MLHEP 2017

day 5.1

Unsupervised learning

Yandex
Data Factory

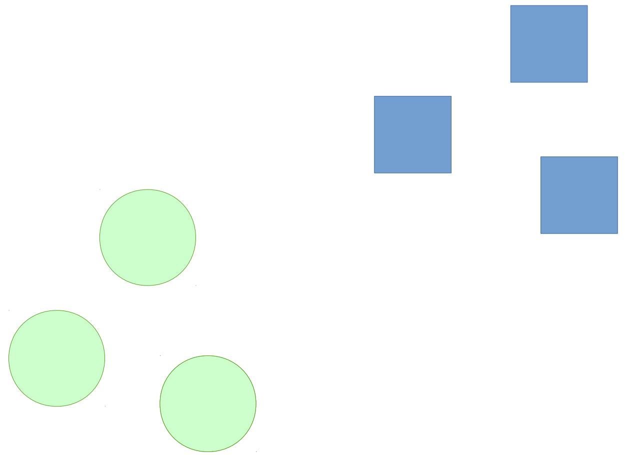
LAMBDA

British Hedgehog
Preservation Society

Supervised vs Unsupervised

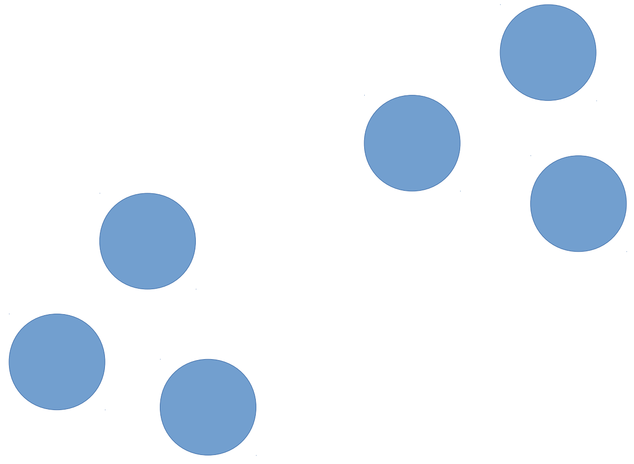
Supervised learning

- Take (x,y) pairs



Unsupervised learning

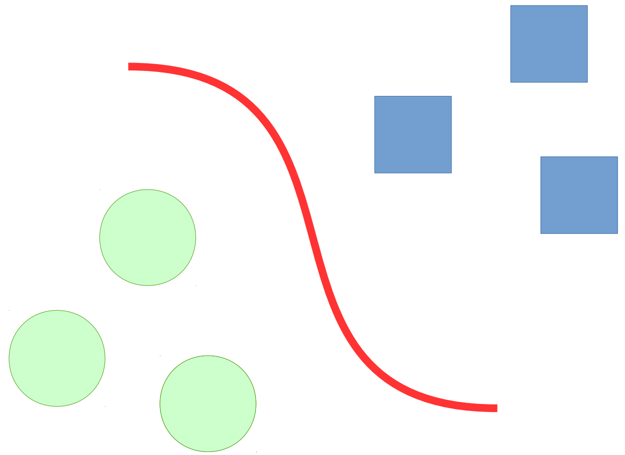
- Take x alone



Supervised vs Unsupervised

Supervised learning

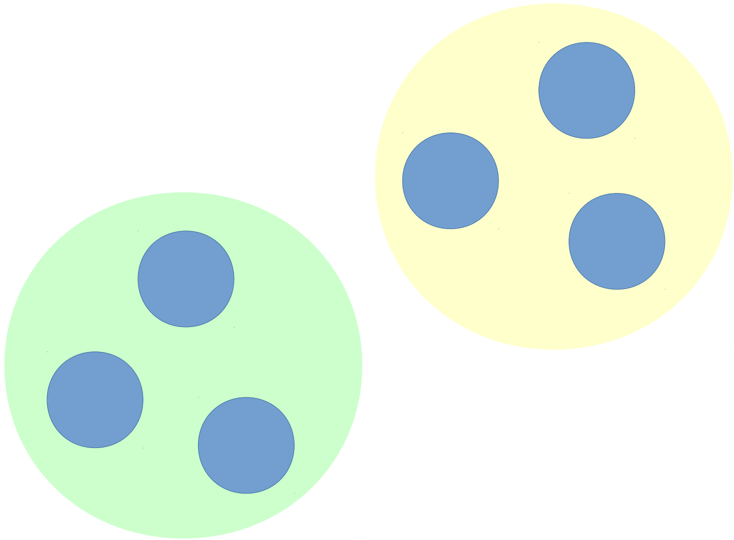
- Take (x,y) pairs
- Learn mapping x → y



Unsupervised learning

- Take unlabeled x
- Learn hidden structure

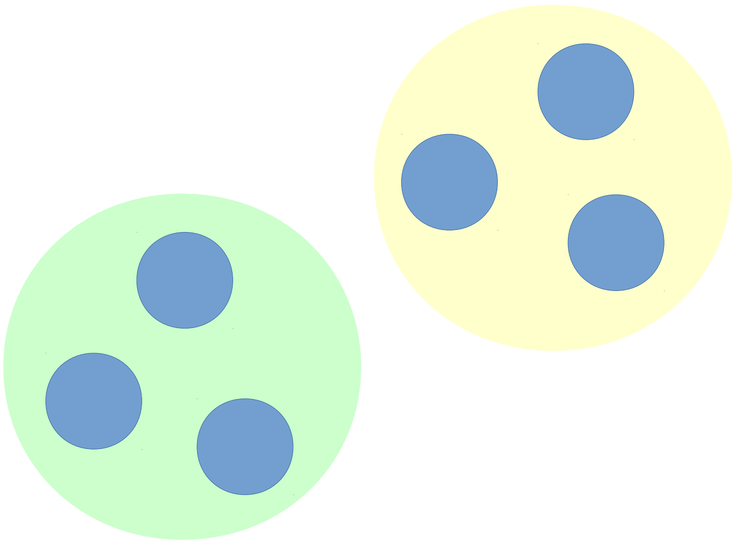
  behind the data

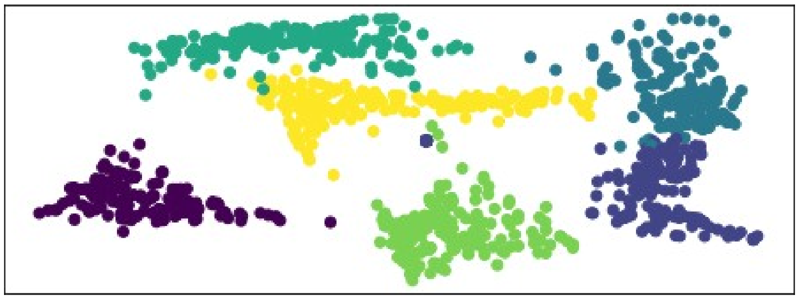


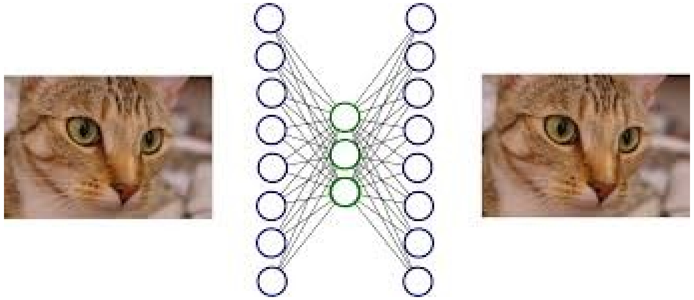
Why bother?

Unsupervised learning:

– Dimensionality reduction
– Find great features
– Explore high-dim data
– Generate new samples



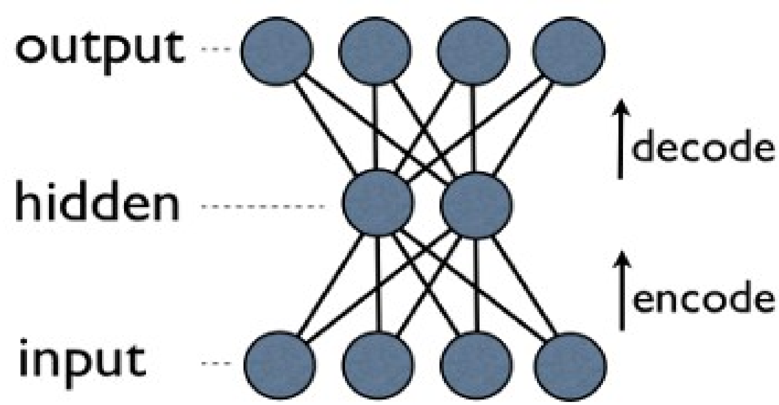




Autoencoders 101

Main idea:

- Take data in some original (high-dimensional) space;
- Project data into a new space **from which it can then be accurately restored;**
- Encoder = data to hidden
- Decoder = hidden to data
- Decoder(Encoder(x)) ~ x



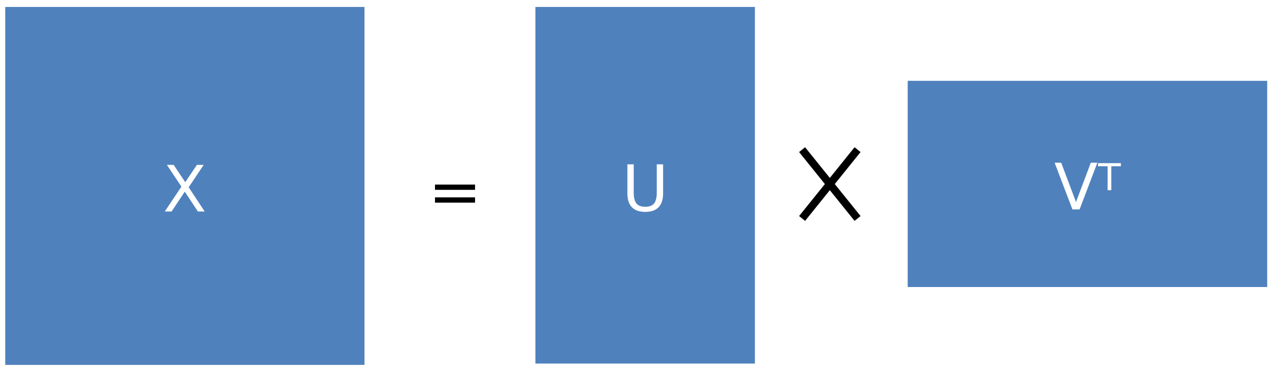
Why do we ever need that?

- Dimensionality reduction
  - |code| << |data|

<to be continued>

Matrix decompositions

Example: matrix factorization (PCA, SVD)

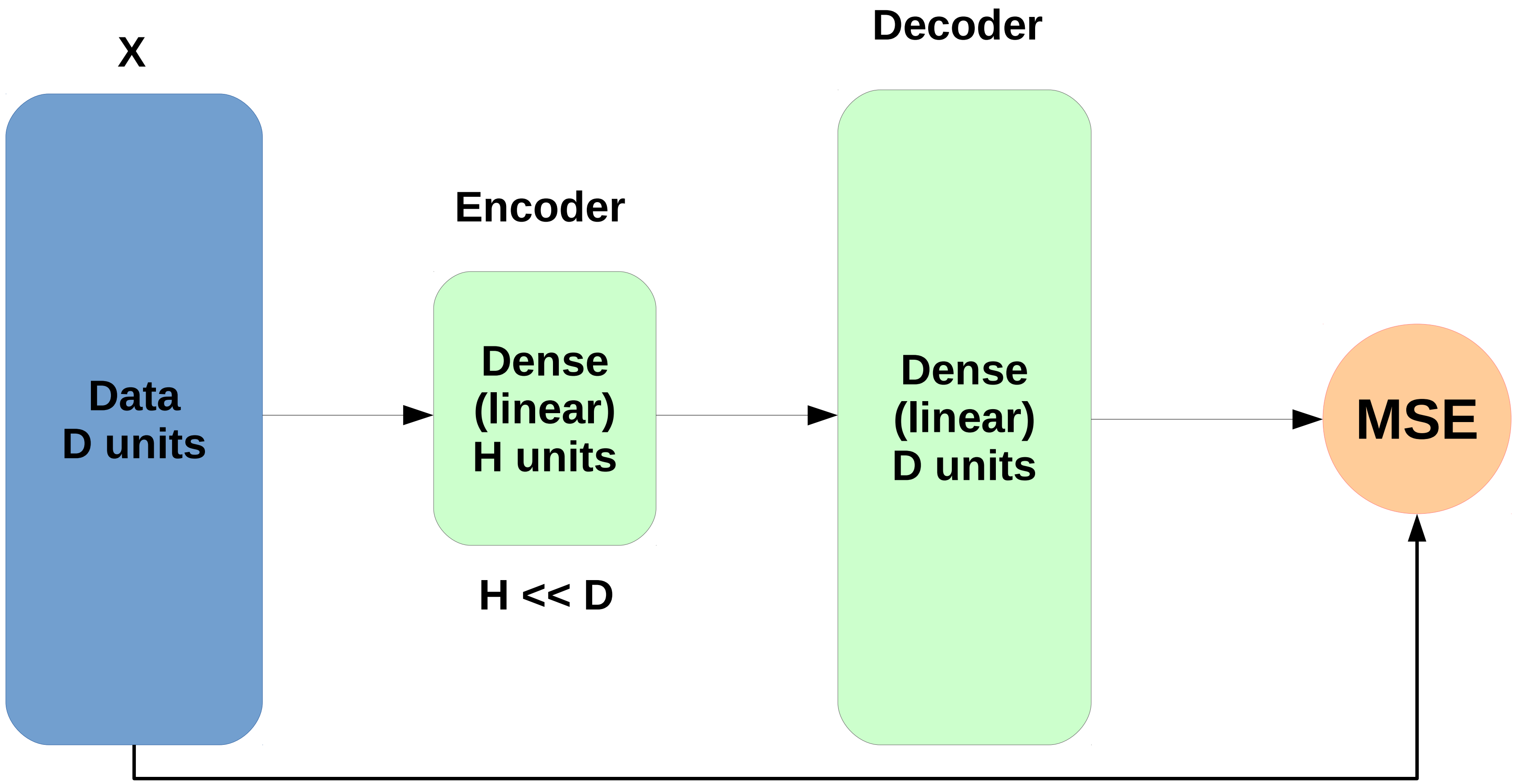


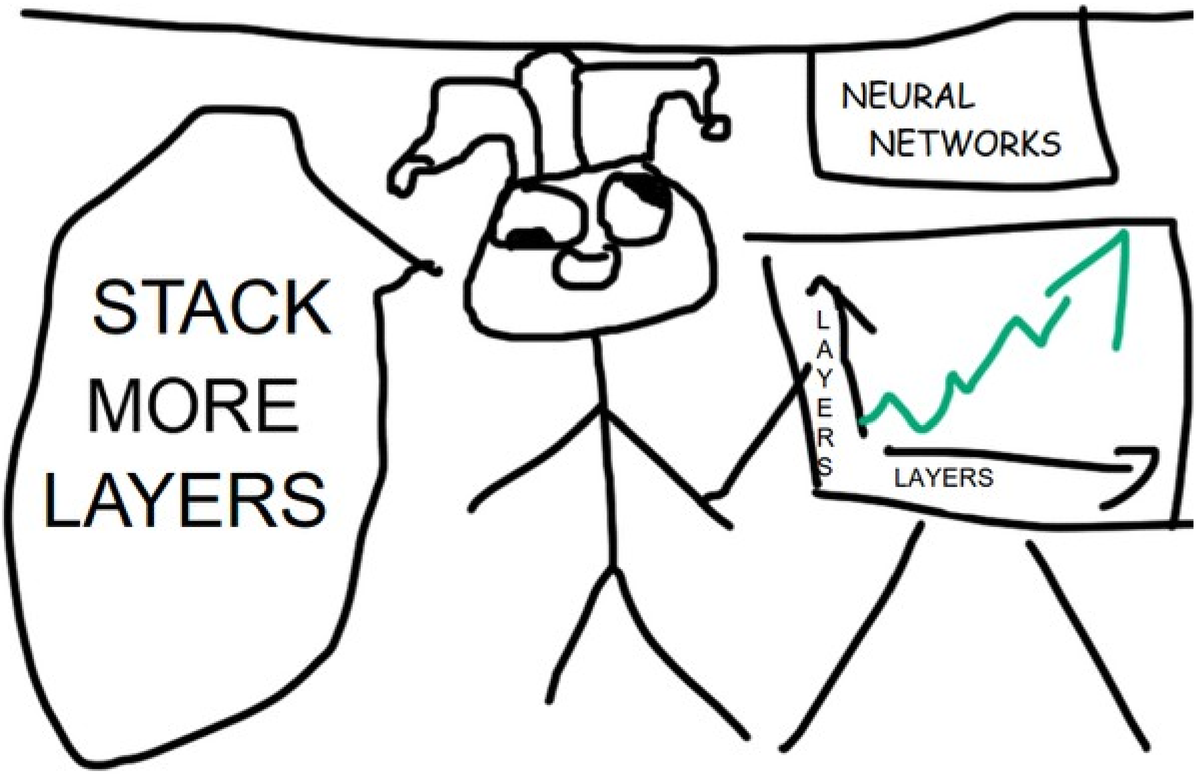
Minimizing reconstruction error

$$\|X - U \cdot V^T\| \to \min_{U,V}$$

Matrix decomposition

- A different perspective

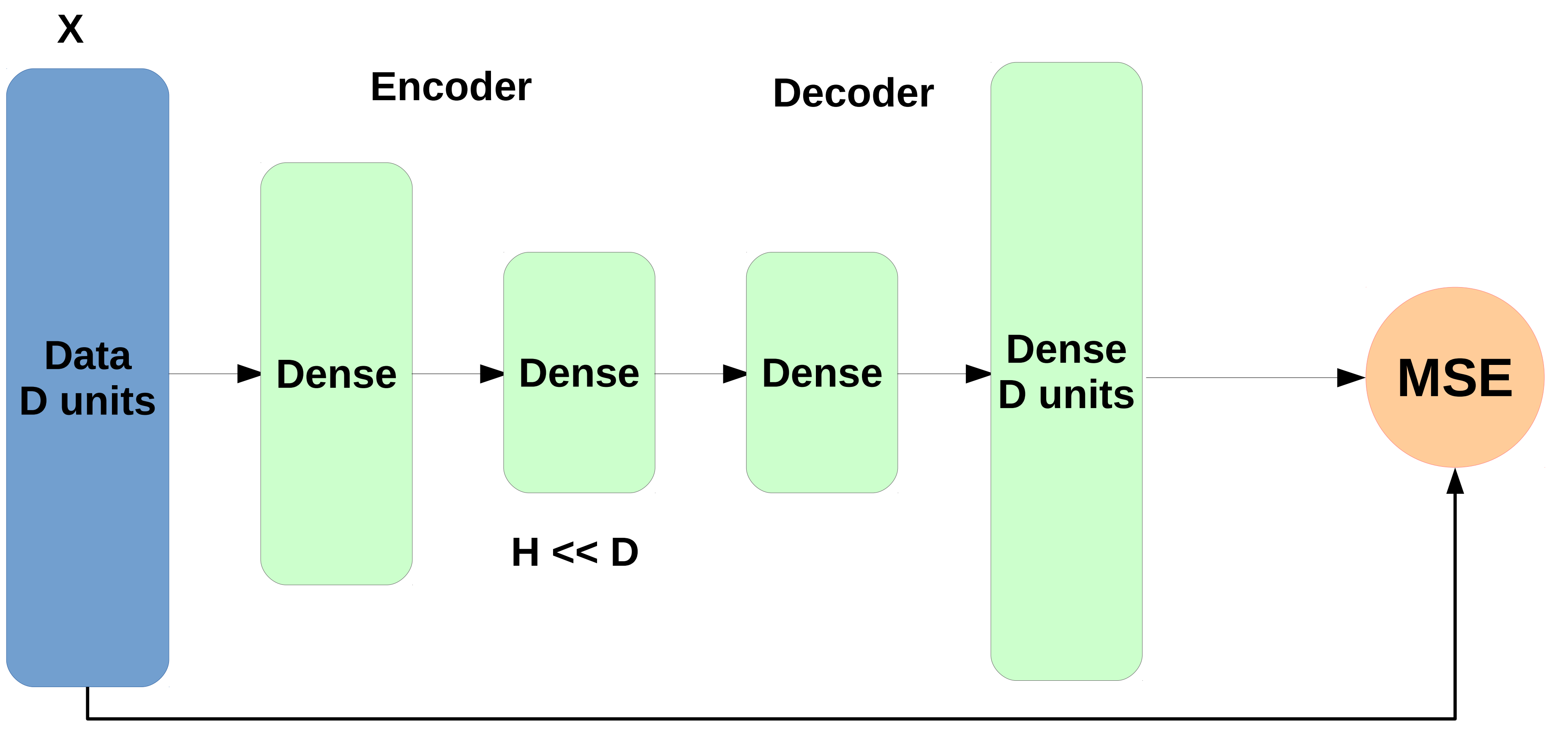




STACK MORE LAYERS
NEURAL NETWORKS
LAYERS
LAYERS

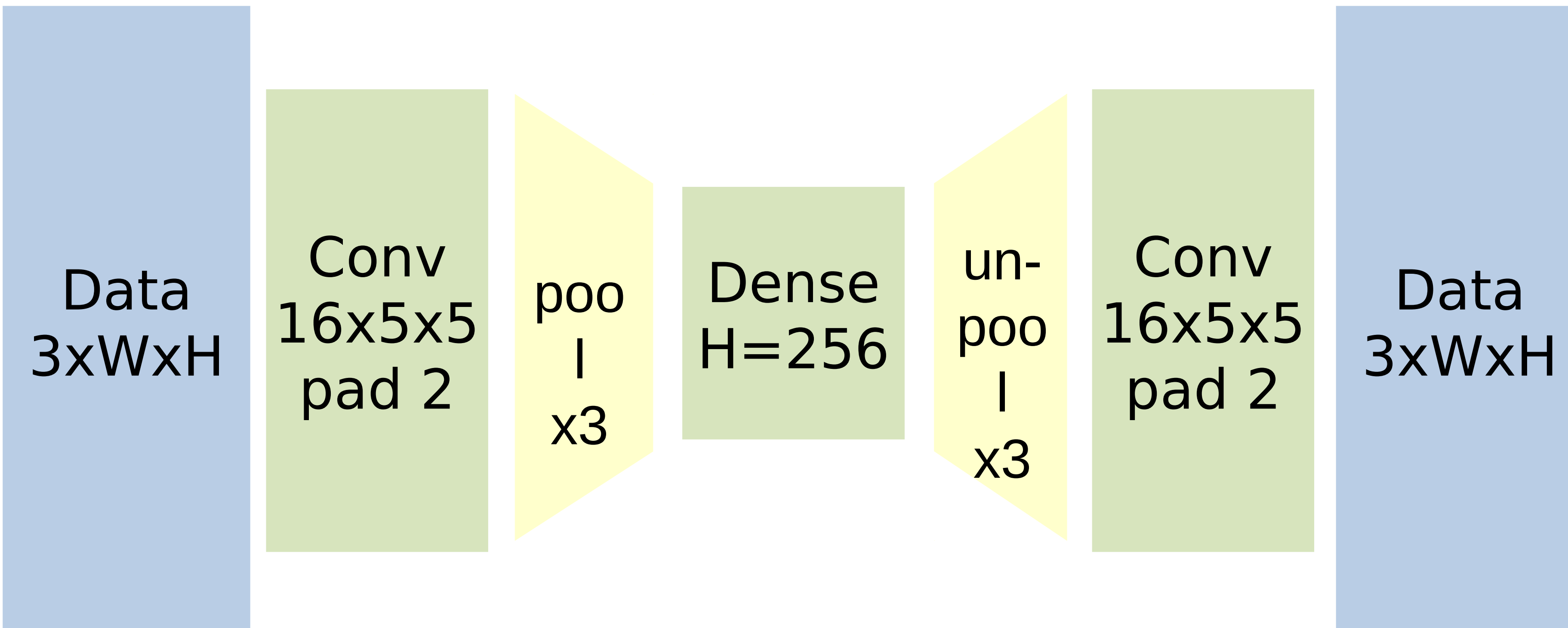
(kinda) Deep autoencoder

- Stack more layers!

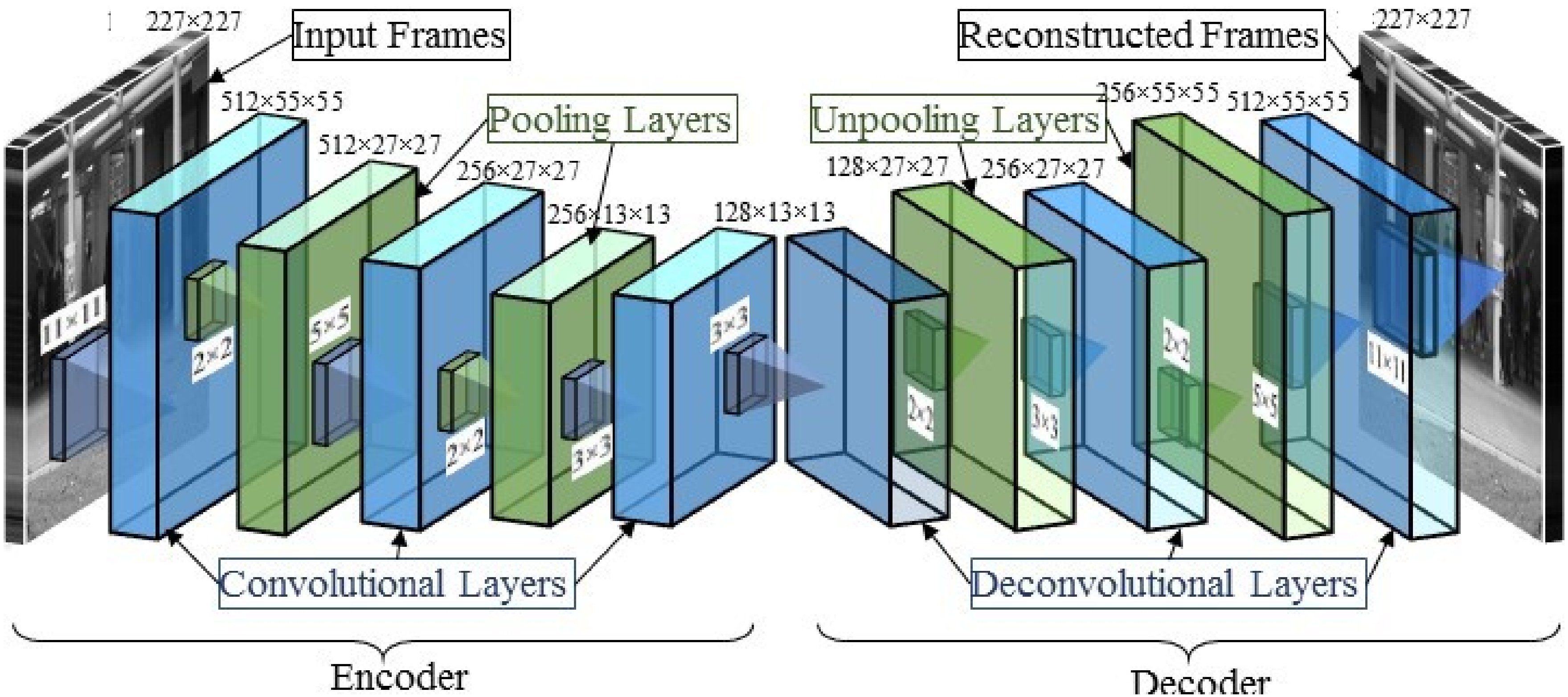


Quiz: What if data is an image?

Convolutional autoencoders



Fully-convolutional

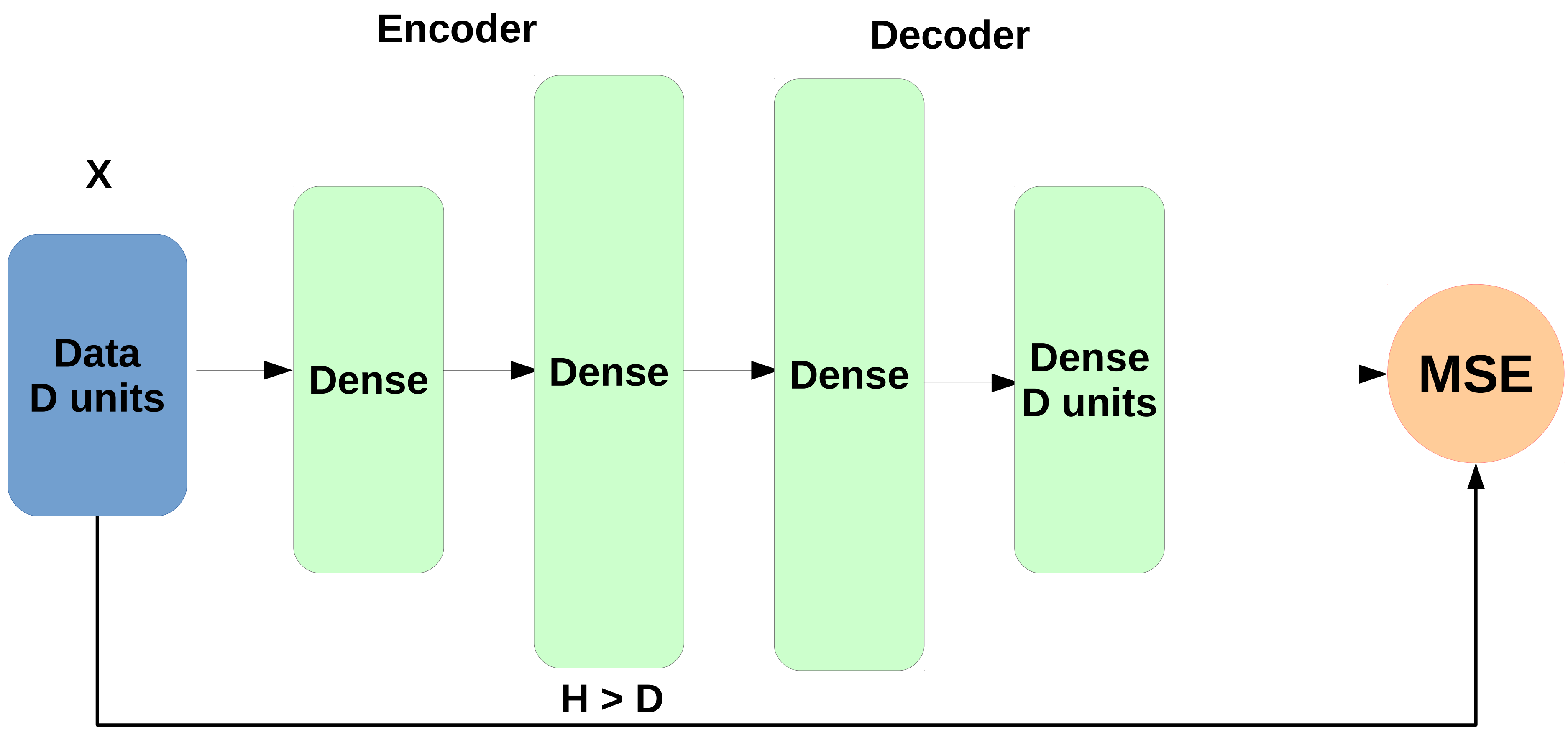


Why do we ever need that?

- Dimensionality reduction
  - |code| << |data|
- **Learn some great features!**
  - Before feeding data to your XGBoost

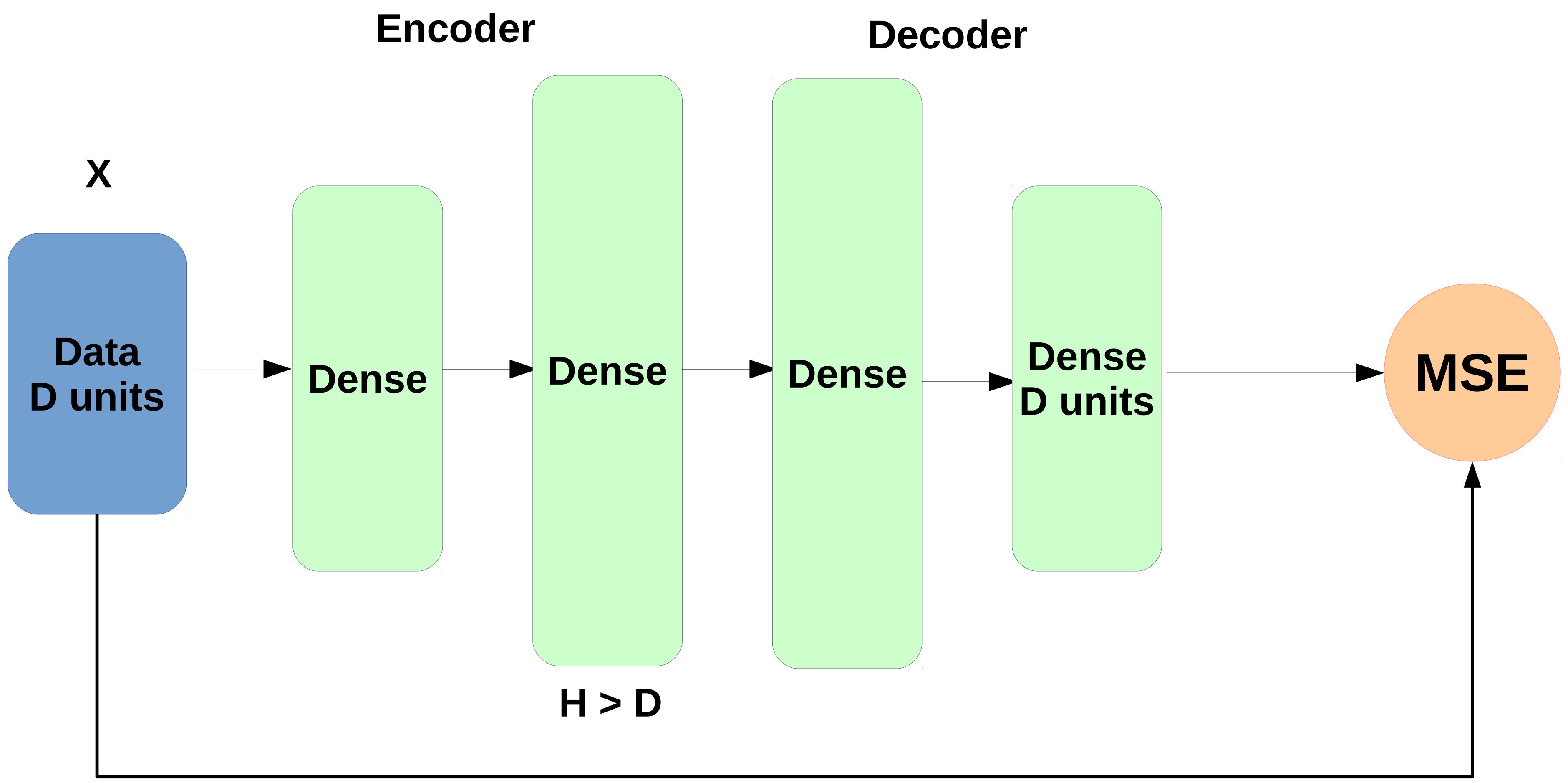
Expanding autoencoder

- Bigger/richer representation



Expanding autoencoder

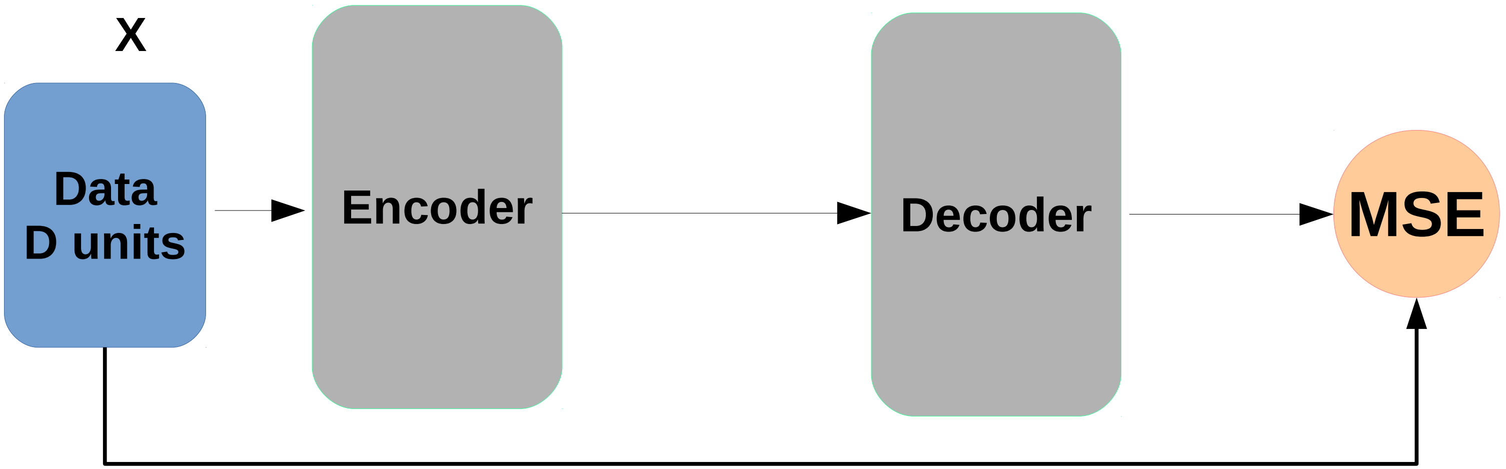
- Bigger/richer representation



Something's wrong with this guy. **Ideas?**

Expanding autoencoder

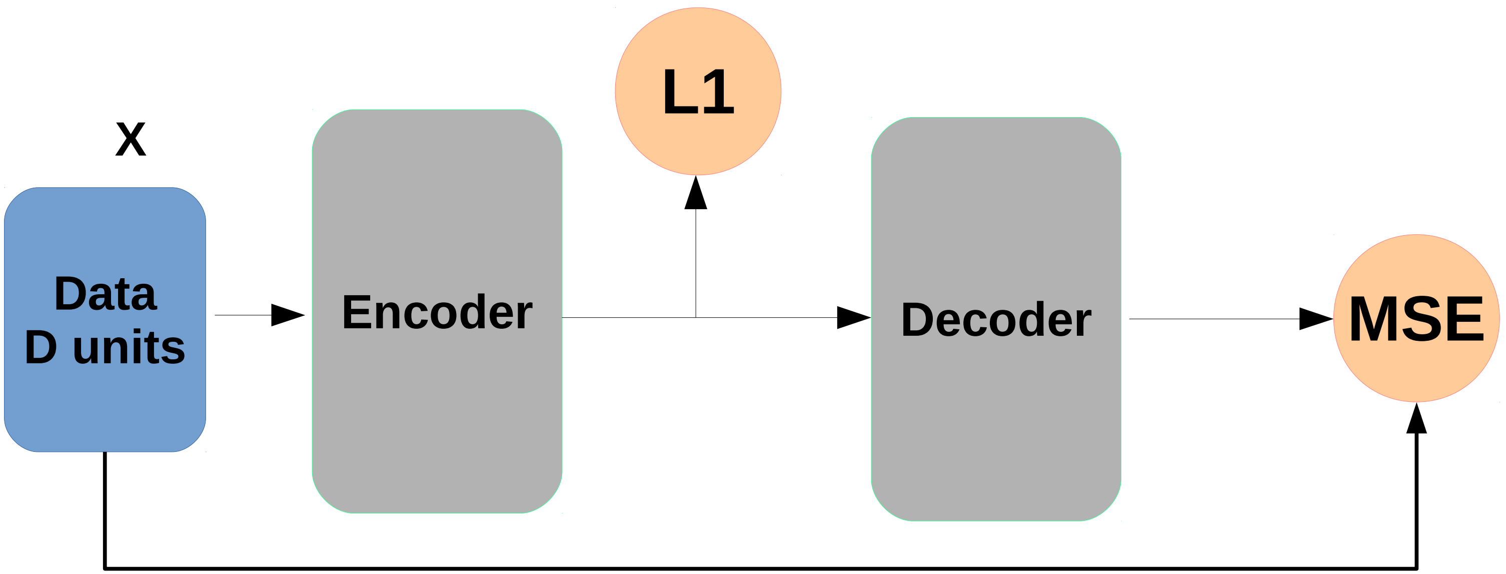
- Naive approach will learn identity function!
- Gotta regularize!



$$L = \| X - Dec(Enc(X)) \|$$

Sparse autoencoder

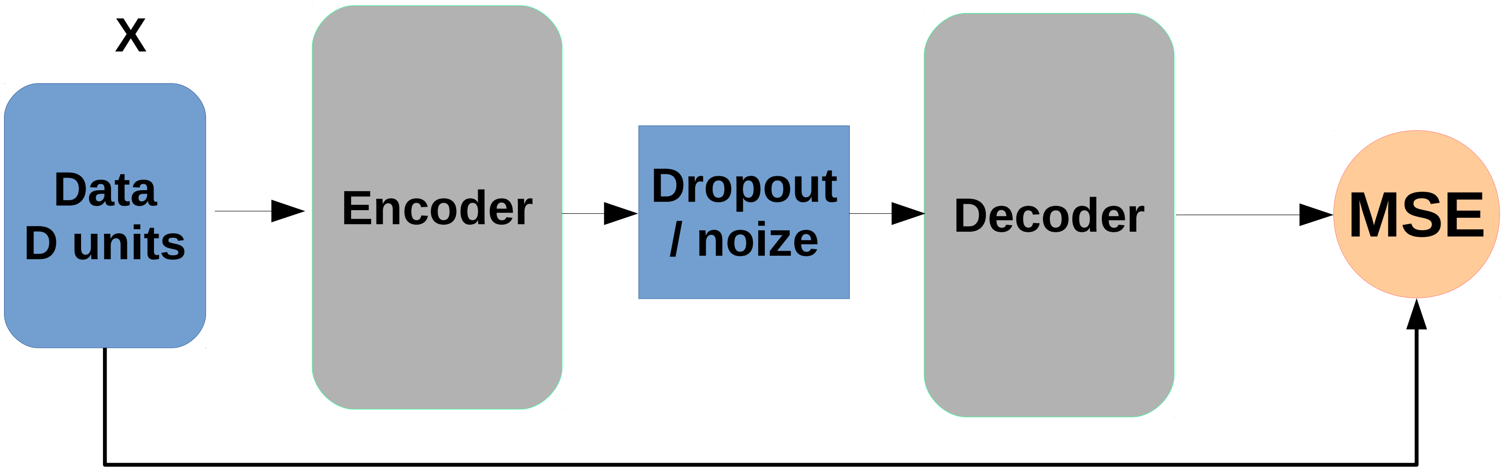
- Naive approach will learn identity function!
- Idea 1: L1 on **activations**, sparse code



$$L = \| X - Dec(Enc(X)) \| + \sum_i |Enc_i(X)|$$

Redundant autoencoder

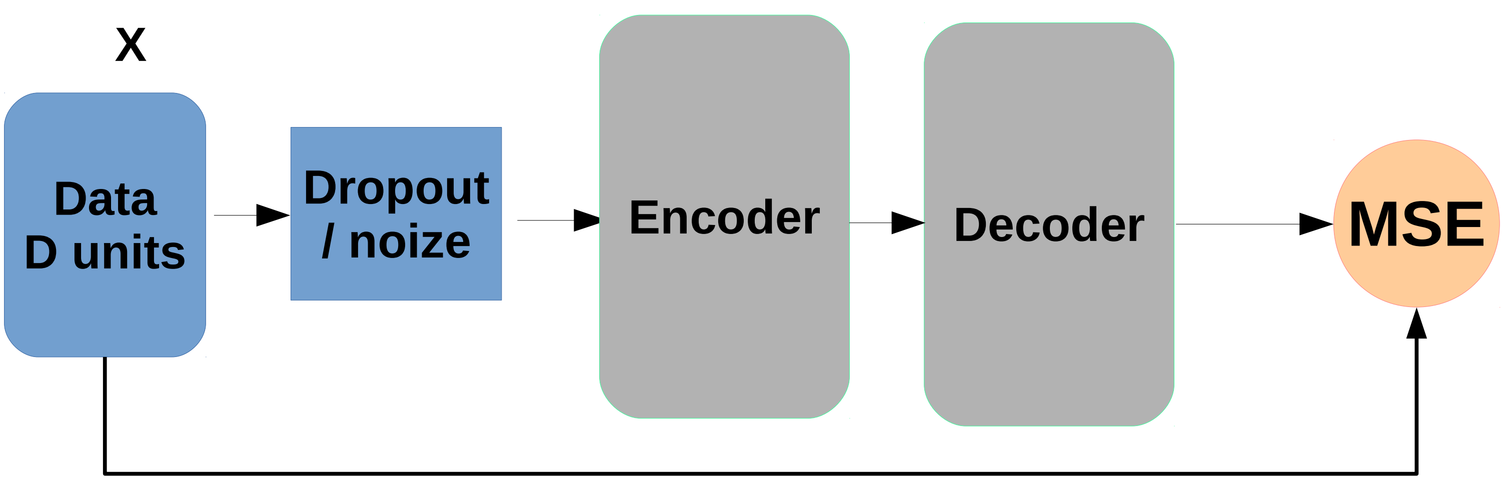
- Naive approach will learn identity function!
- Idea 2: noize/dropout, redundant code



$$L = \| X - Enc(Noize(Dec(X))) \|$$

Denoising autoencoder

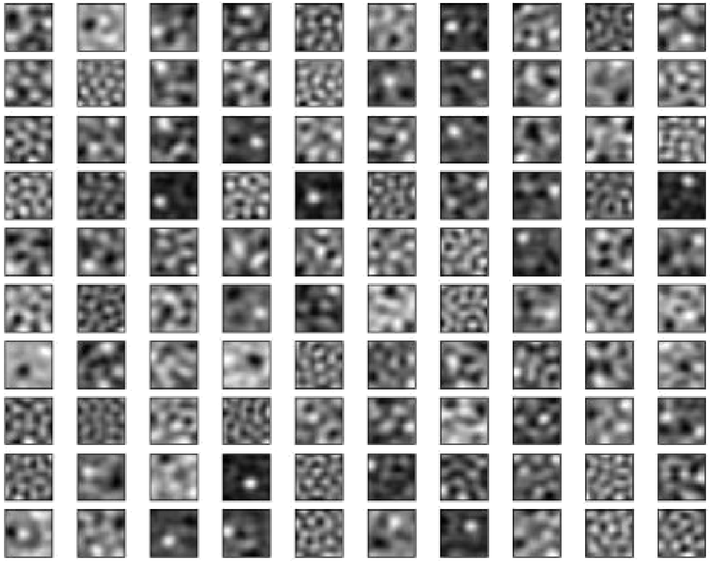
- Naive approach will learn identity function!
- Idea 3: distort input, learn to undo distortion



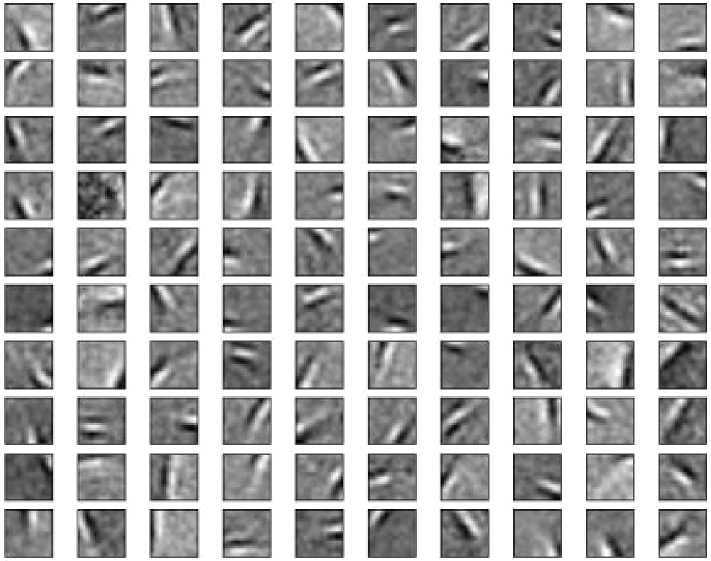
$$L = \| X - Enc(Dec(Noize(X))) \|$$

Sparse Vs Denoising

- Filter weights, 12x12 patches



Sparse AE



Denoizing AE

Actually meaningless :)

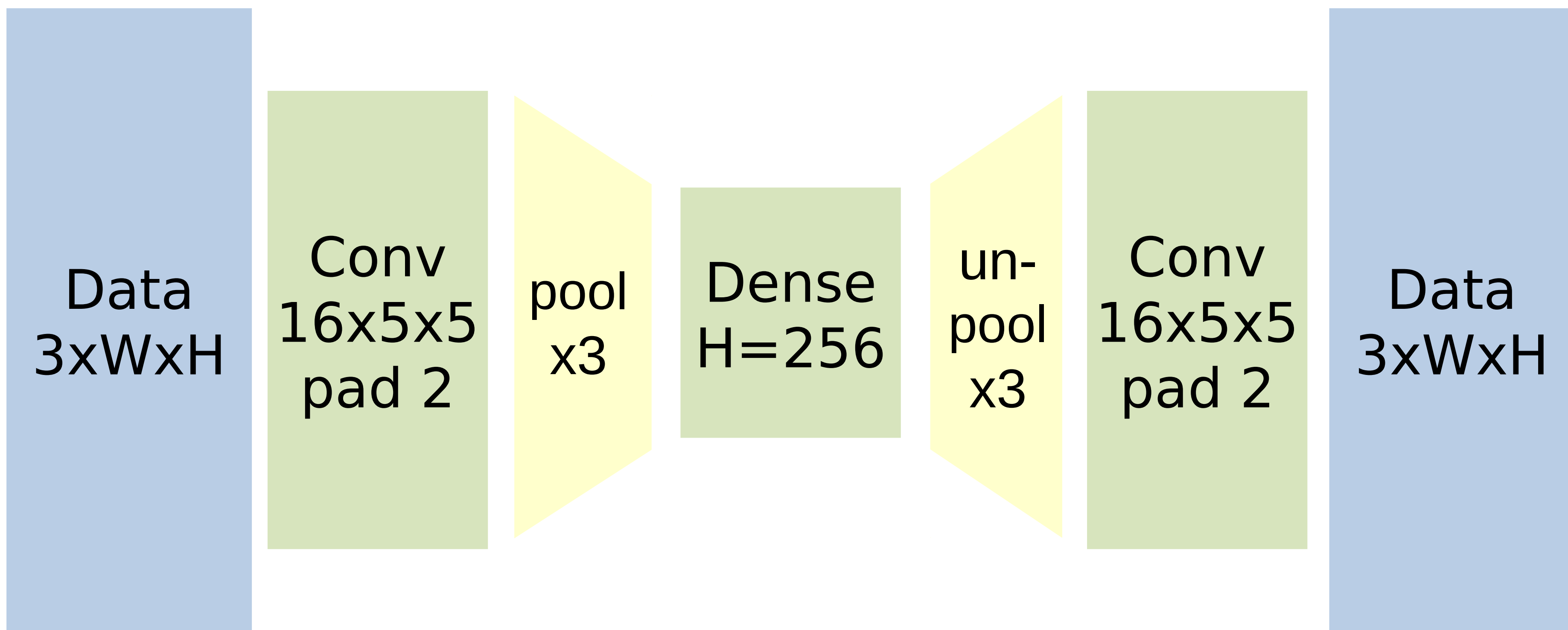
[Vincent et al. 2010]

Why do we ever need that?

- Dimensionality reduction
  - |code| << |data|
- Learn some great features!
  - Before feeding data to your XGBoost
- **Unsupervised pretraining**
  - Exploit unlabeled data to improve classifier

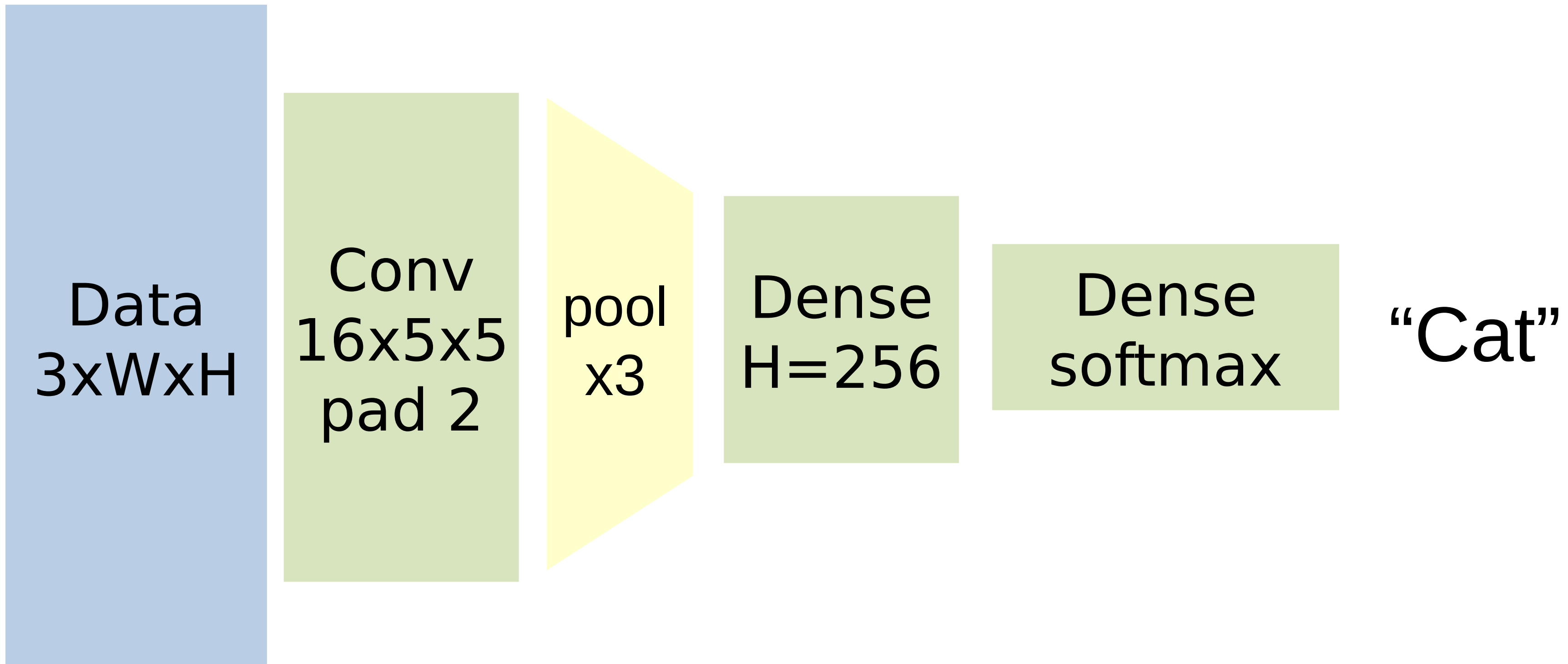
Unsupervised pre-training

Step 1: train autoencoder



Unsupervised pre-training

Use autoencoder as initialization

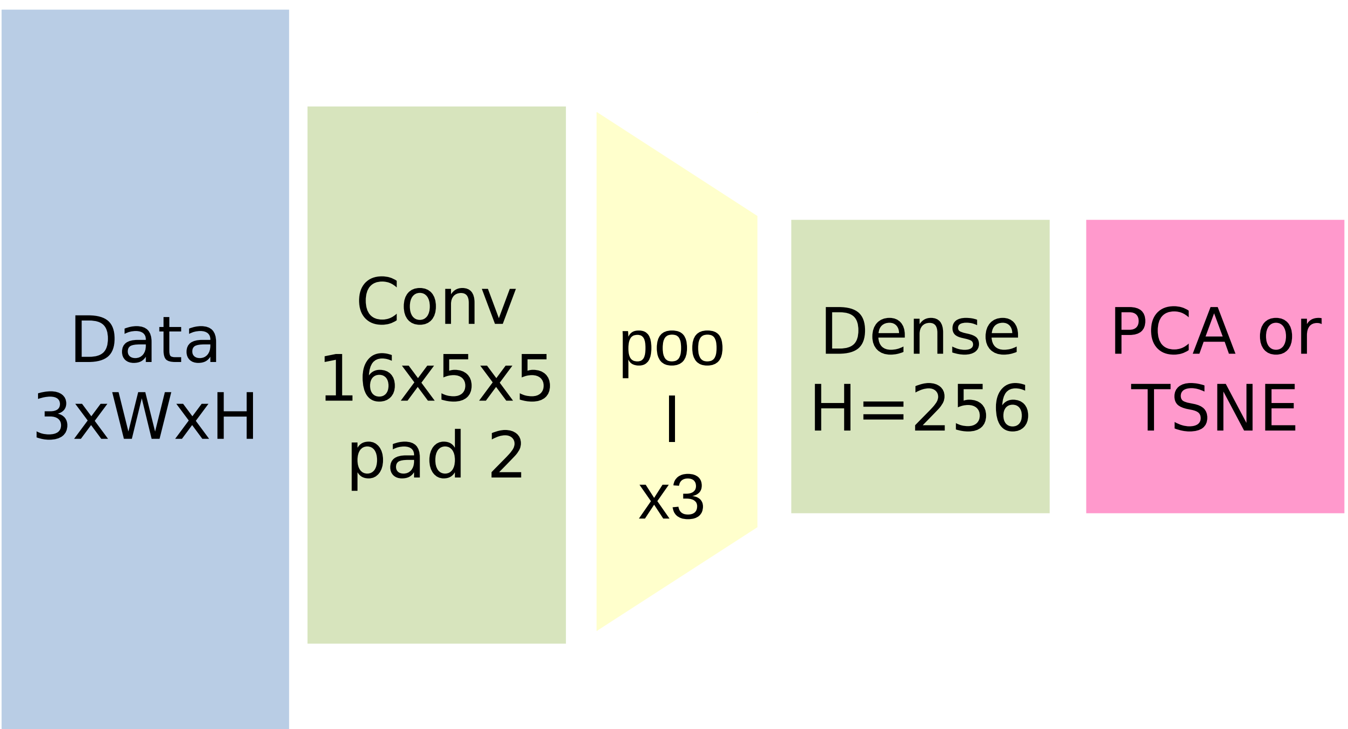


Why do we ever need that?

- Dimensionality reduction
  - |code| << |data|
- Learn some great features!
  - Before feeding data to your XGBoost
- Unsupervised pretraining
  - Exploit unlabeled data to improve classifier
- Visualizing data structure

Exploratory analysis

Visualize data in hidden space



Exploratory analysis

Visualize data in hidden space

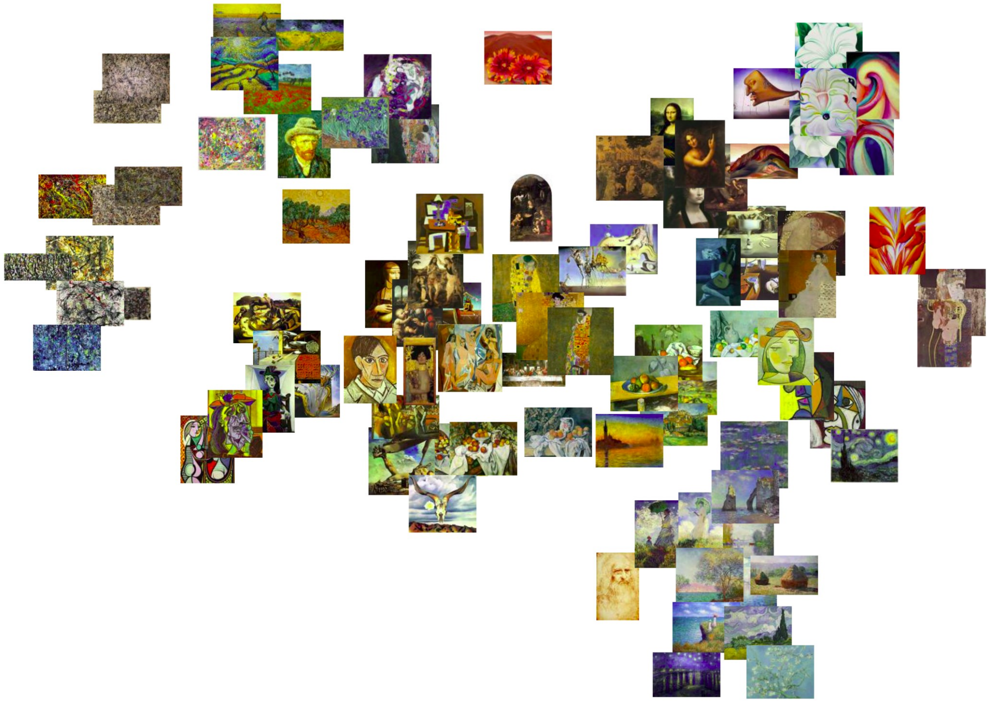


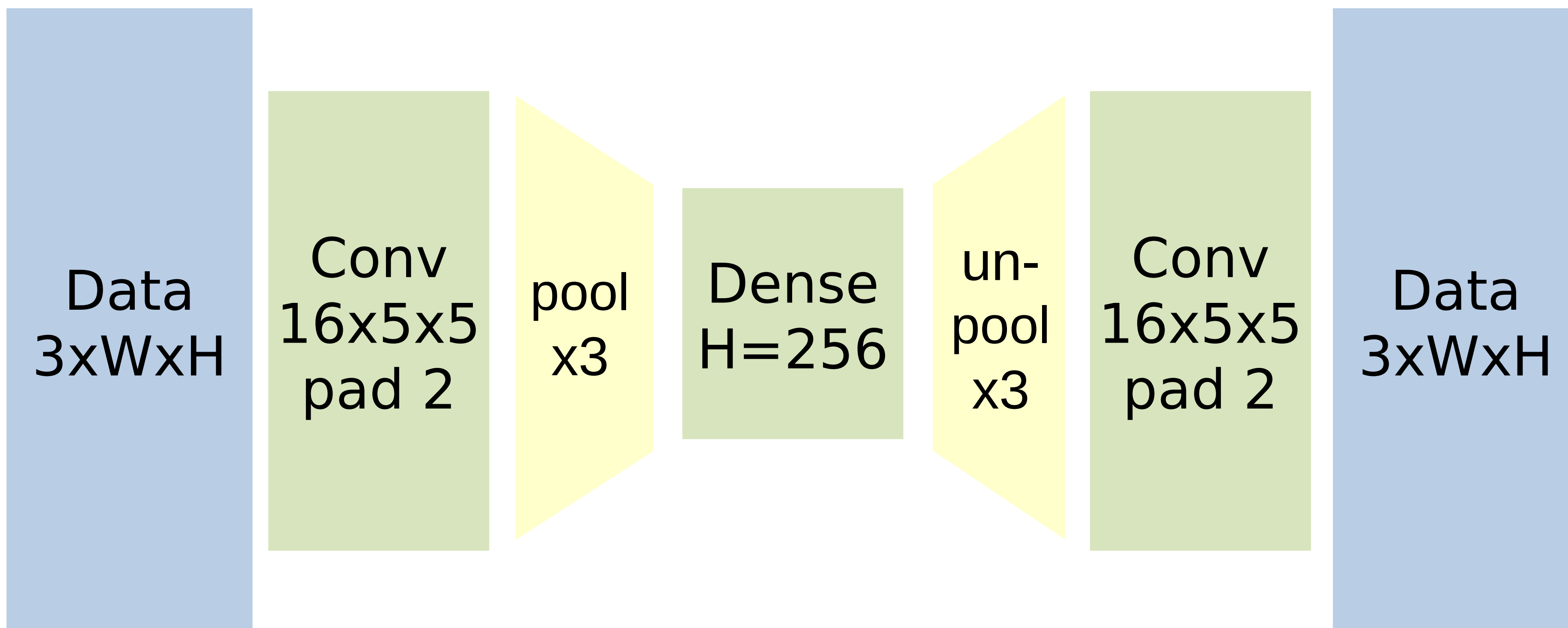
Image: https://razi.xyz/vgg2vec/picasso

Why do we ever need that?

- Dimensionality reduction
  - |code| << |data|
- Learn some great features!
  - Before feeding data to your XGBoost
- Unsupervised pretraining
  - Exploit unlabeled data to improve classifier
- Visualizing data structure
- **Generating new data**
  - Your trainable monte-carlo

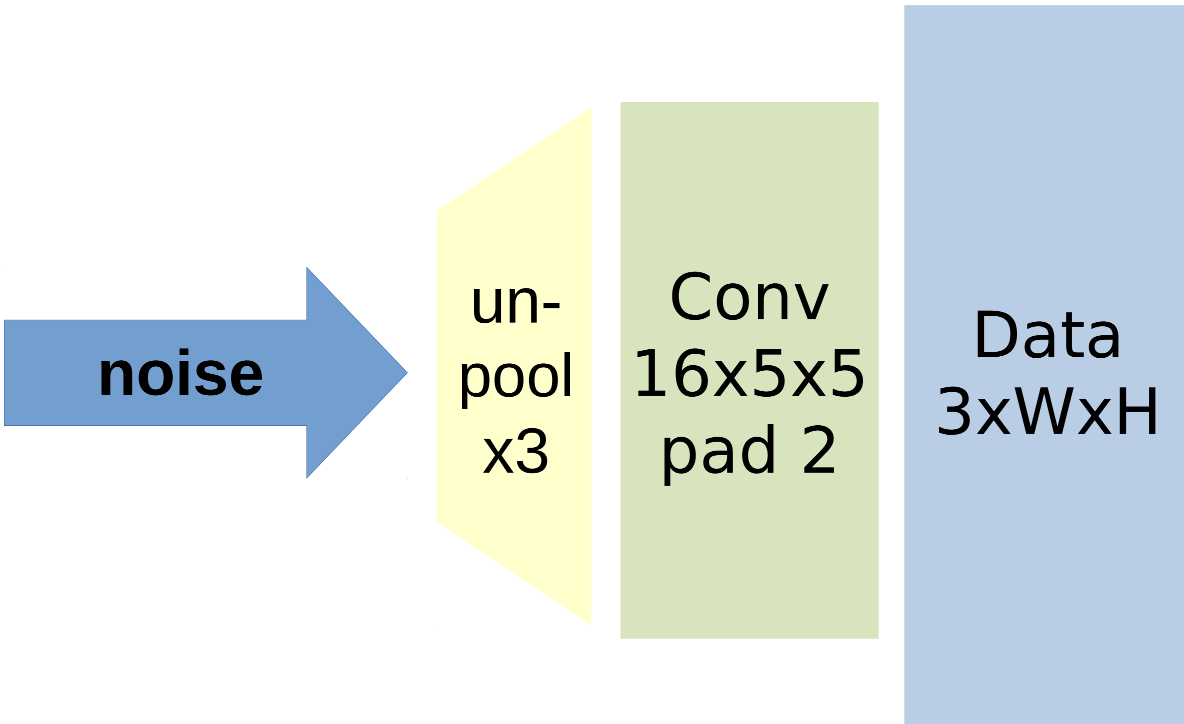
Generating images

Step 1: train autoencoder



Generating images

Step 2: use decoder to generate data



Disclaimer: this isn't the state of the art approach

Generating images

Step 2: use decoder to generate data

Img: decoded trajectories from hidden space

Image morphing with AE

Idea:

- If Enc(image1) = c1

  Enc(image2) = c2

- Than maybe (c1+c2)/2 is a semantic average of the two images

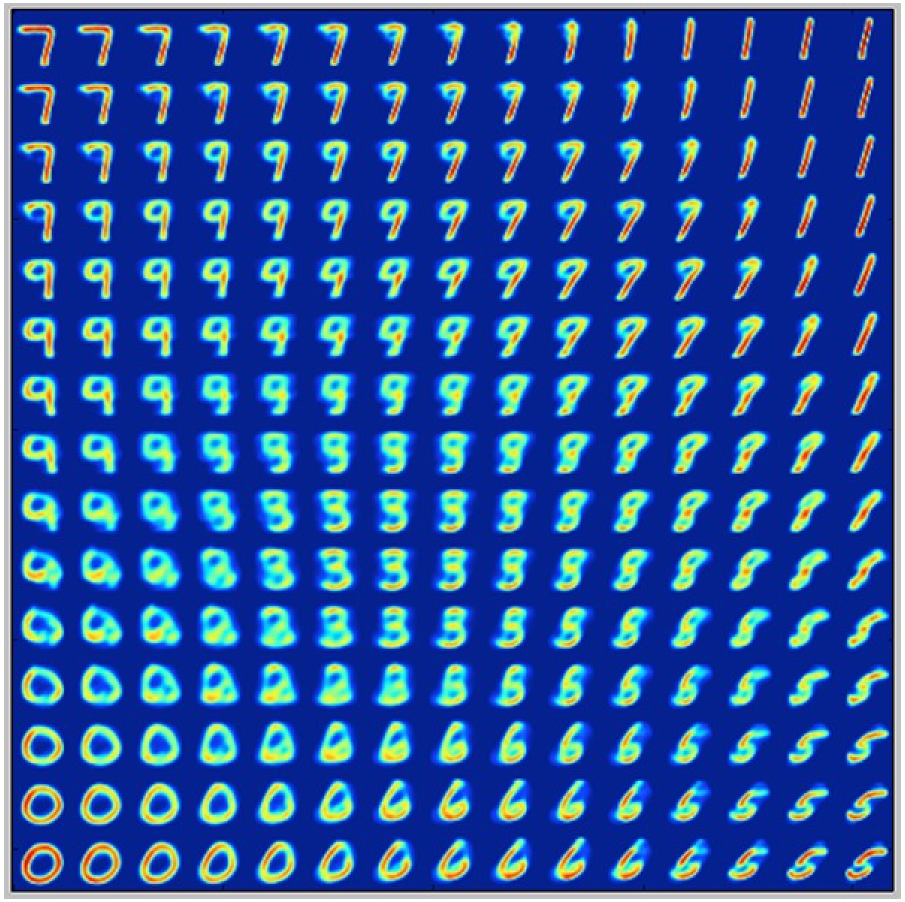
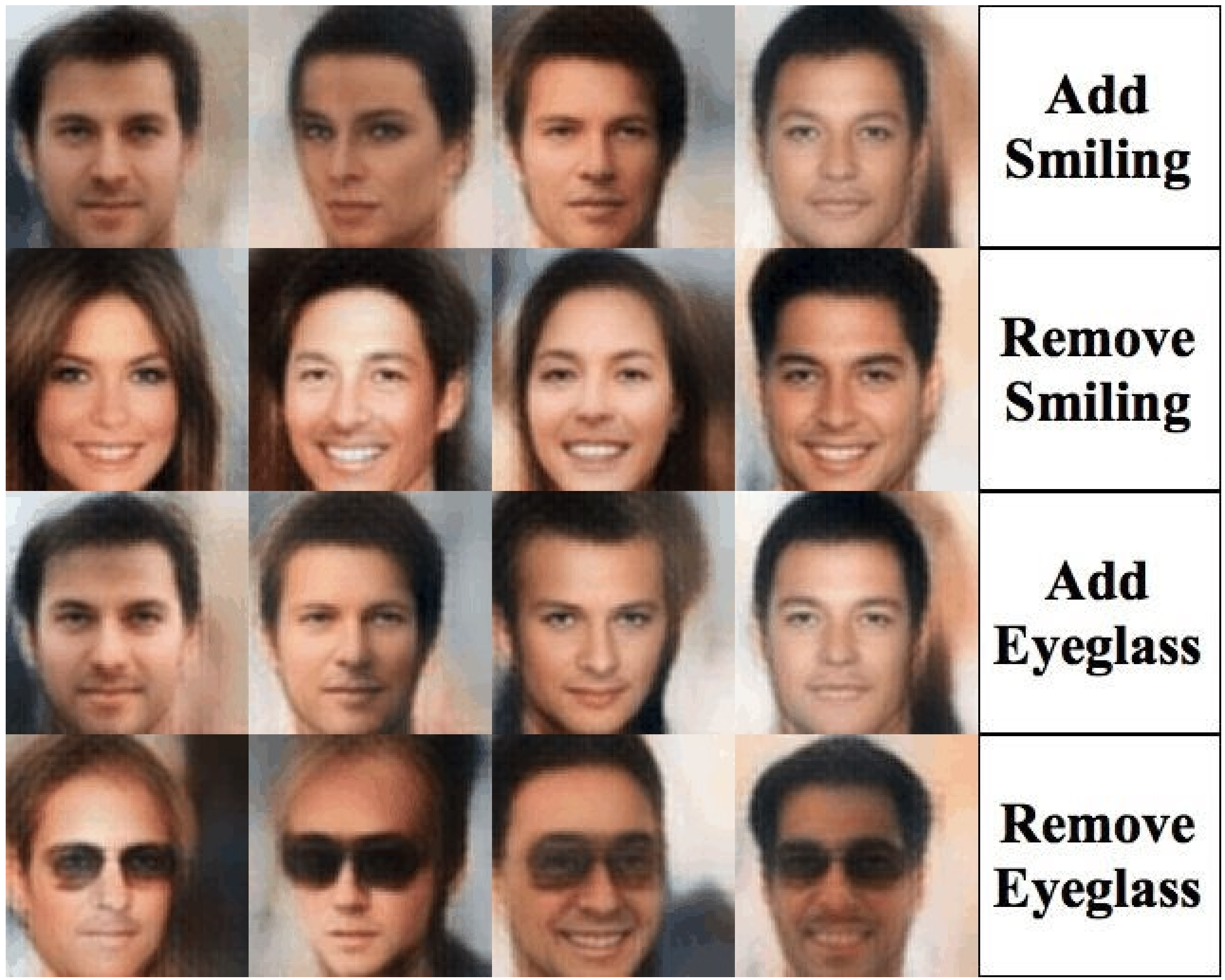


Image morphing with AE

Idea:

- Look for a common direction vector for "add mustache" or "add age" changes.
- Apply to new images

Image morphing with AE



Brace yourselves