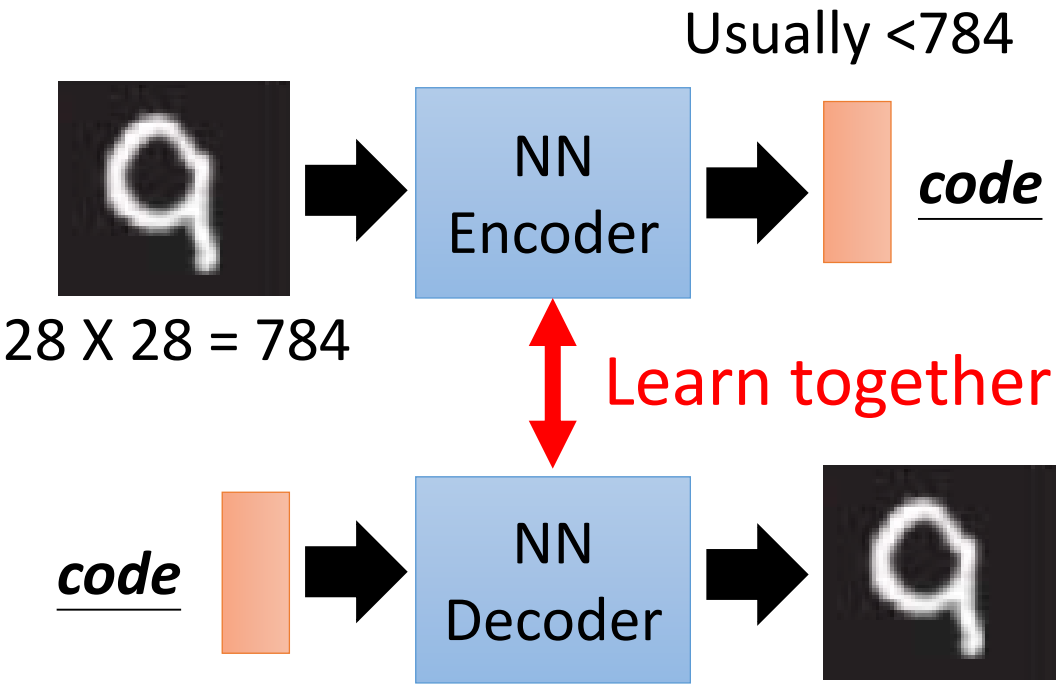
Unsupervised Learning:
Deep Auto-encoder

Unsupervised Learning

“We expect unsupervised learning to become far more important in the longer term. Human and animal learning is largely unsupervised: we discover the structure of the world by observing it, not by being told the name of every object.”
– LeCun, Bengio, Hinton, Nature 2015

As I've said in previous statements: most of human and animal learning is unsupervised learning. If intelligence was a cake, unsupervised learning would be the cake, supervised learning would be the icing on the cake, and reinforcement learning would be the cherry on the cake. We know how to make the icing and the cherry, but we don't know how to make the cake.
- Yann LeCun, March 14, 2016 (Facebook)

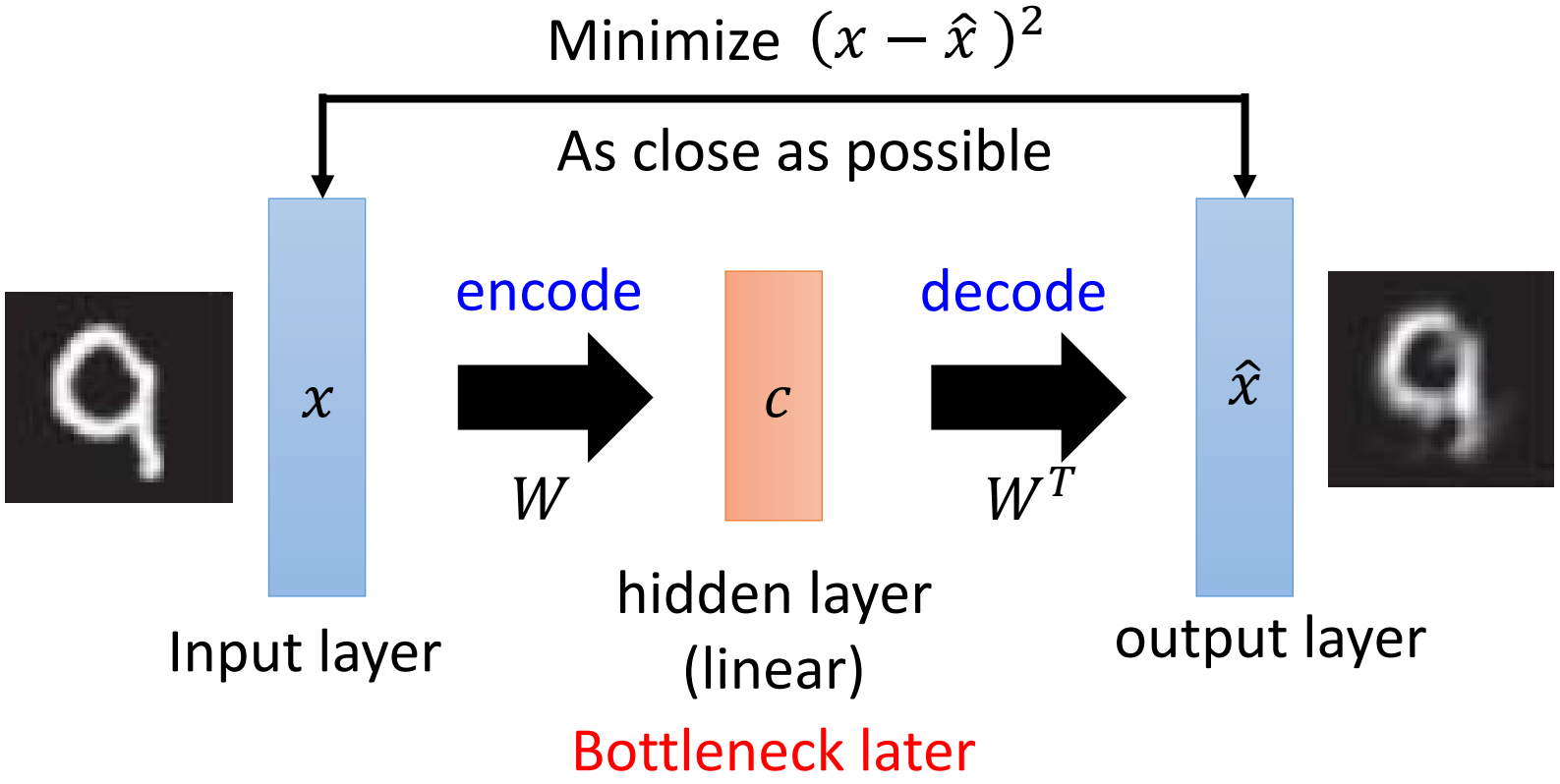
Auto-encoder



Compact representation of the input object

Can reconstruct the original object

Recap: PCA

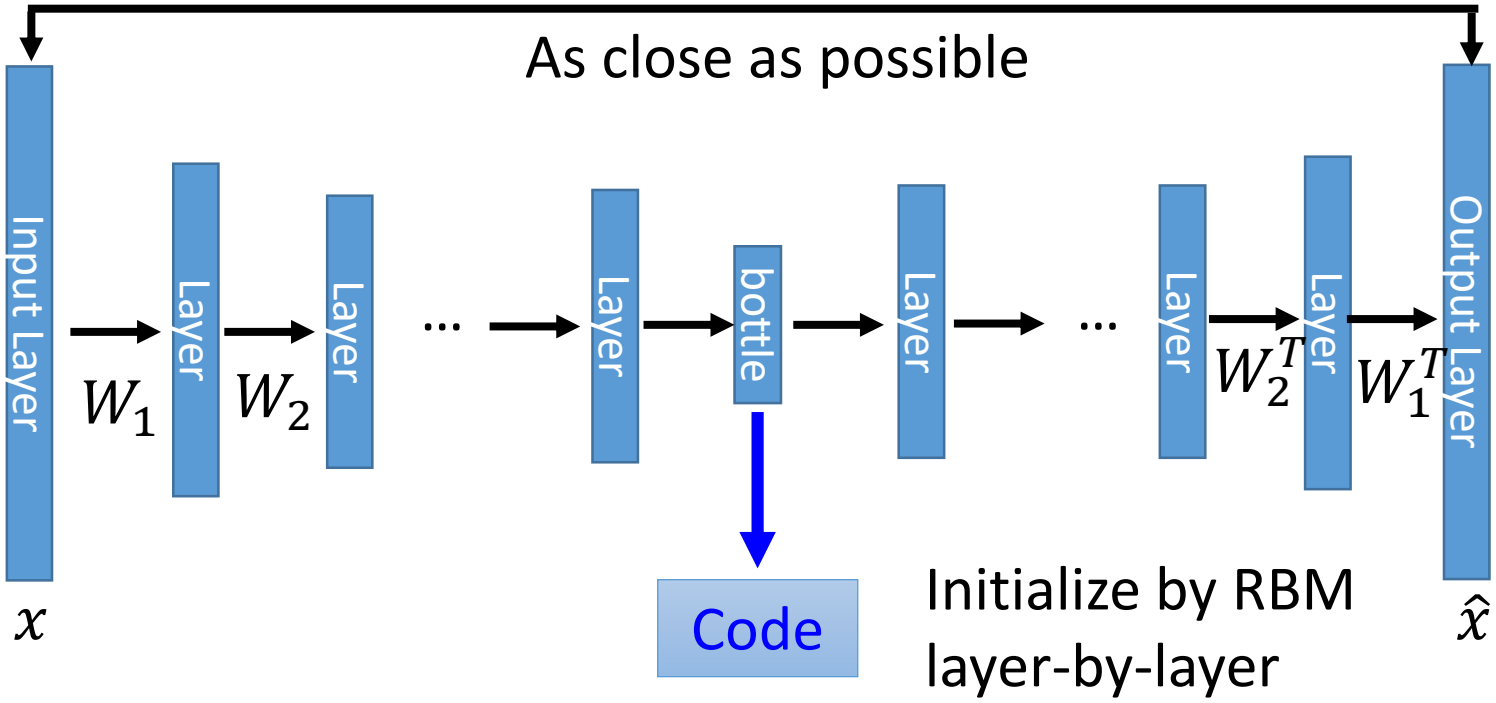


Output of the hidden layer is the code

Deep Auto-encoder

Symmetric is not necessary.

- Of course, the auto-encoder can be deep



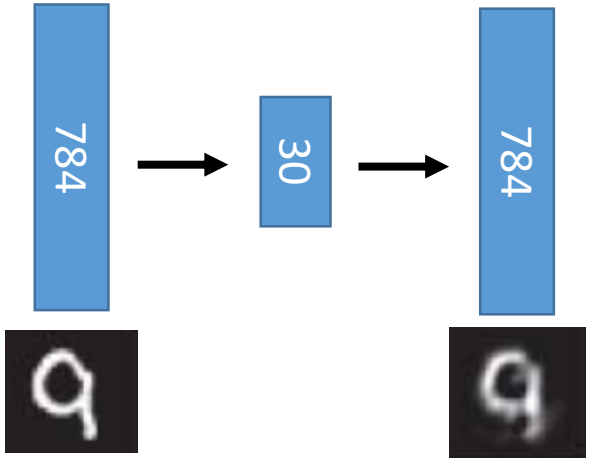
Reference: Hinton, Geoffrey E., and Ruslan R. Salakhutdinov. "Reducing the dimensionality of data with neural networks." *Science* 313.5786 (2006): 504-507

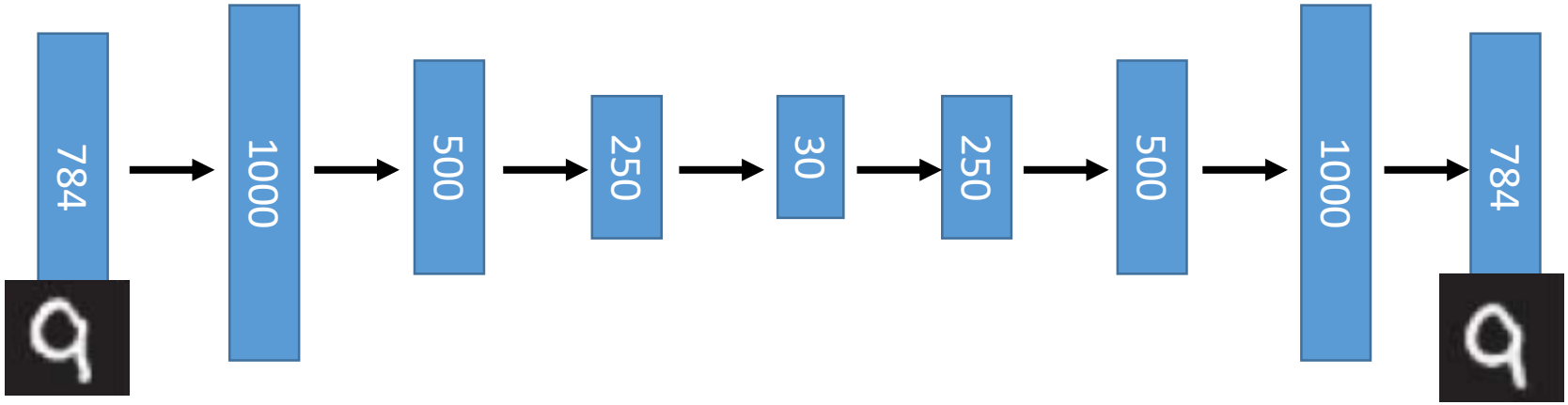
Deep Auto-encoder

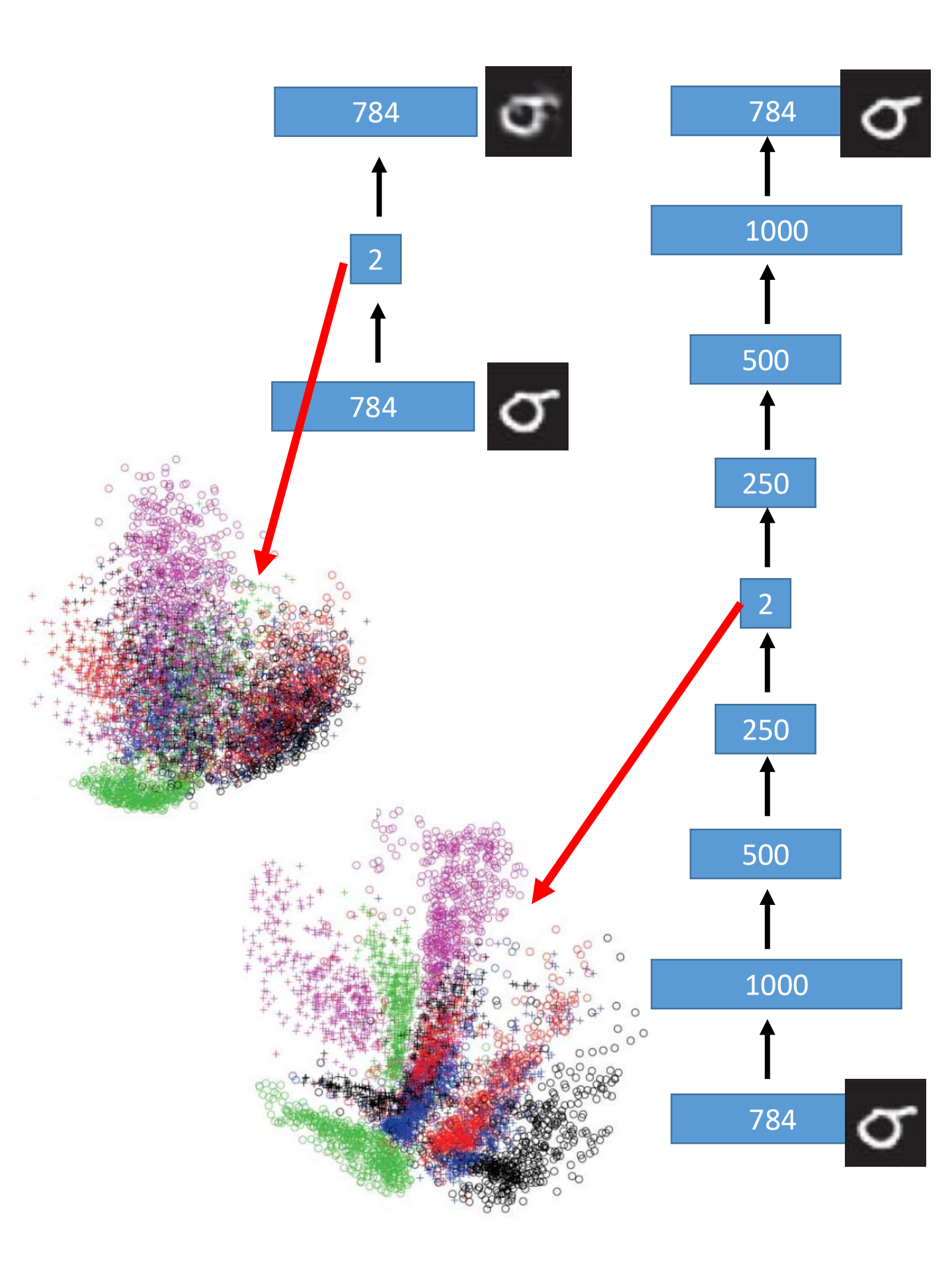
Original Image

PCA

Deep Auto-encoder





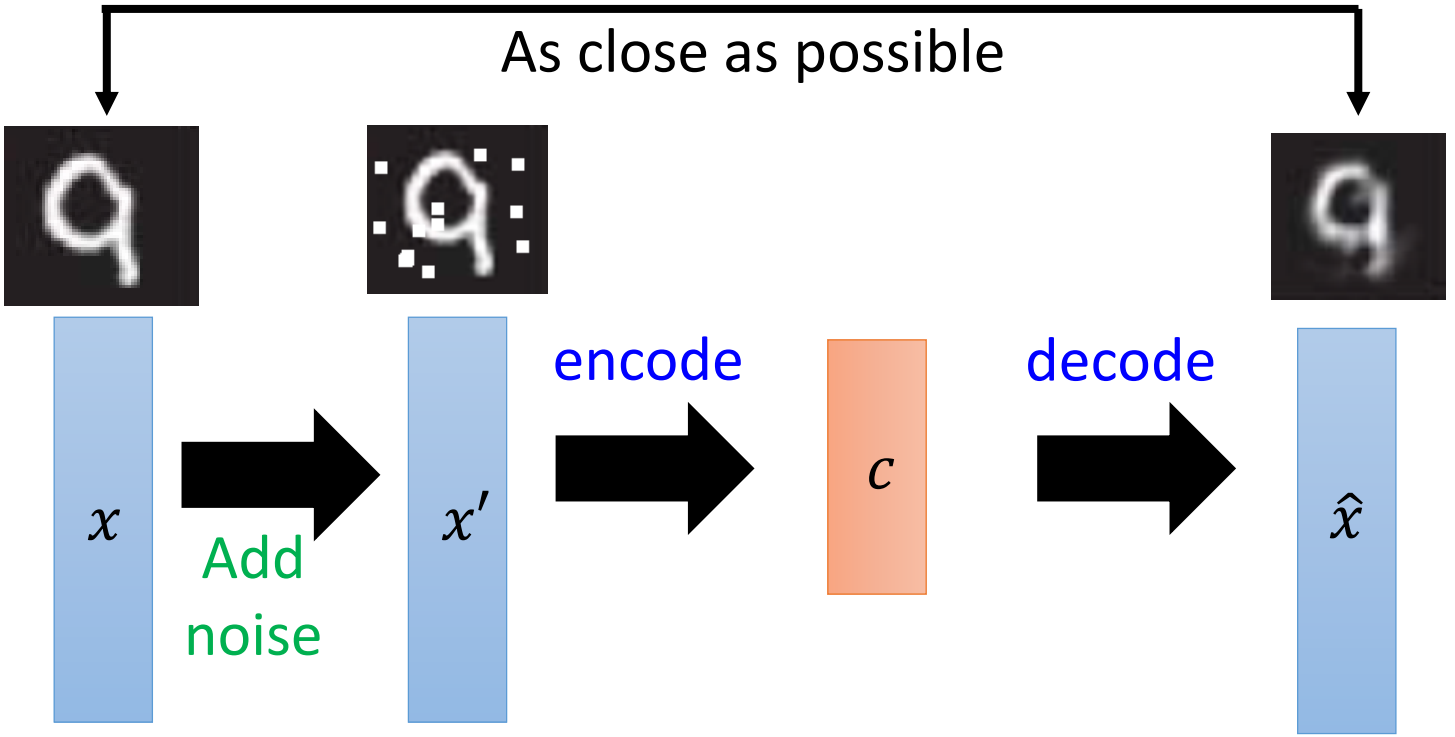

784
2
784
784
1000
500
250
2
250
500
1000
784

More: Contractive auto-encoder

Auto-encoder

Ref: Rifai, Salah, et al. "Contractive auto-encoders: Explicit invariance during feature extraction." *Proceedings of the 28th International Conference on Machine Learning (ICML-11)*. 2011.

- De-noising auto-encoder

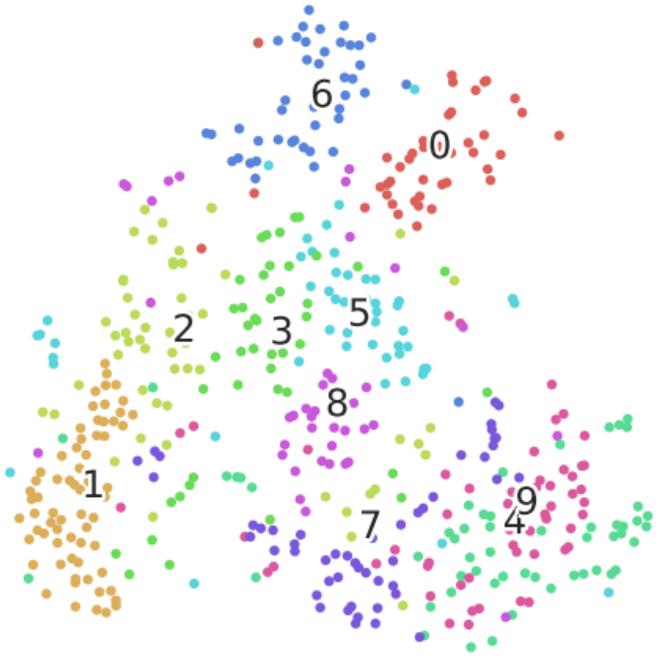


Vincent, Pascal, et al. "Extracting and composing robust features with denoising autoencoders." *ICML,* 2008.

Deep Auto-encoder - Example

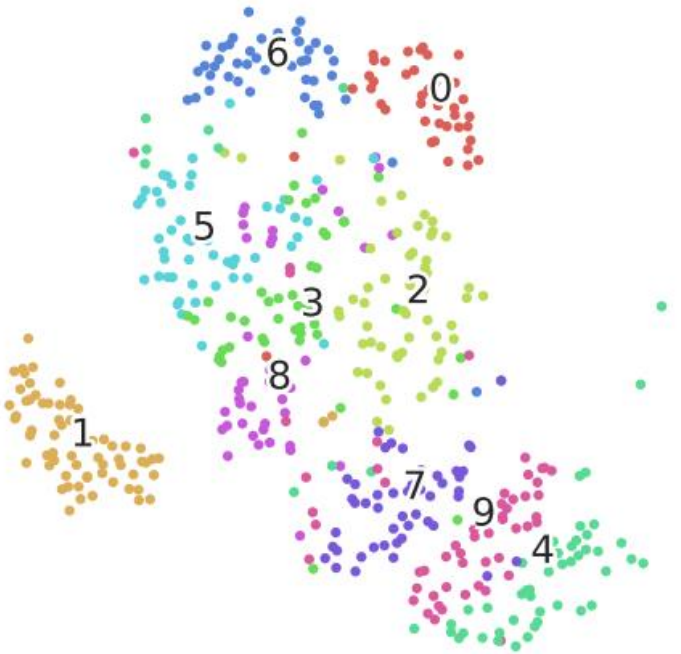
NN Encoder

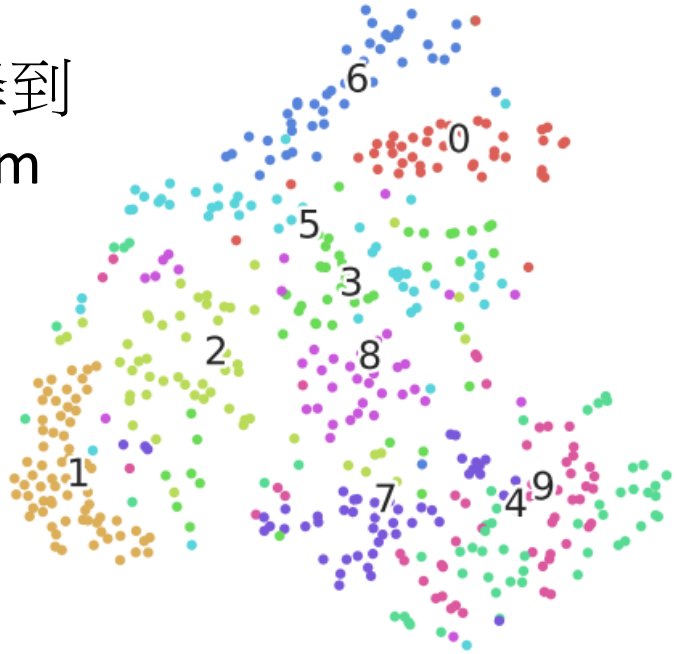
c



Pixel -> tSNE

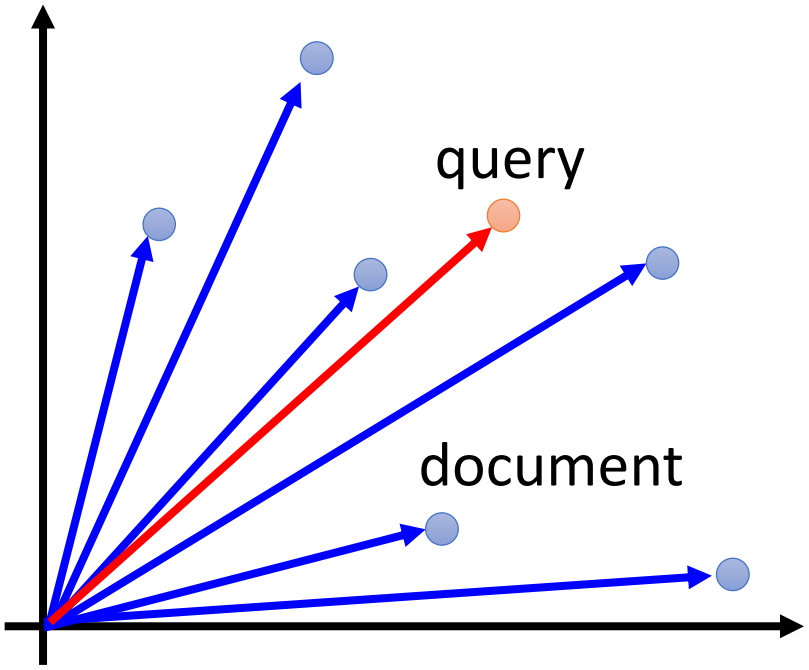
PCA 降到 32-dim





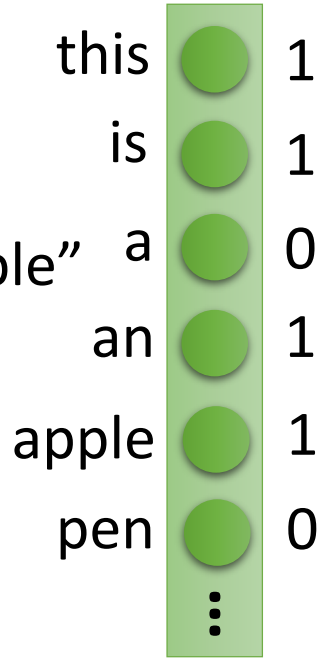
Auto-encoder – Text Retrieval

Vector Space Model



Bag-of-word

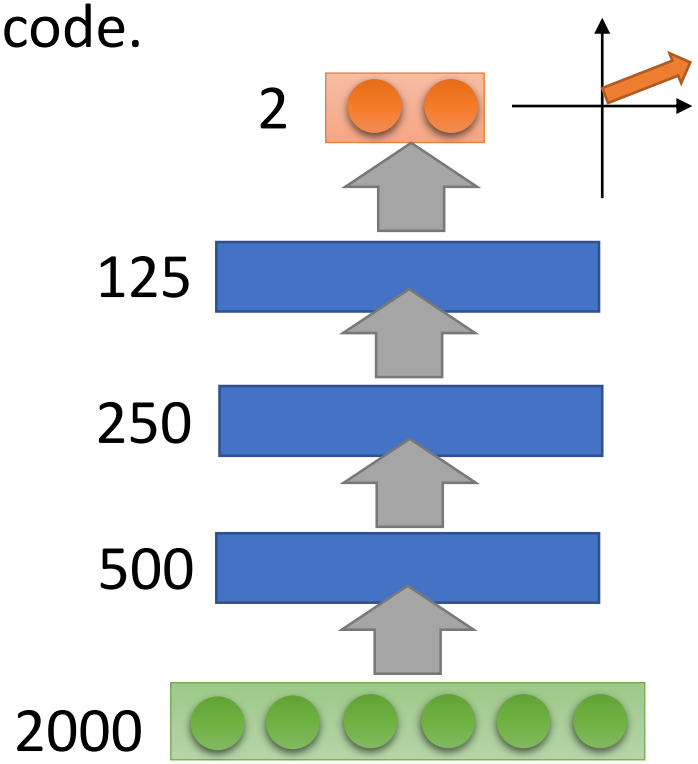
word string:
"This is an apple"



Semantics are not considered.

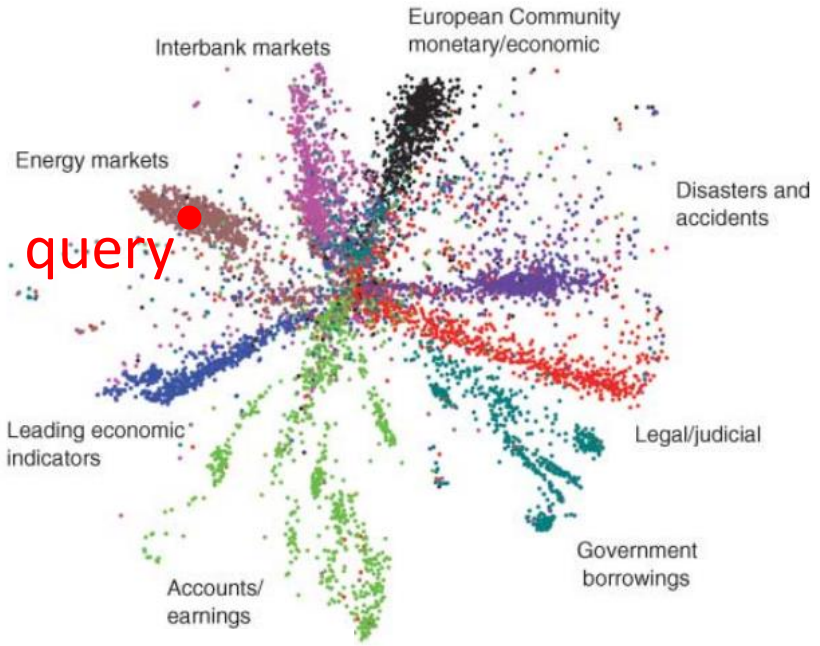
Auto-encoder – Text Retrieval

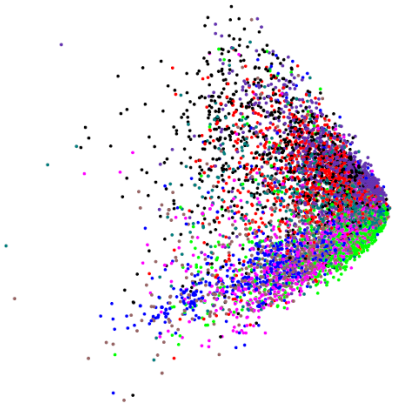
The documents talking about the same thing will have close code.



Bag-of-word

(document or query)





LSA: project documents to 2 latent topics

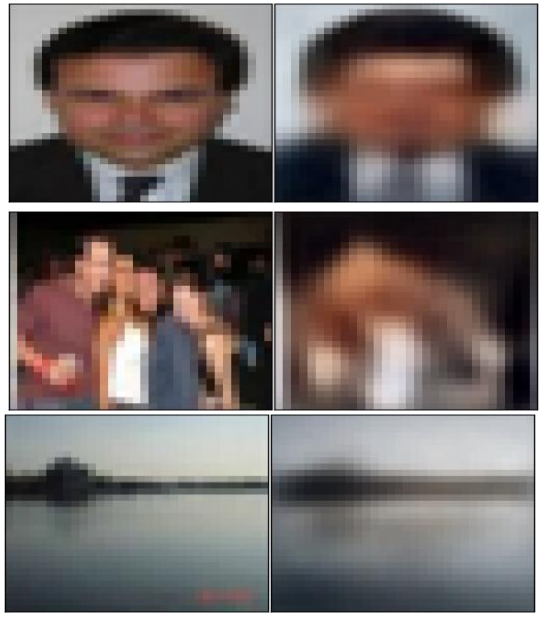
Auto-encoder – Similar Image Search

Retrieved using Euclidean distance in pixel intensity space

(Images from Hinton's slides on Coursera)

Reference: Krizhevsky, Alex, and Geoffrey E. Hinton. "Using very deep autoencoders for content-based image retrieval." *ESANN*. 2011.

Auto-encoder – Similar Image Search



32x32

8192

4096

2048

1024

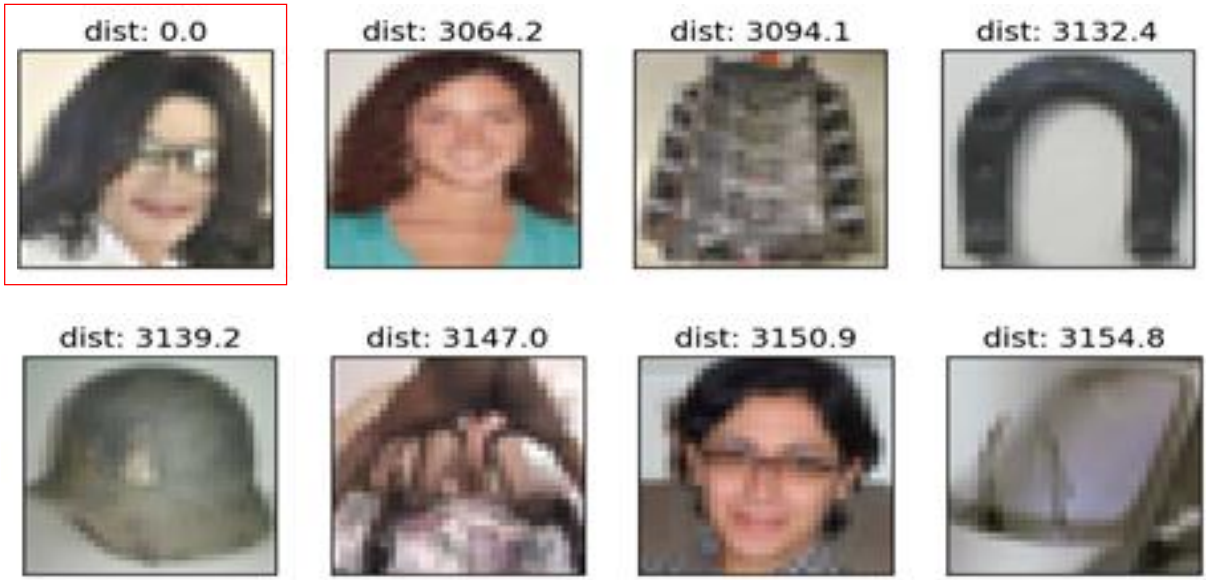
512

code

256

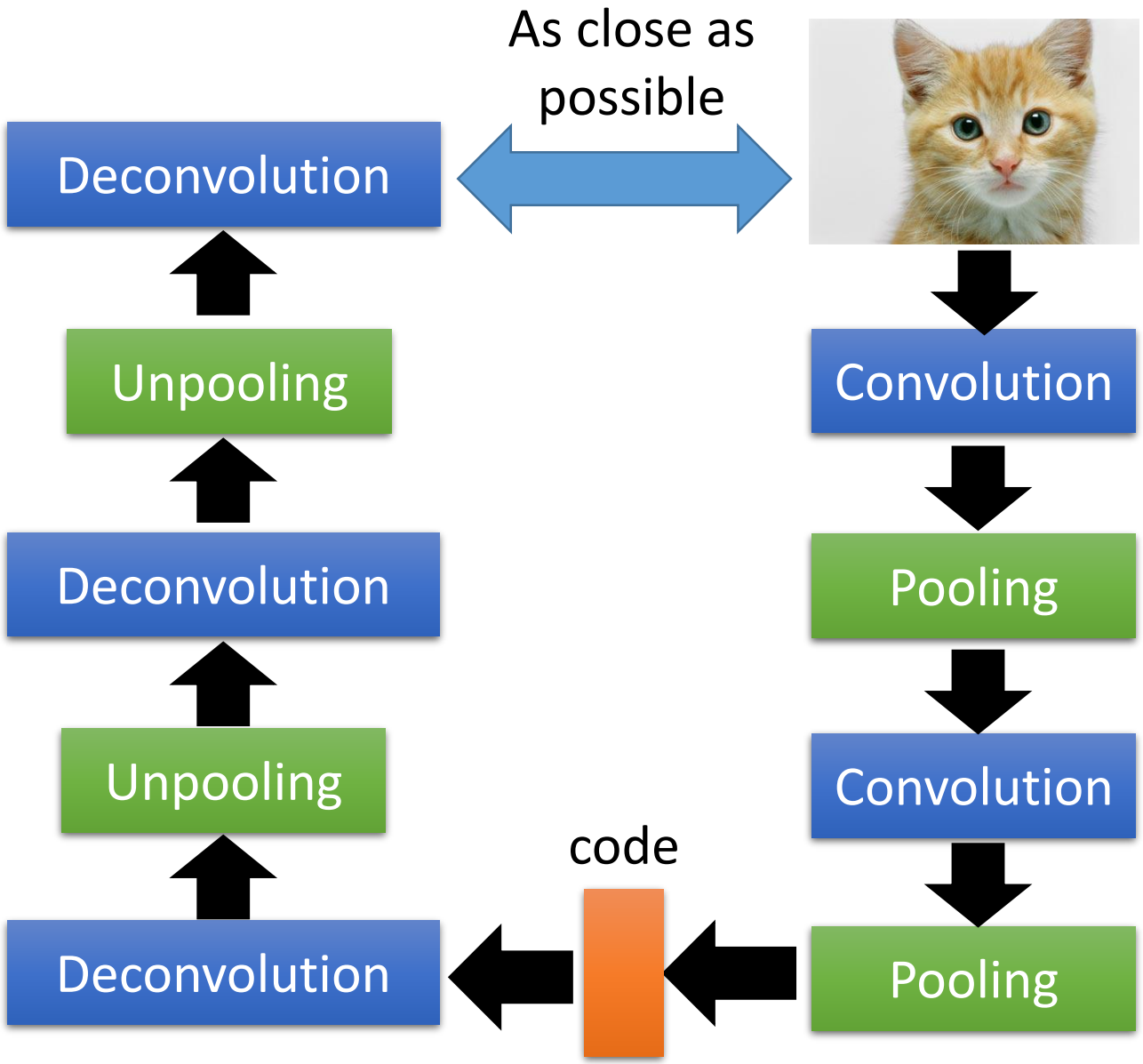
(crawl millions of images from the Internet)

Retrieved using Euclidean distance in pixel intensity space

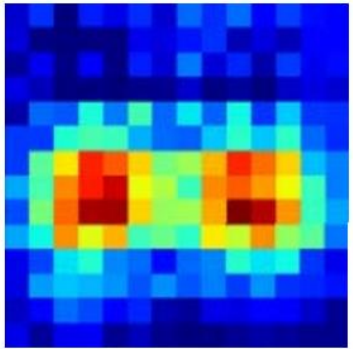


retrieved using 256 codes

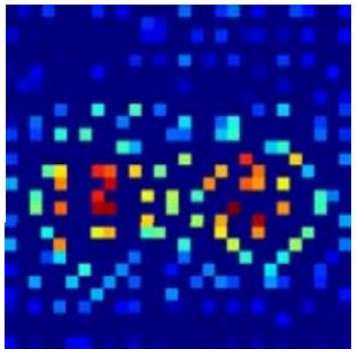
Auto-encoder for CNN



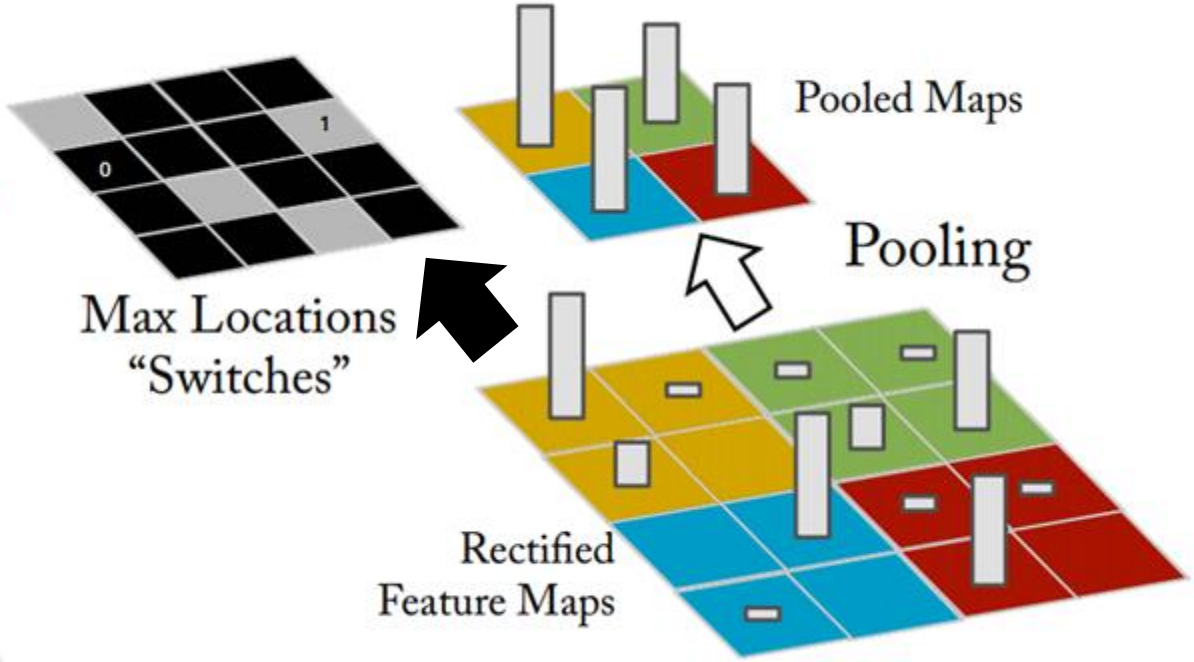
CNN -Unpooling



14 x 14



28 x 28

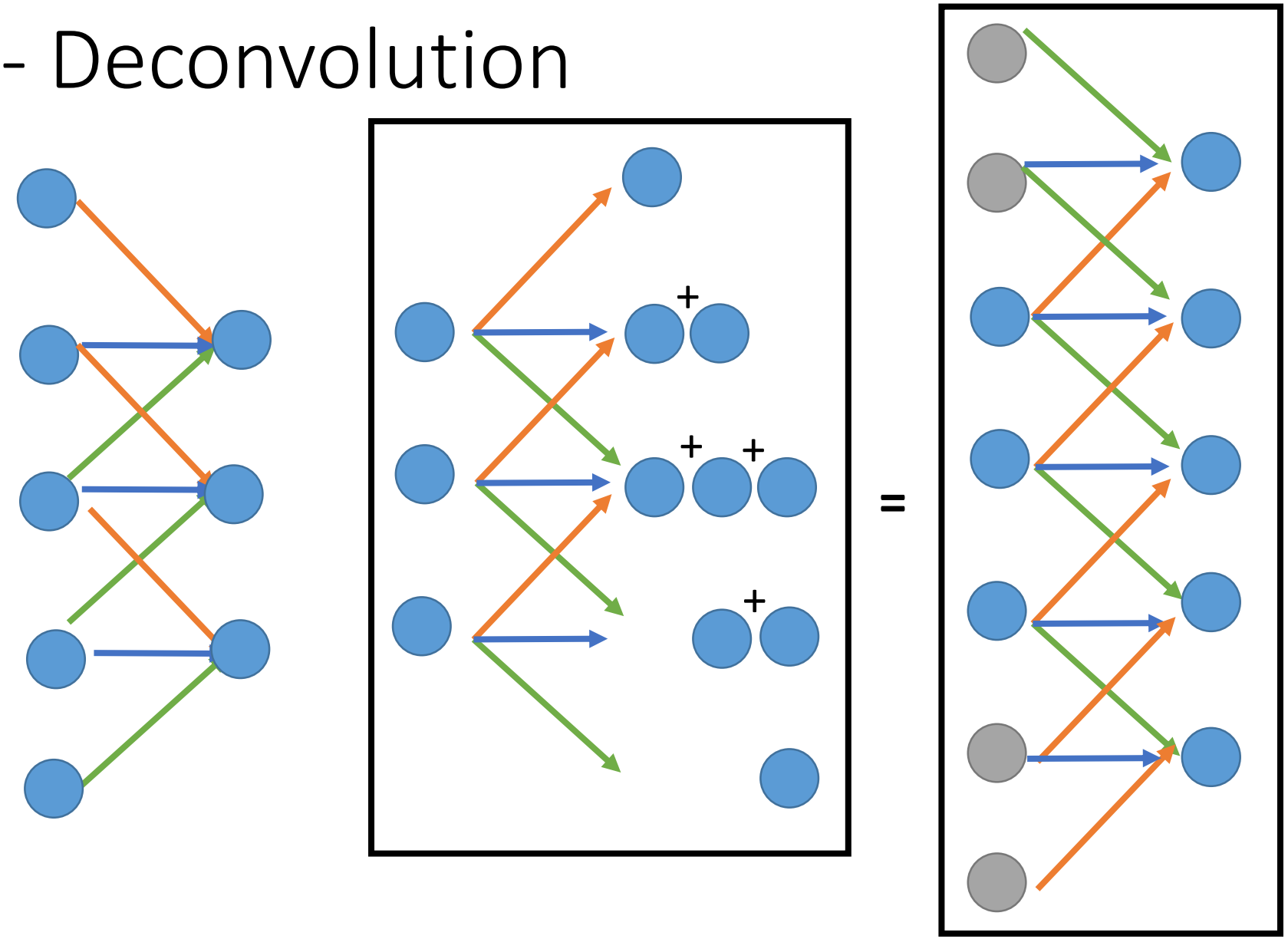


Alternative: simply repeat the values

Source of image : https://leonardoaraujosantos.gitbooks.io/artificial-inteligence/content/image_segmentation.html

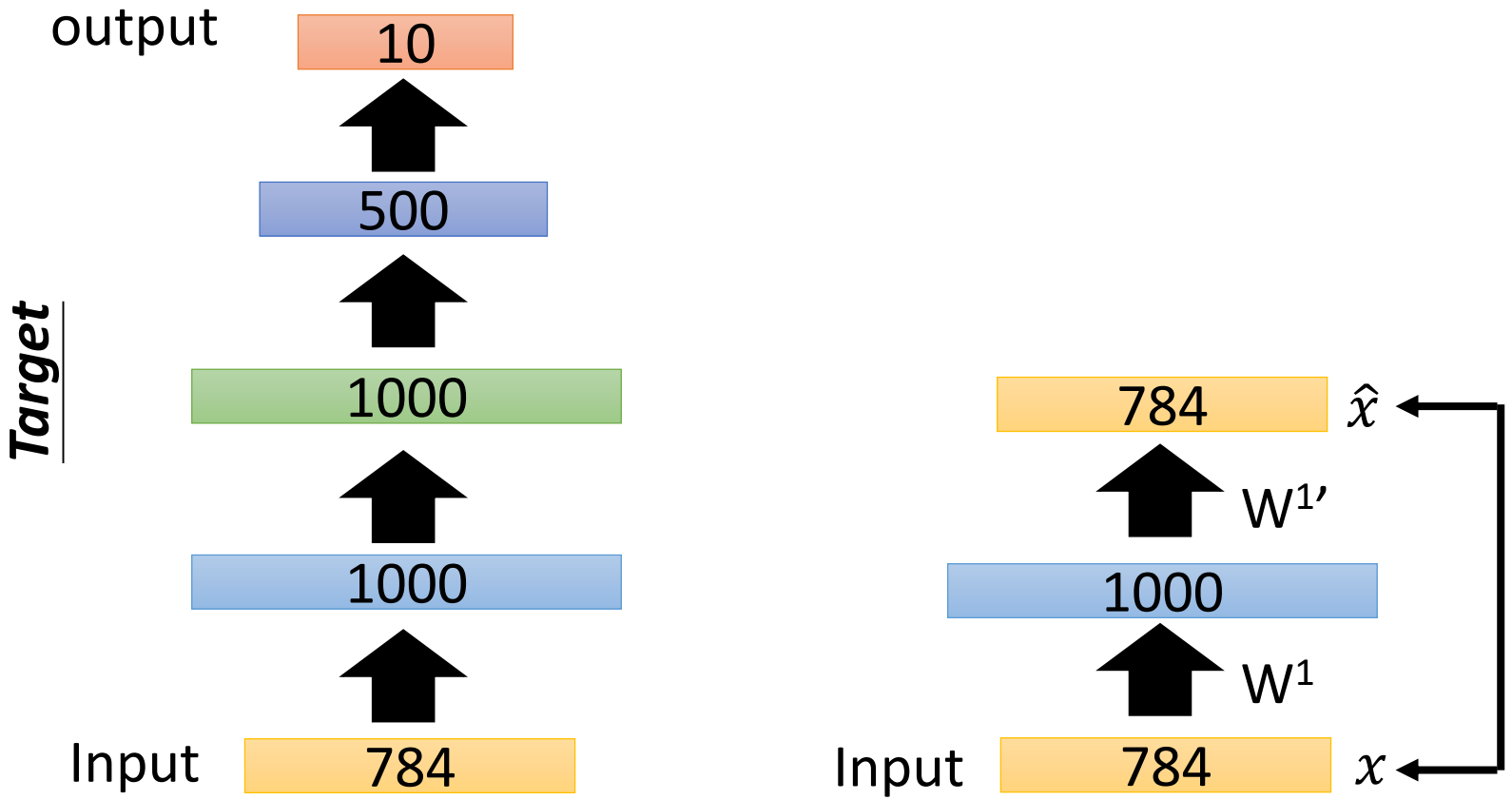
CNN
- Deconvolution

Actually, deconvolution is convolution.



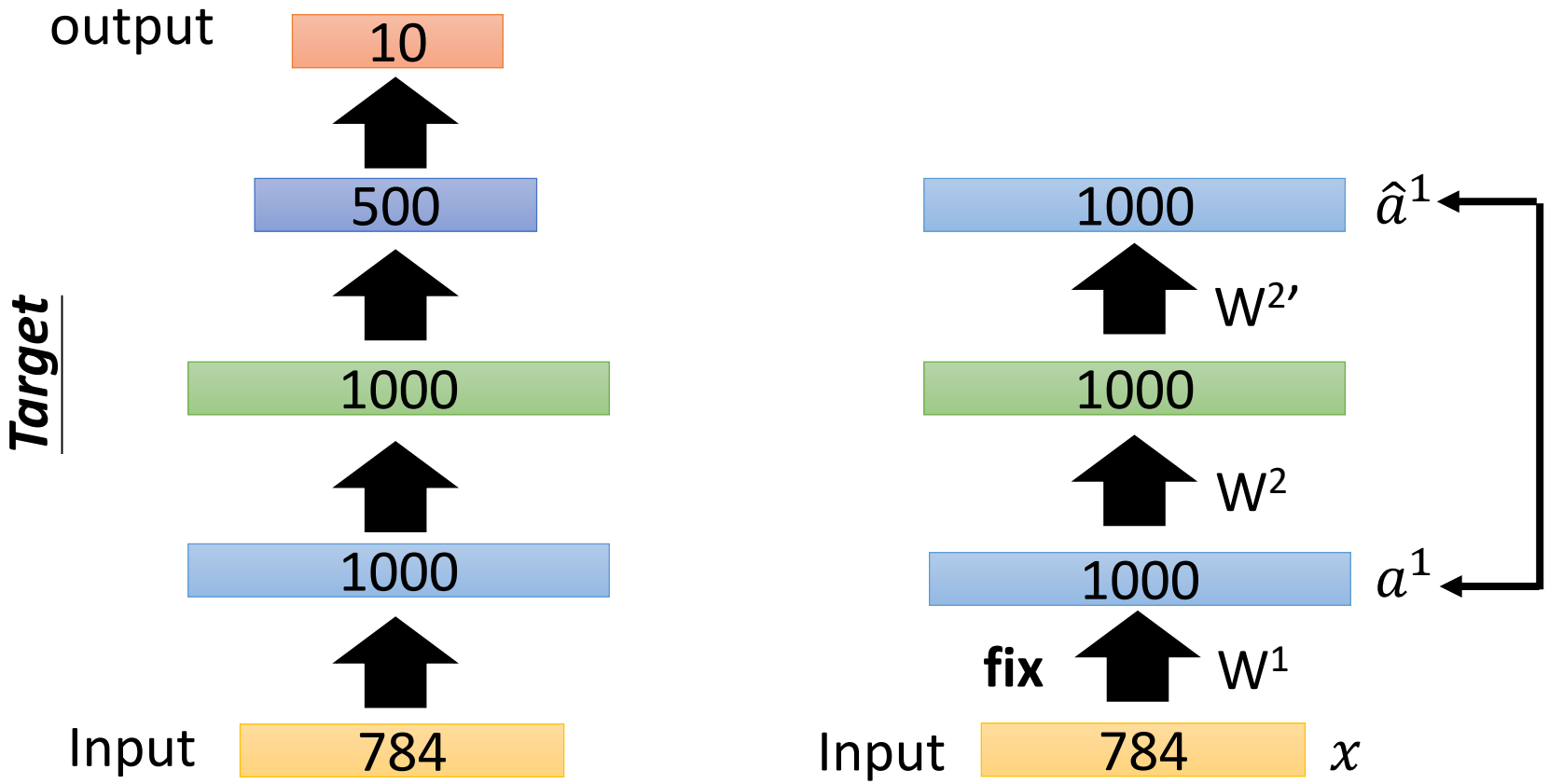
Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



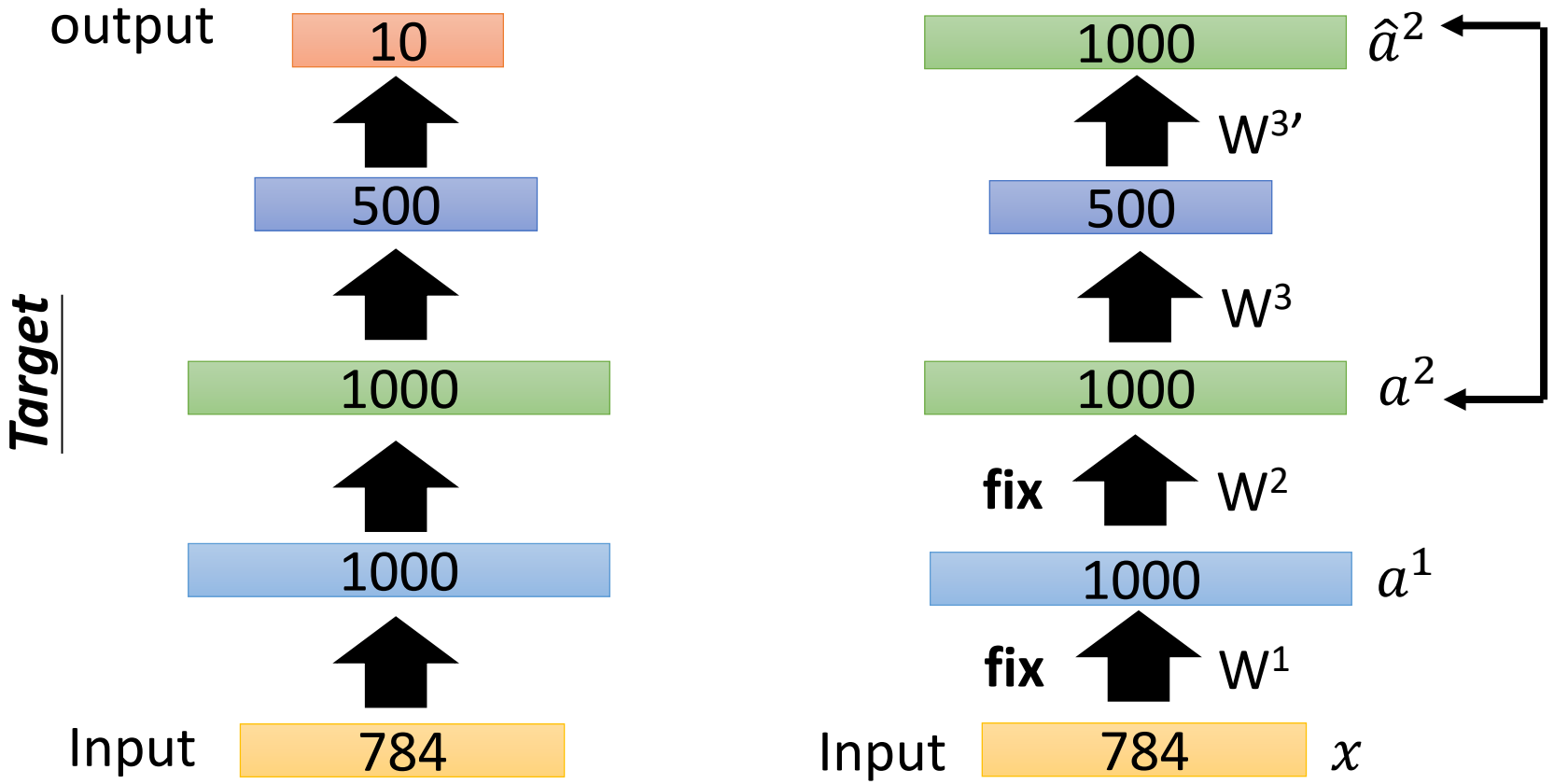
Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



Auto-encoder – Pre-training DNN

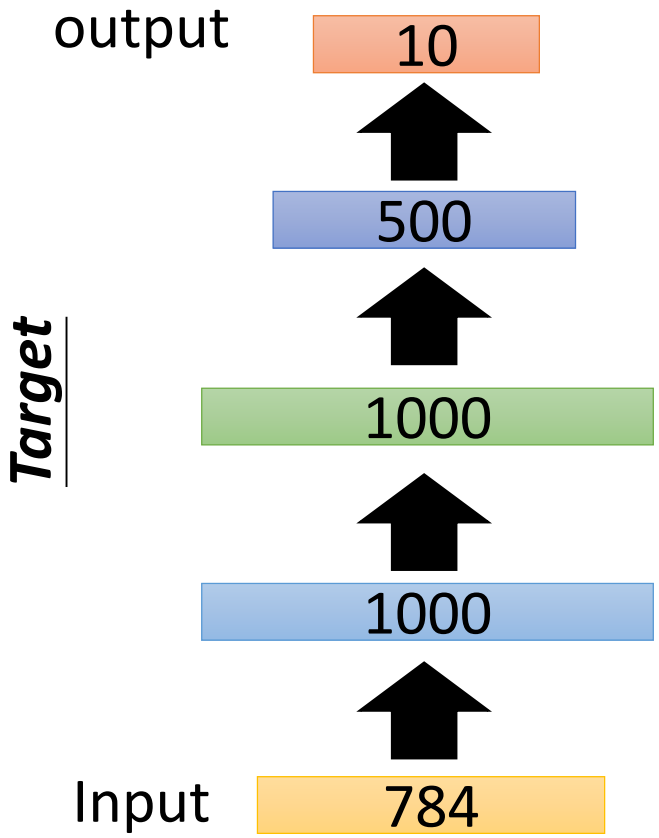
- Greedy Layer-wise Pre-training *again*

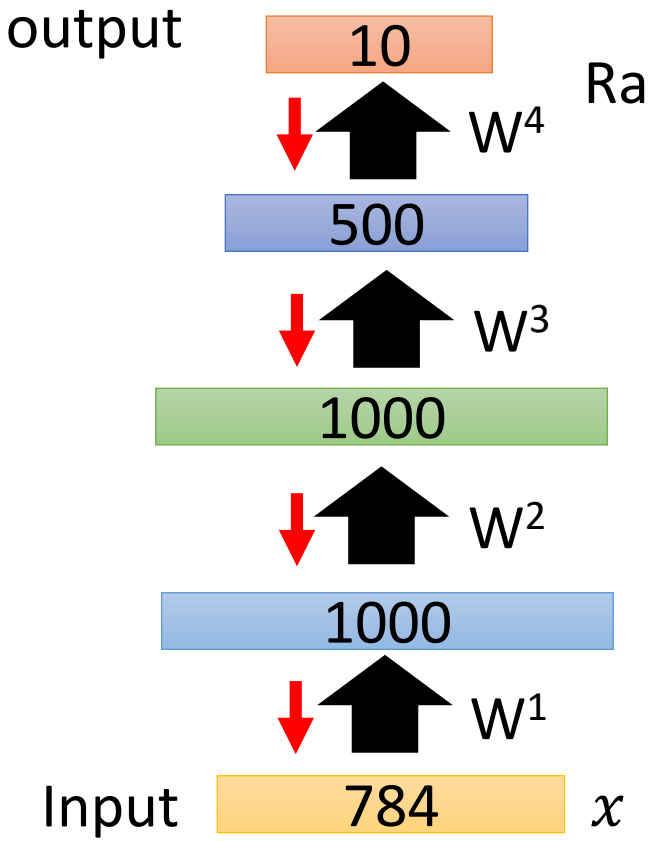


Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*

Find-tune by backpropagation





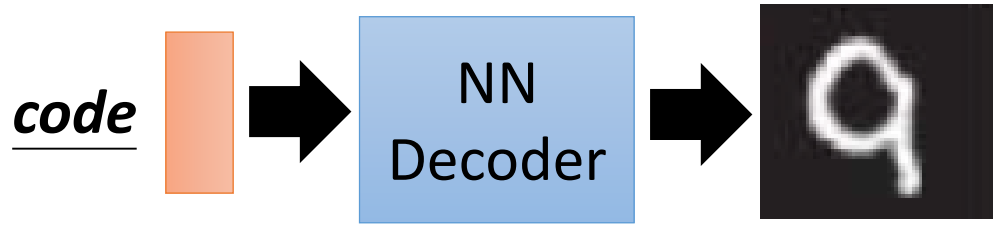
Learning More
- Restricted Boltzmann Machine

- Neural networks [5.1] : Restricted Boltzmann machine – definition
  - https://www.youtube.com/watch?v=p4Vh_zMw-HQ&index=36&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH
- Neural networks [5.2] : Restricted Boltzmann machine – inference
  - https://www.youtube.com/watch?v=lekCh_i32iE&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=37
- Neural networks [5.3] : Restricted Boltzmann machine - free energy
  - https://www.youtube.com/watch?v=e0Ts_7Y6hZU&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=38

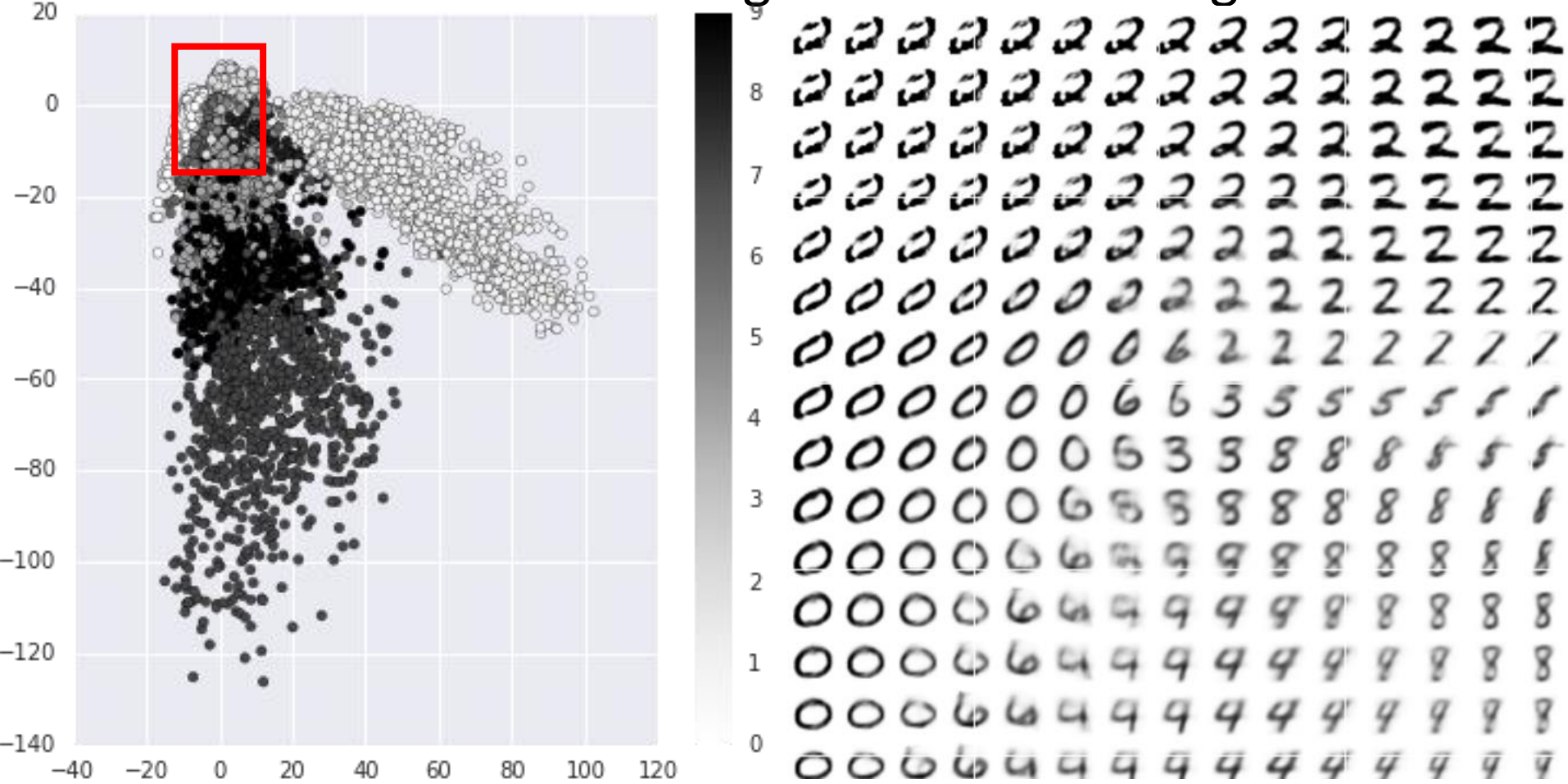
Learning More
- Deep Belief Network

- Neural networks [7.7] : Deep learning - deep belief network
  - https://www.youtube.com/watch?v=vkb6AWYXZ5I&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=57
- Neural networks [7.8] : Deep learning - variational bound
  - https://www.youtube.com/watch?v=pStDscJh2Wo&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=58
- Neural networks [7.9] : Deep learning - DBN pre-training
  - https://www.youtube.com/watch?v=35MUlYCColk&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=59

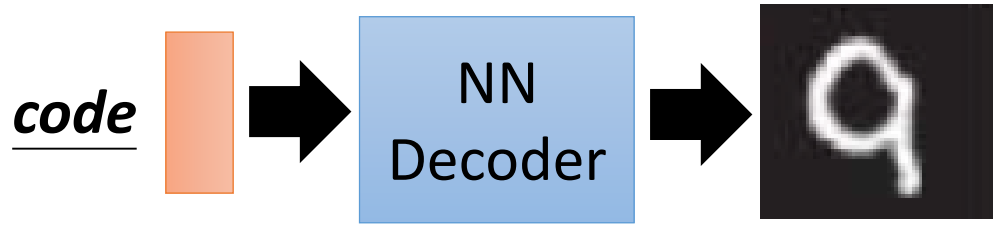
Next .....



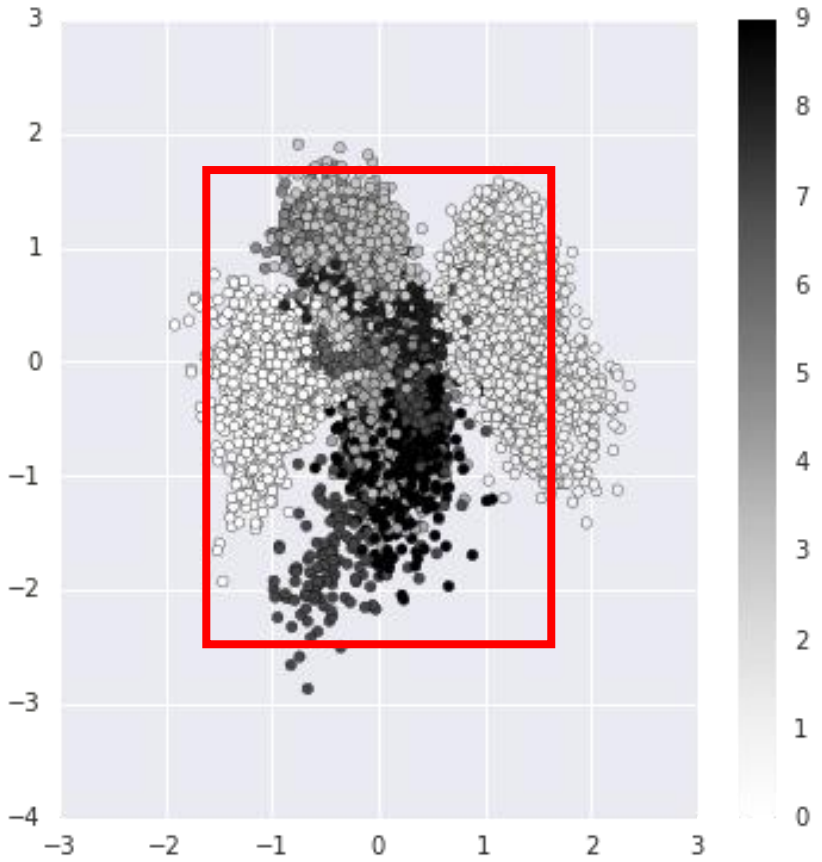
- Can we use decoder to generate something?

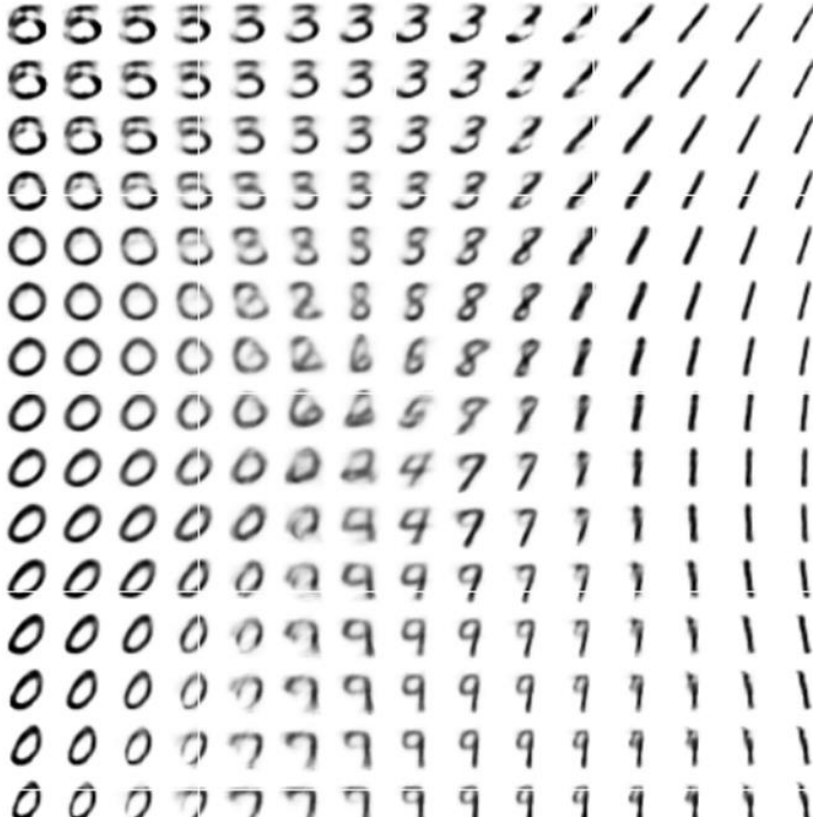


Next .....



- Can we use decoder to generate something?

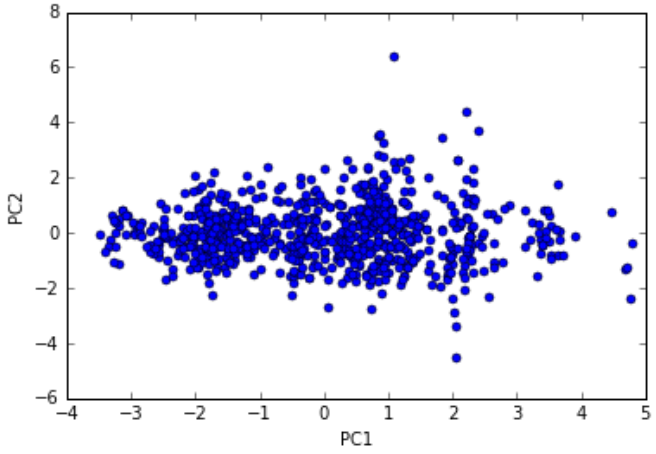


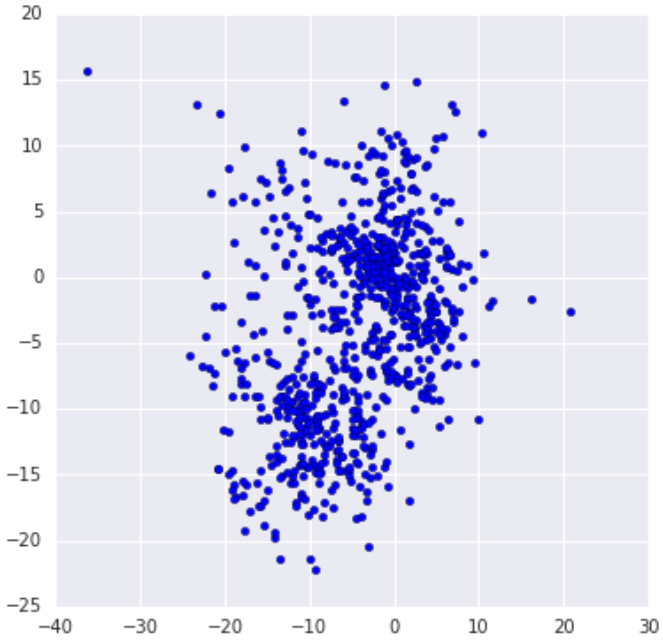


Appendix

Pokémon

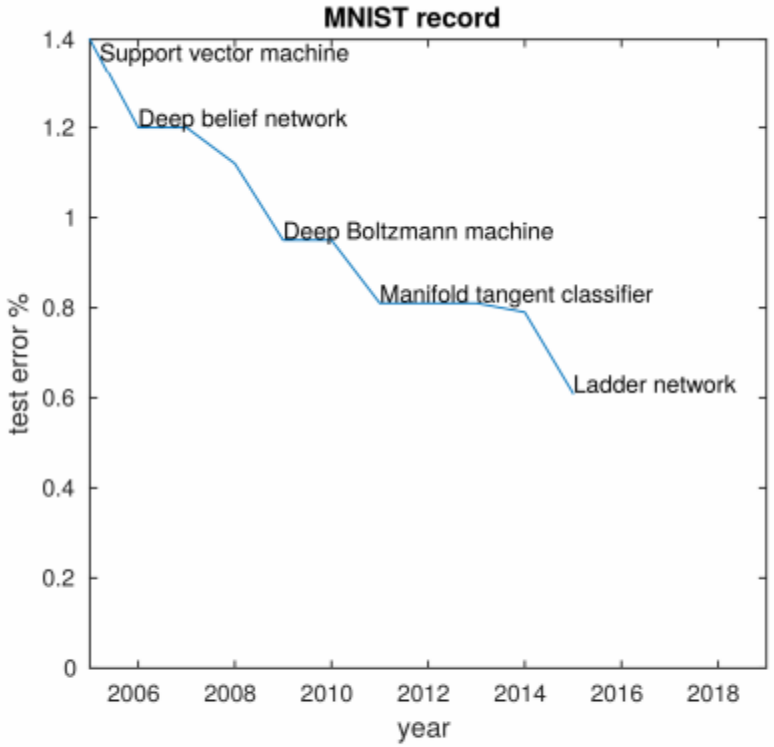
- http://140.112.21.35:2880/~tlkagk/pokemon/pca.html
- http://140.112.21.35:2880/~tlkagk/pokemon/auto.html
- The code is modified from
  - http://jkunst.com/r/pokemon-visualize-em-all/





Add: Ladder Network

- http://rinuboney.github.io/2016/01/19/ladder-network.html
- https://mycourses.aalto.fi/pluginfile.php/146701/mod_resource/content/1/08%20semisup%20ladder.pdf
- https://arxiv.org/abs/1507.02672



Yearly progress in permutation-invariant MNIST.

A. Rasmus, H. Valpola, M. Honkala, M. Berglund, and T. Raiko.

Semi-Supervised Learning with Ladder Network. To appear in NIPS 2015.