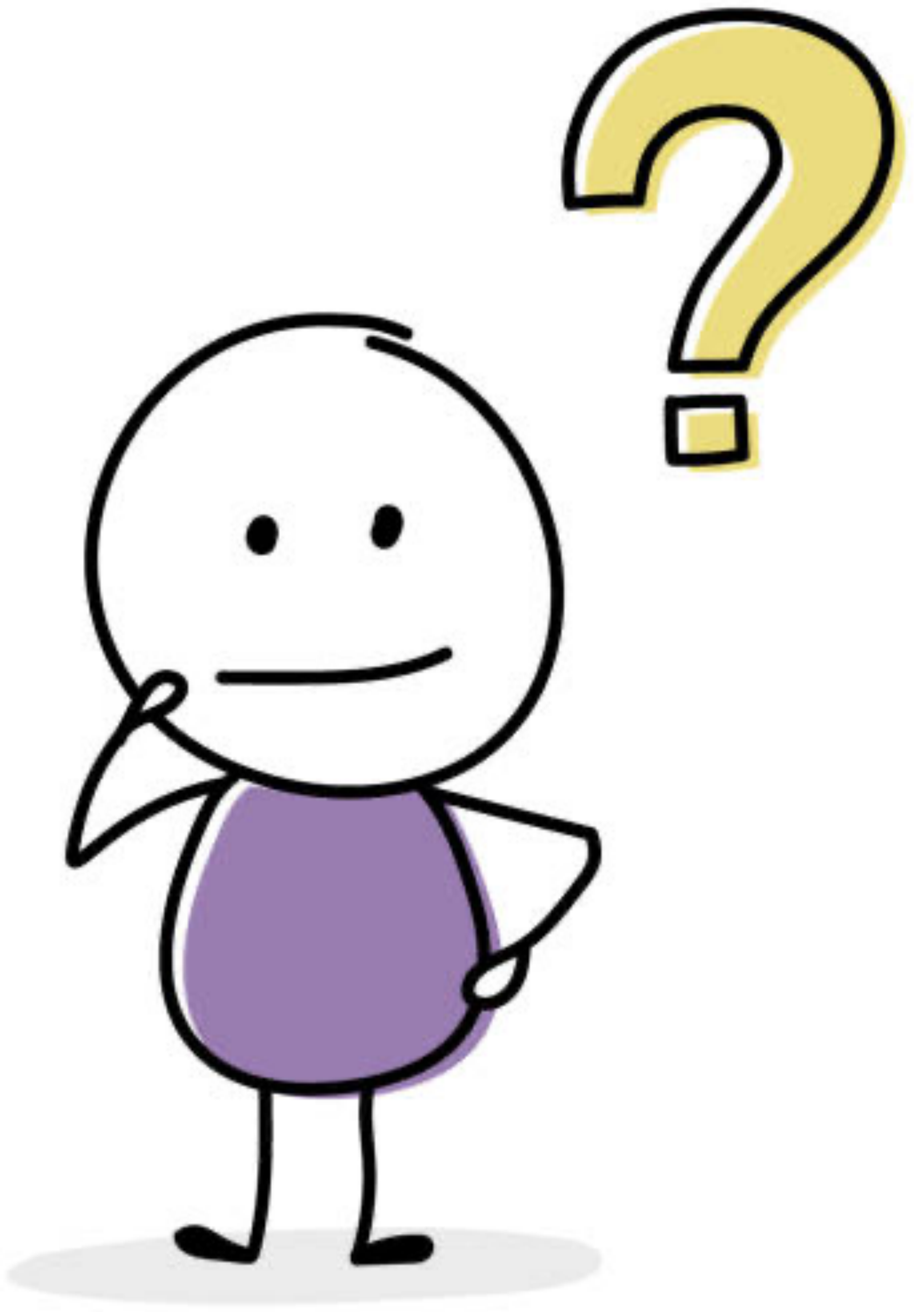

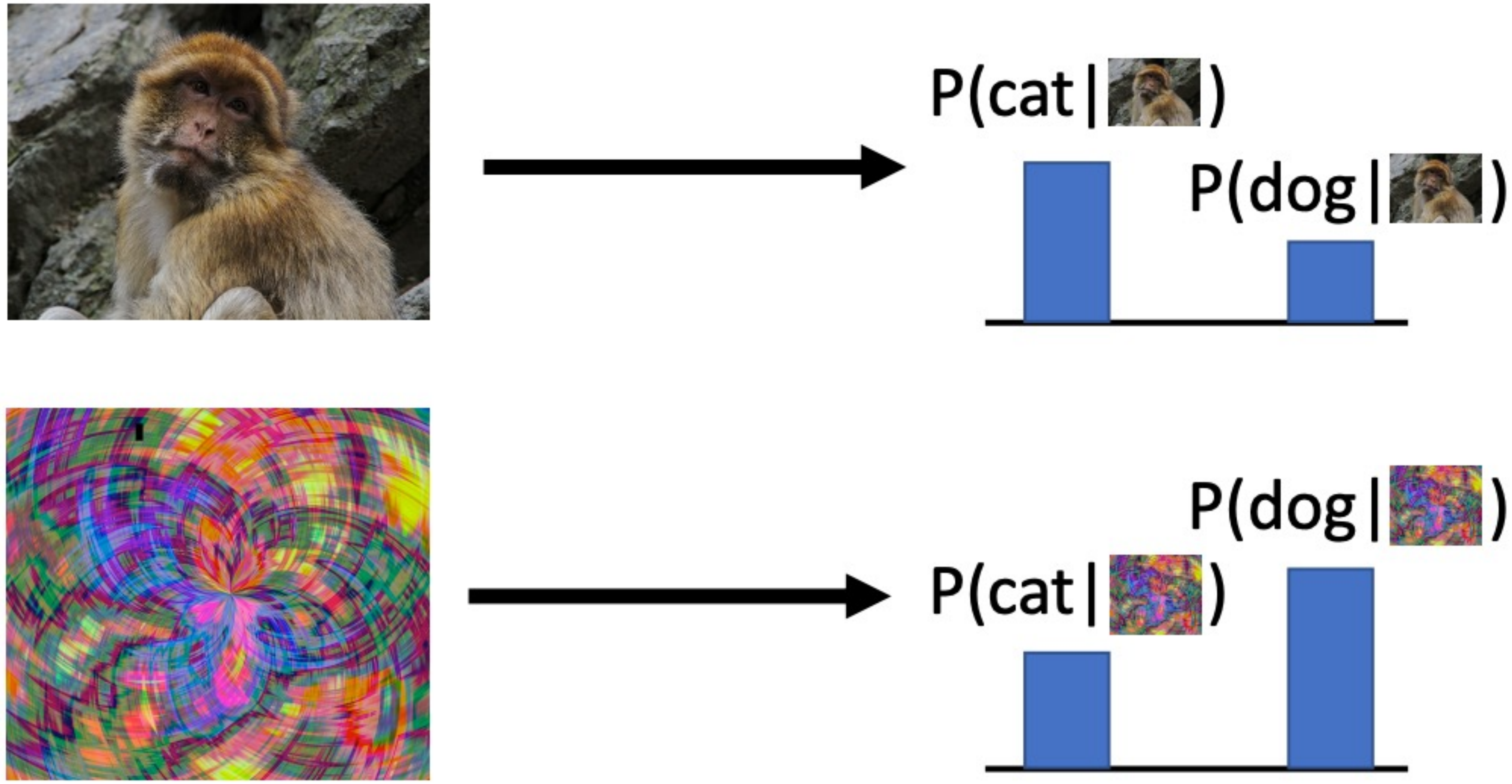

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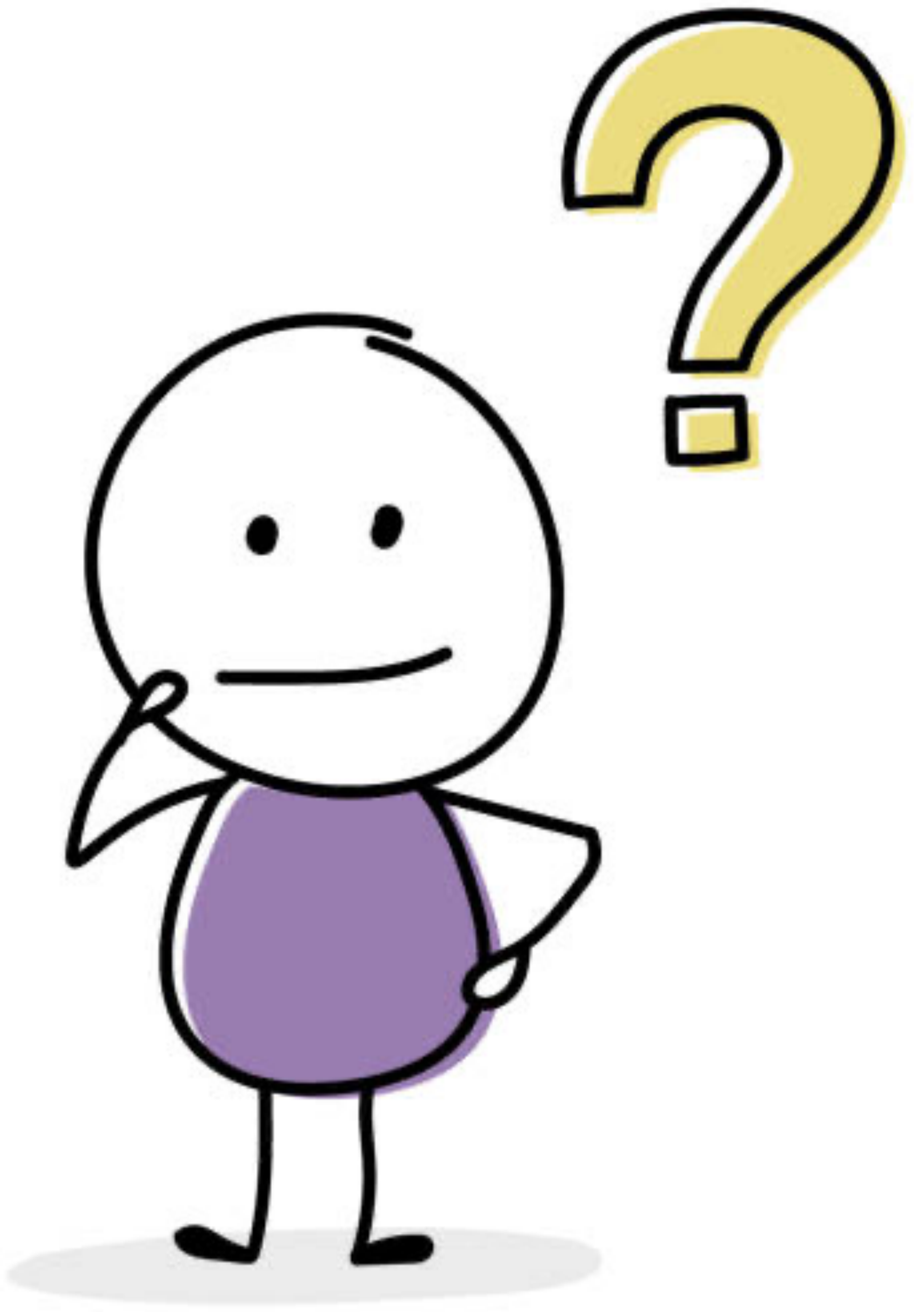
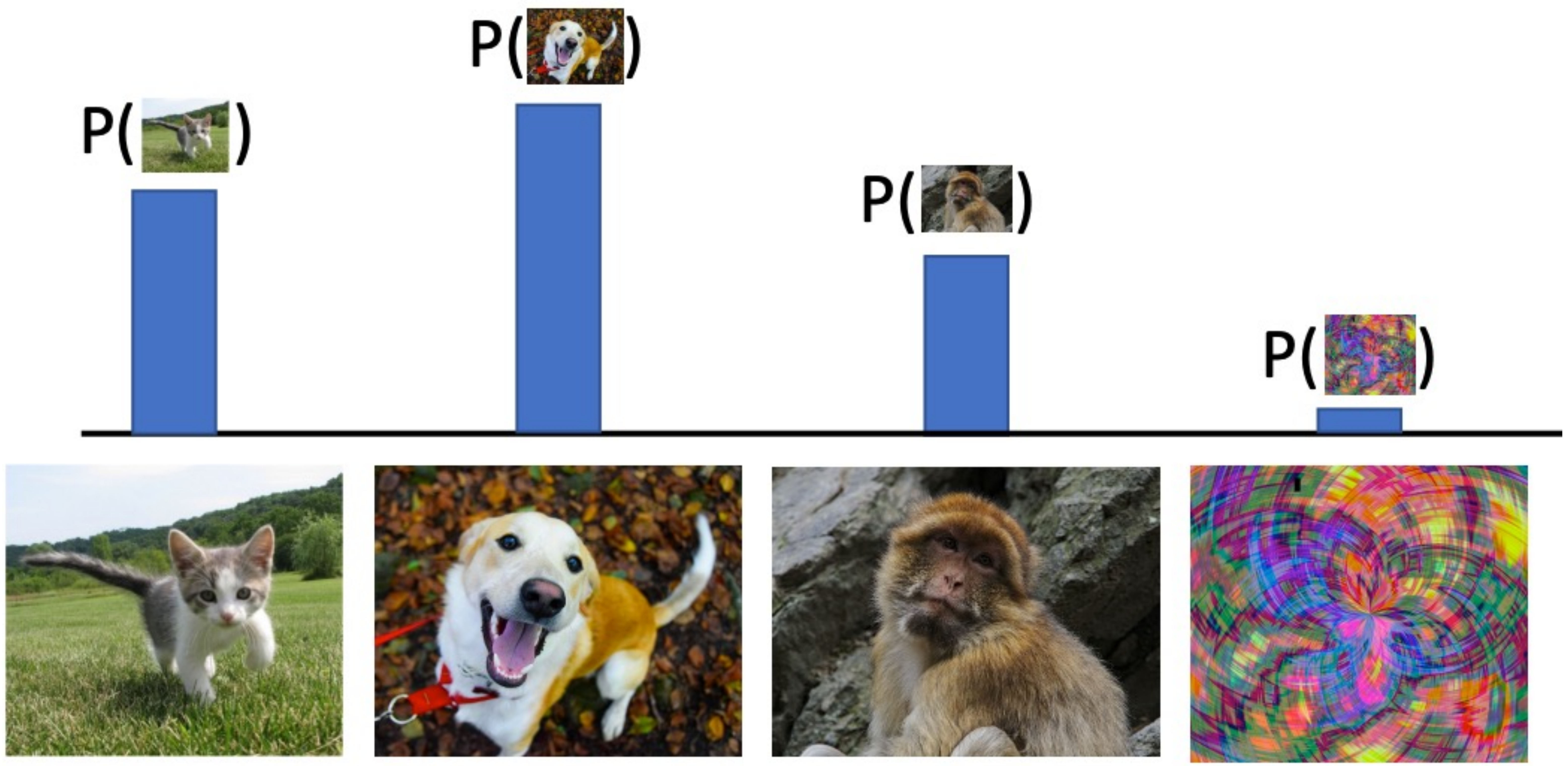
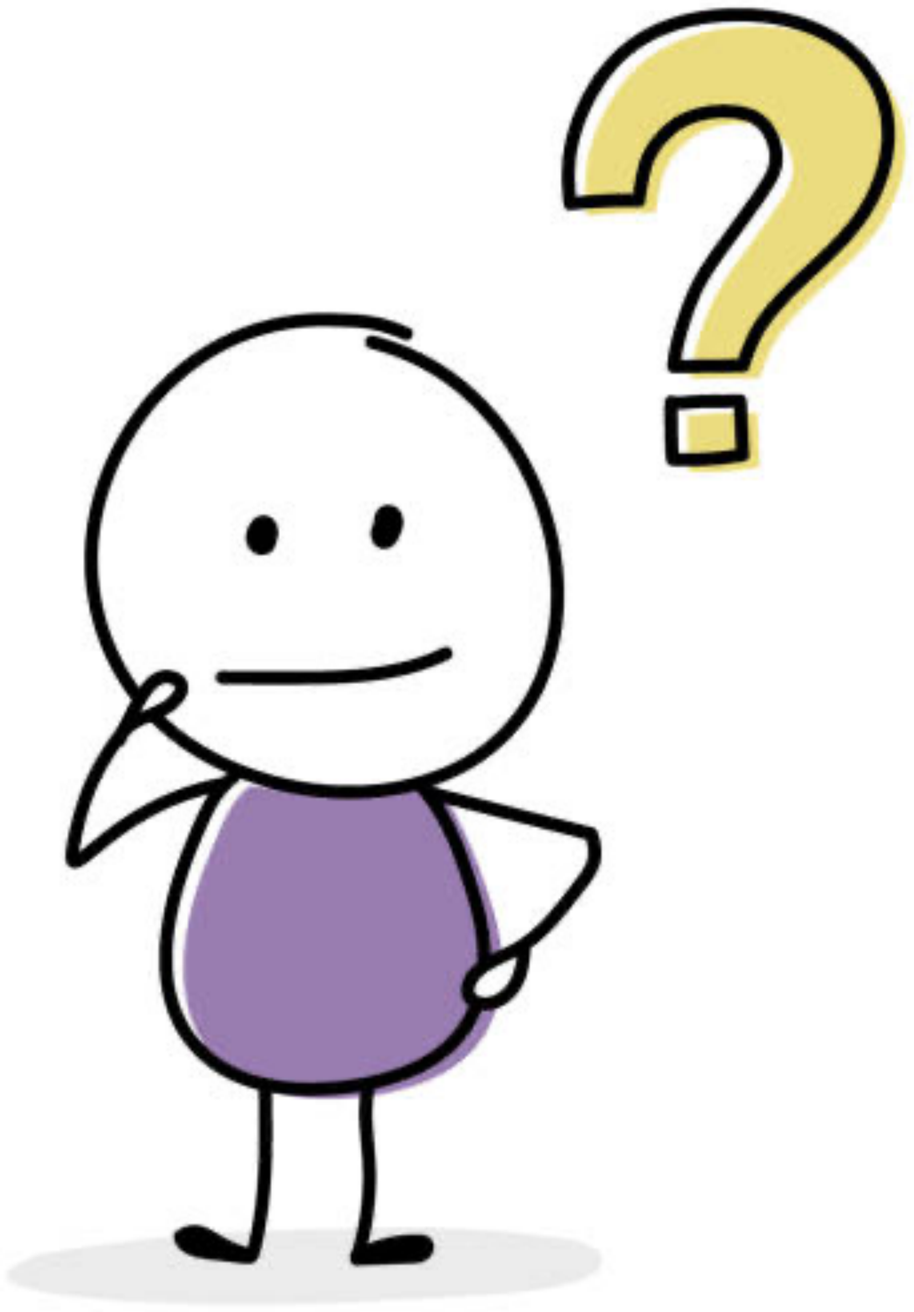
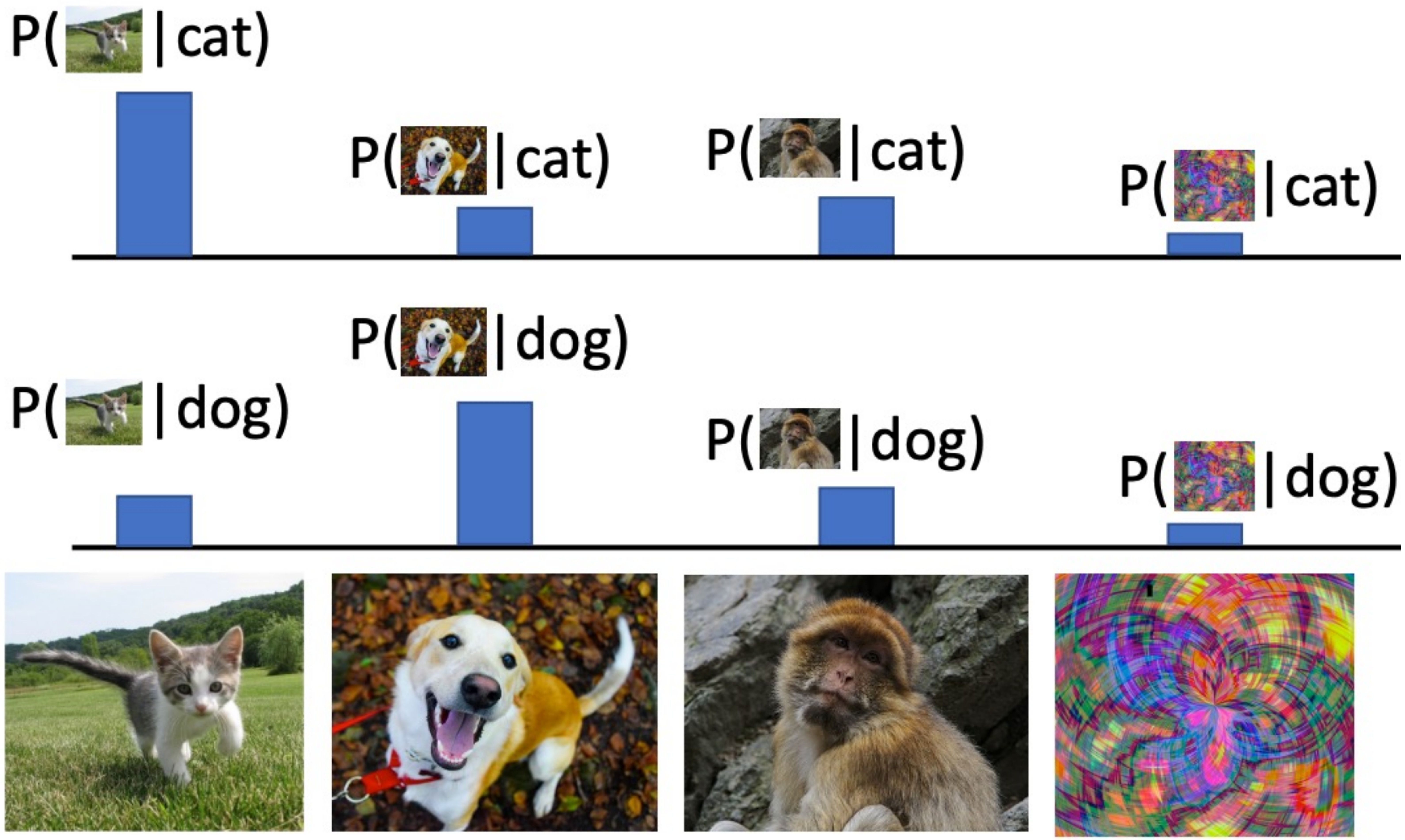




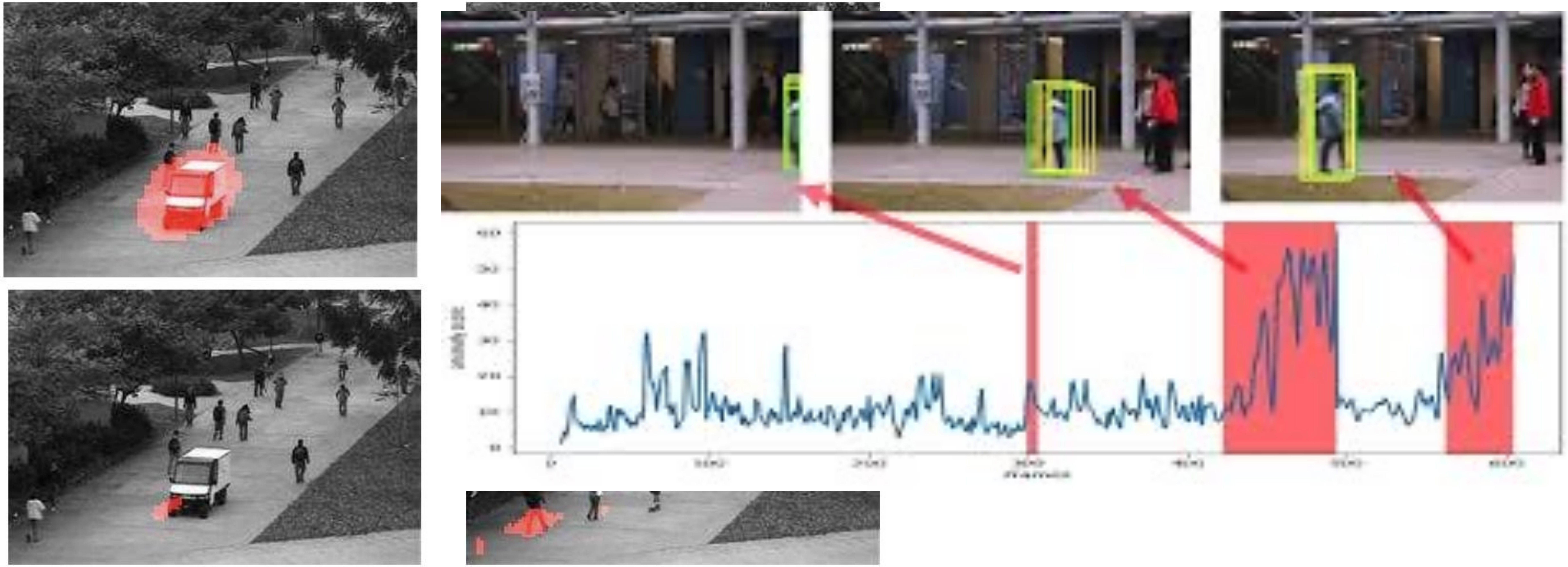
# Discriminative or Generative?





# What can we do with a generative model?

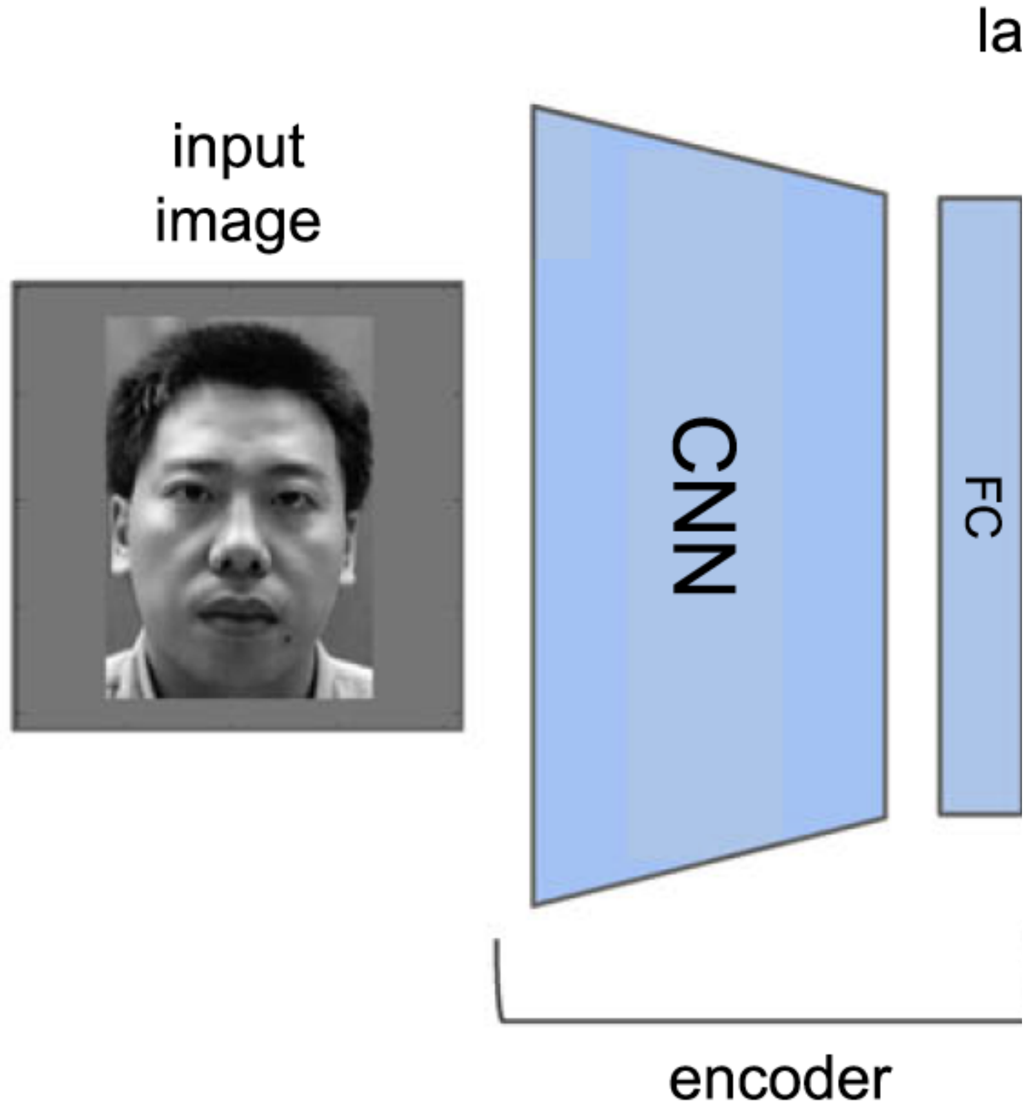
- **Detect outliers / Anomaly Detection**

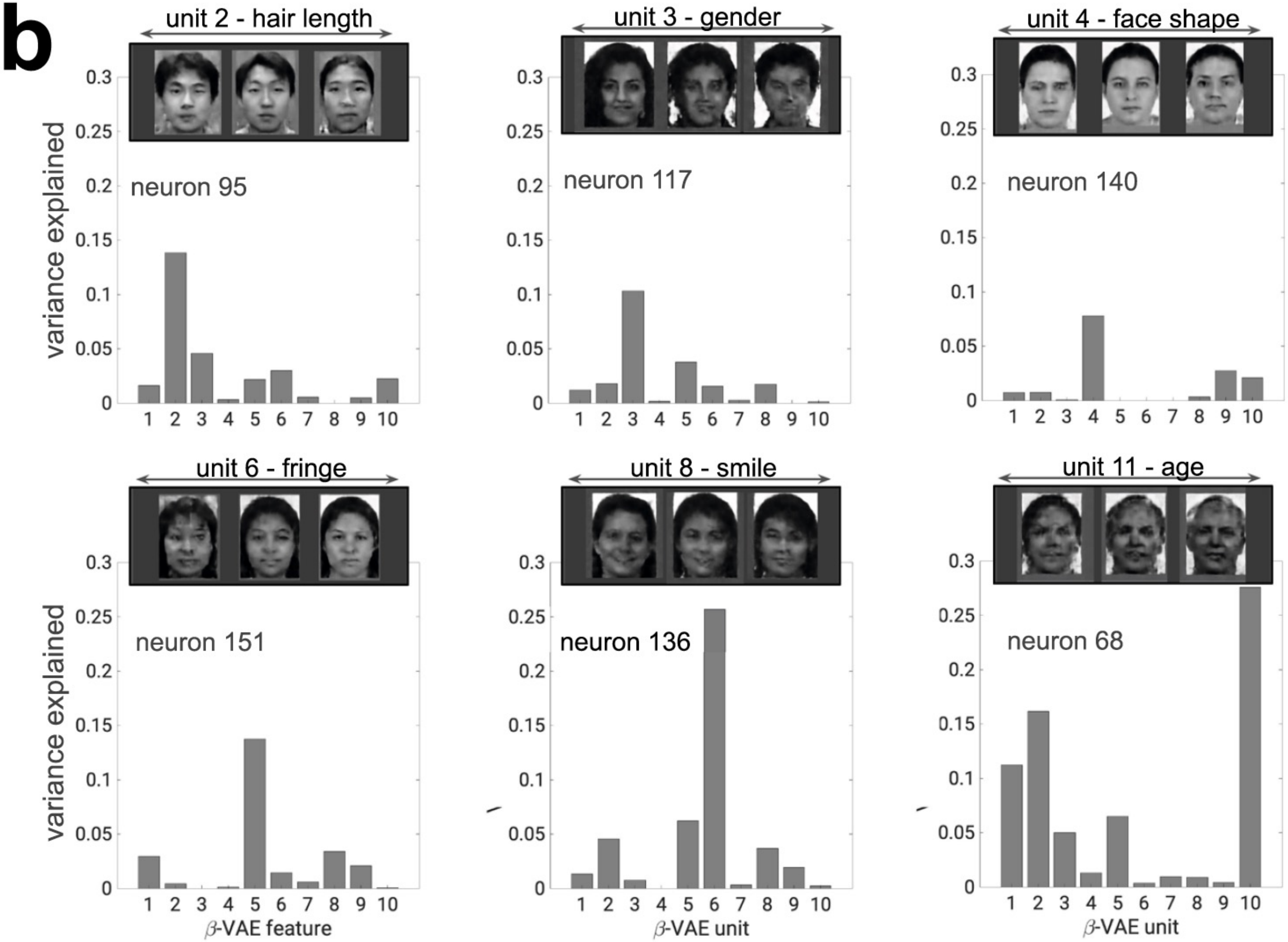


USCD Ped2 Dataset

# What ca

- Detect out
- **Feature le**




Inferotemporal face patch neurons

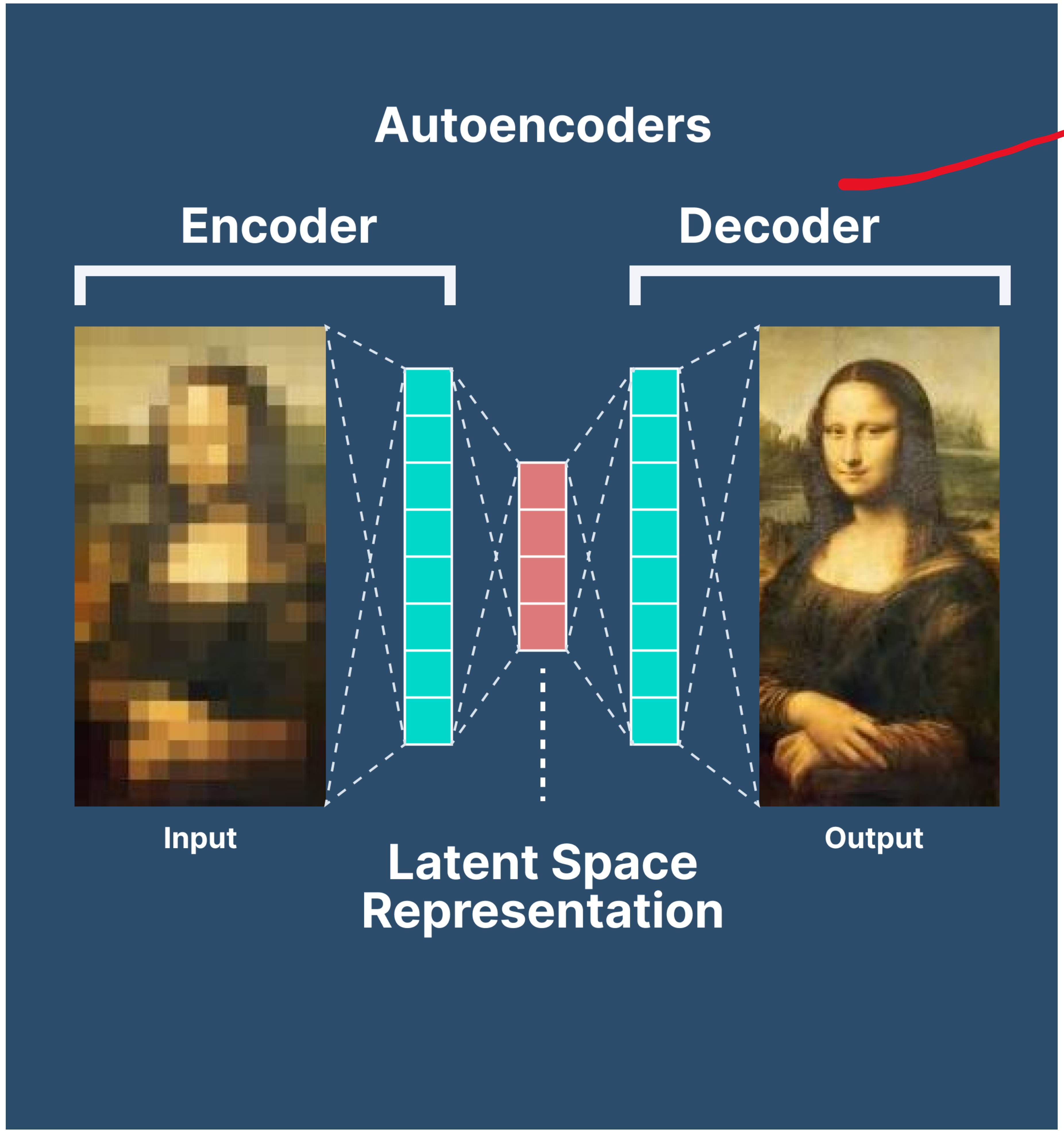
# What can we do with a Generative model?

- Detect outliers / Anomaly Detection
- Feature learning (without labels)
- **Sample to generate new data**
  - Conditional: generate new data conditioned on input labels

Example: MNIST
https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/generative/cvae.ipynb

https://ijdykeman.github.io/ml/2016/12/21/cvae.html

# Autoencoder



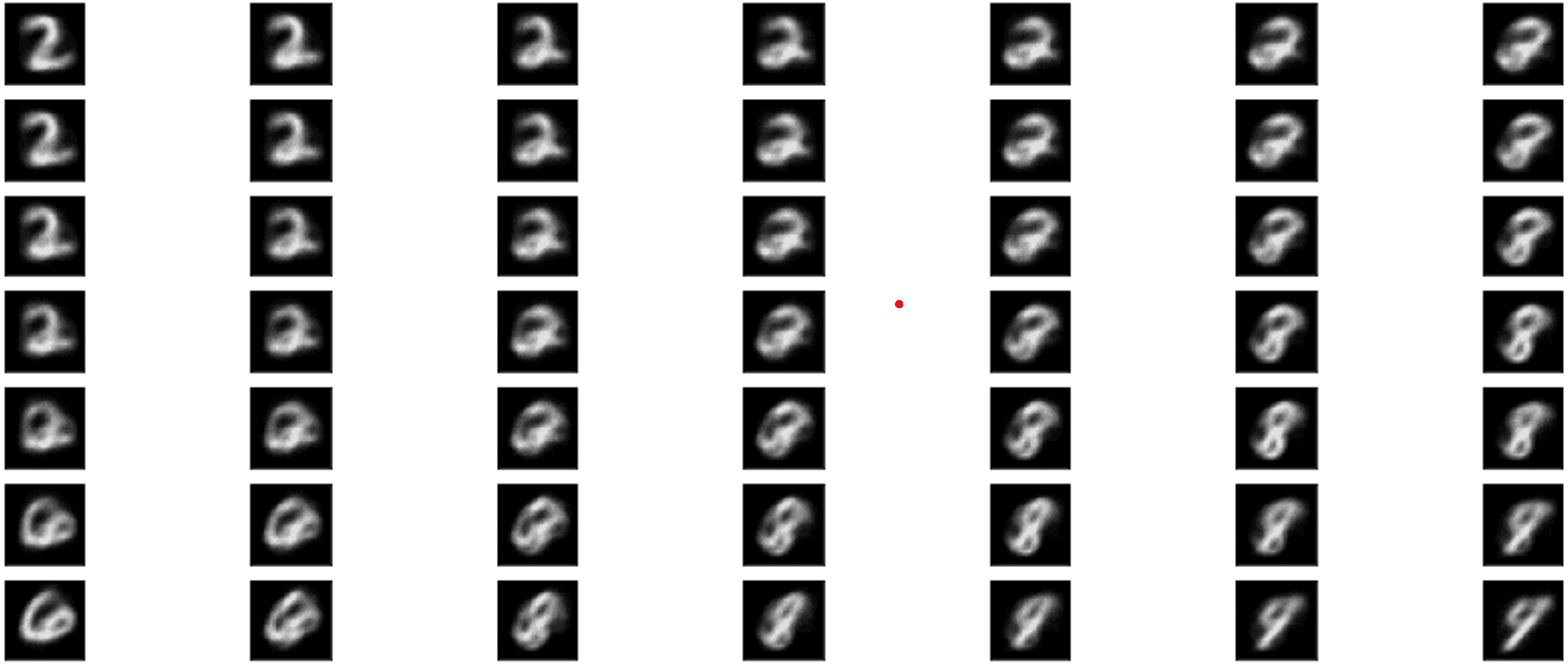

Decoder: Generative!

Reconstruction

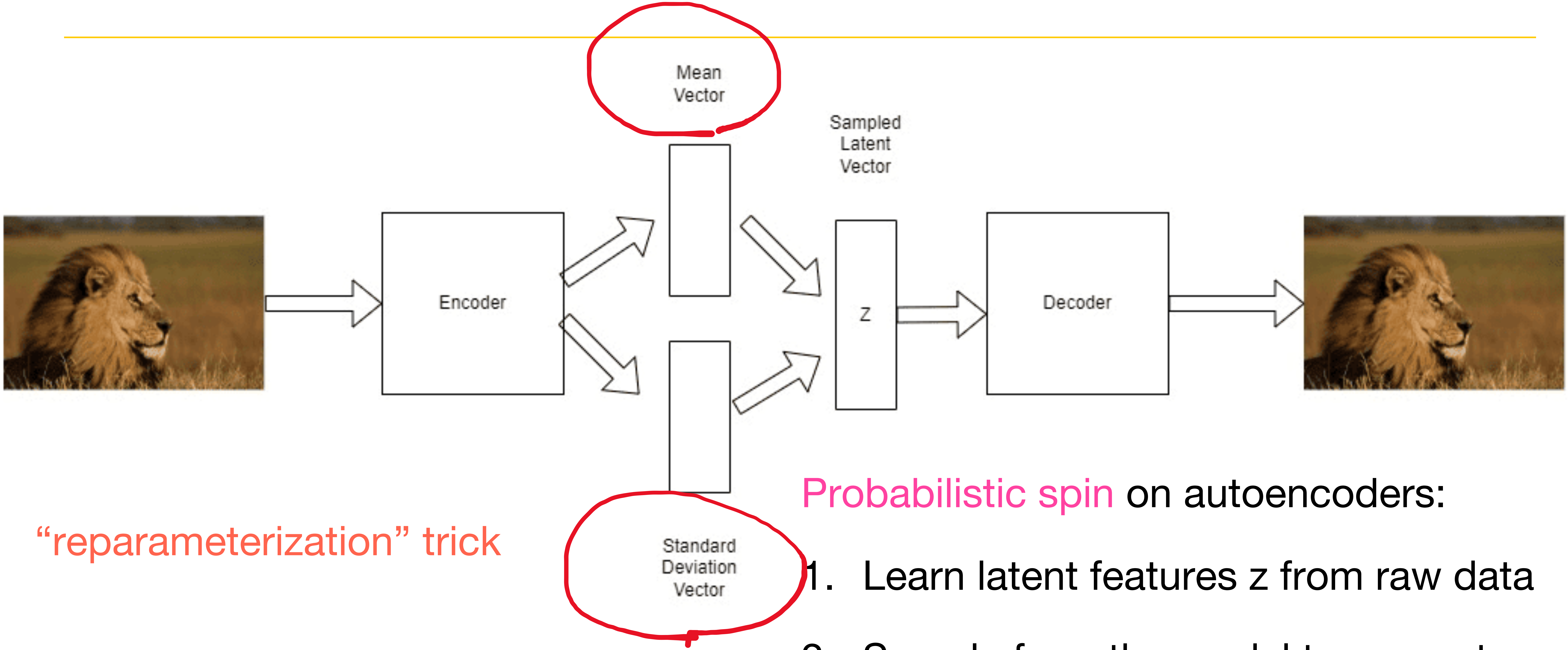
Minimizing the difference between original input and reconstructed output

# Some problems with Autoencoder

2? 9? Smooth transition ❌



# Variational Autoencoder (VAE)

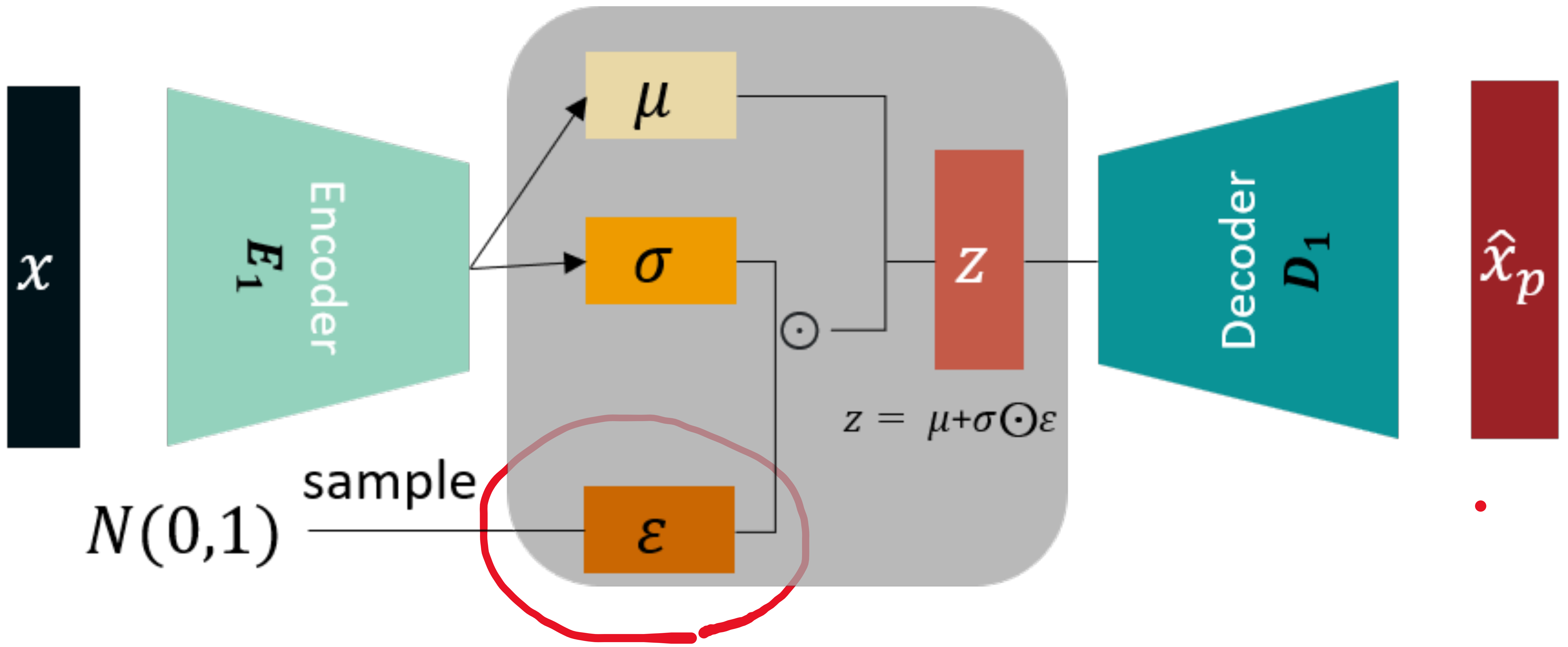



"reparameterization" trick

Probabilistic spin on autoencoders:

1. Learn latent features z from raw data
2. Sample from the model to generate new data

# Variational Autoencoder (VAE)




"reparameterization" trick

# What can we do with a Generative model?

example:

## Variational Autoencoders: Generating Data

32x32 CIFAR-10

Labeled Faces in the Wild

Figures from (L) Dirk Kingma et al. 2016; (R) Anders Larsen et al. 2017.

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