

Unsupervised Learning:

Deep Auto-encoder

Unsupervised Learning

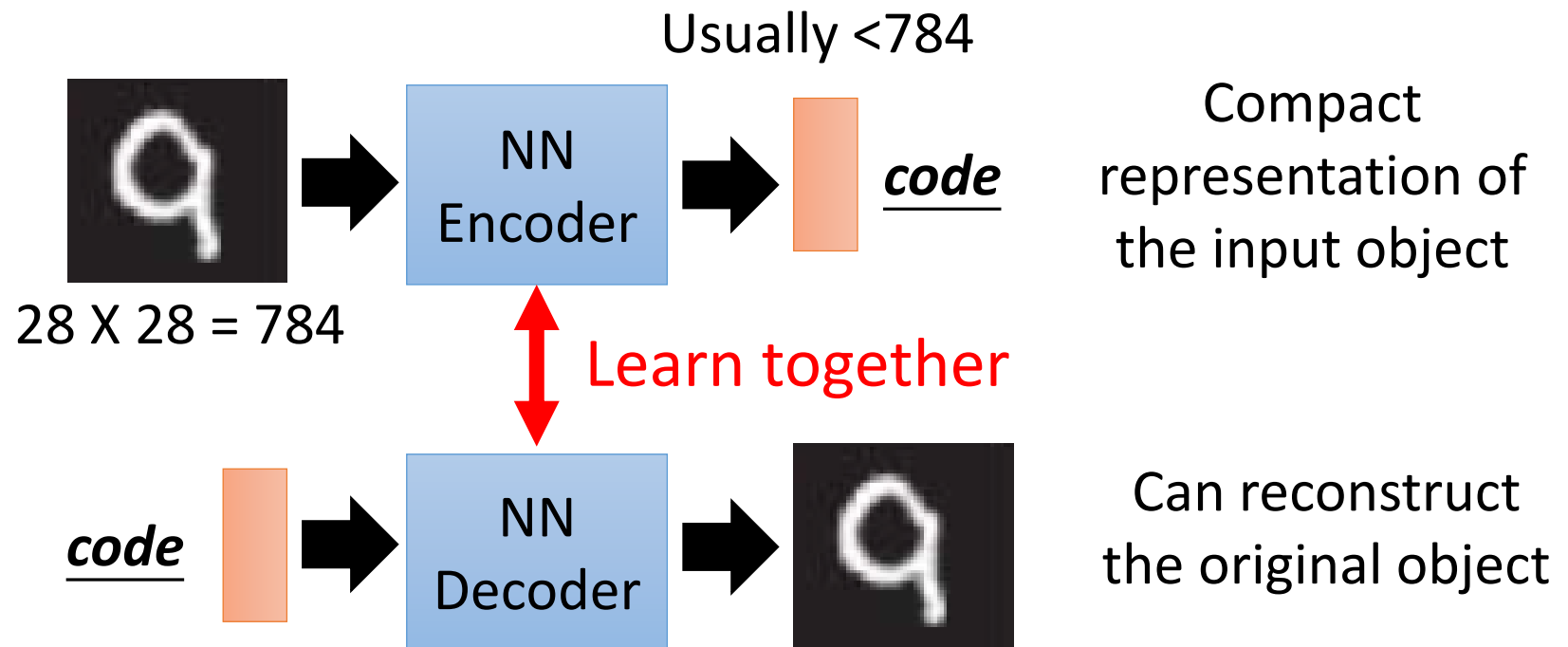
“We expect unsupervised learning to become far more important in the longer term. Human and animal learning is largely unsupervised: we discover the structure of the world by observing it, not by being told the name of every object.”

– LeCun, Bengio, Hinton, Nature 2015

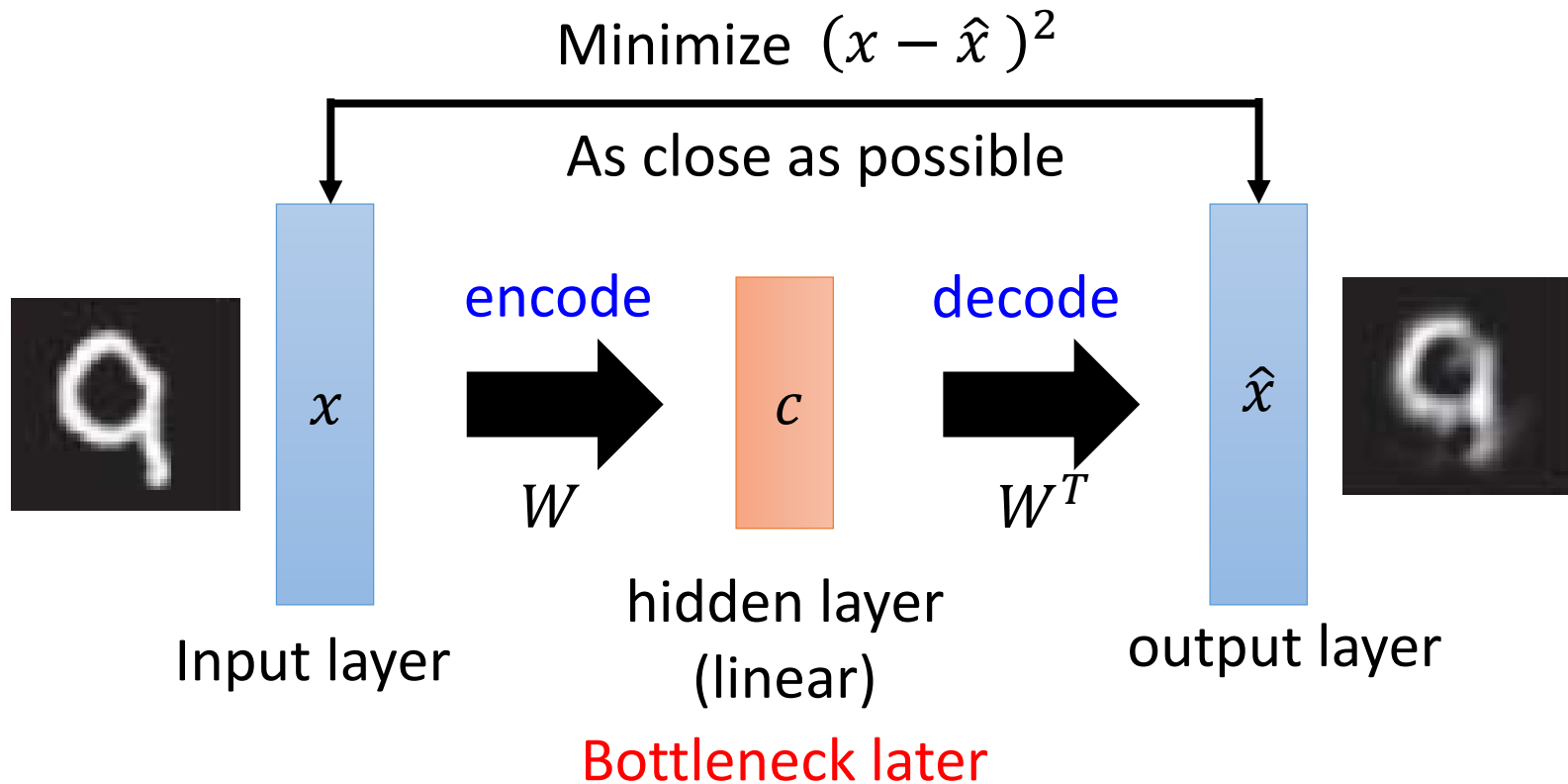
As I've said in previous statements: most of human and animal learning is unsupervised learning. If intelligence was a cake, unsupervised learning would be the cake, supervised learning would be the icing on the cake, and reinforcement learning would be the cherry on the cake. We know how to make the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

- Yann LeCun, March 14, 2016 (Facebook)

Auto-encoder



Recap: PCA

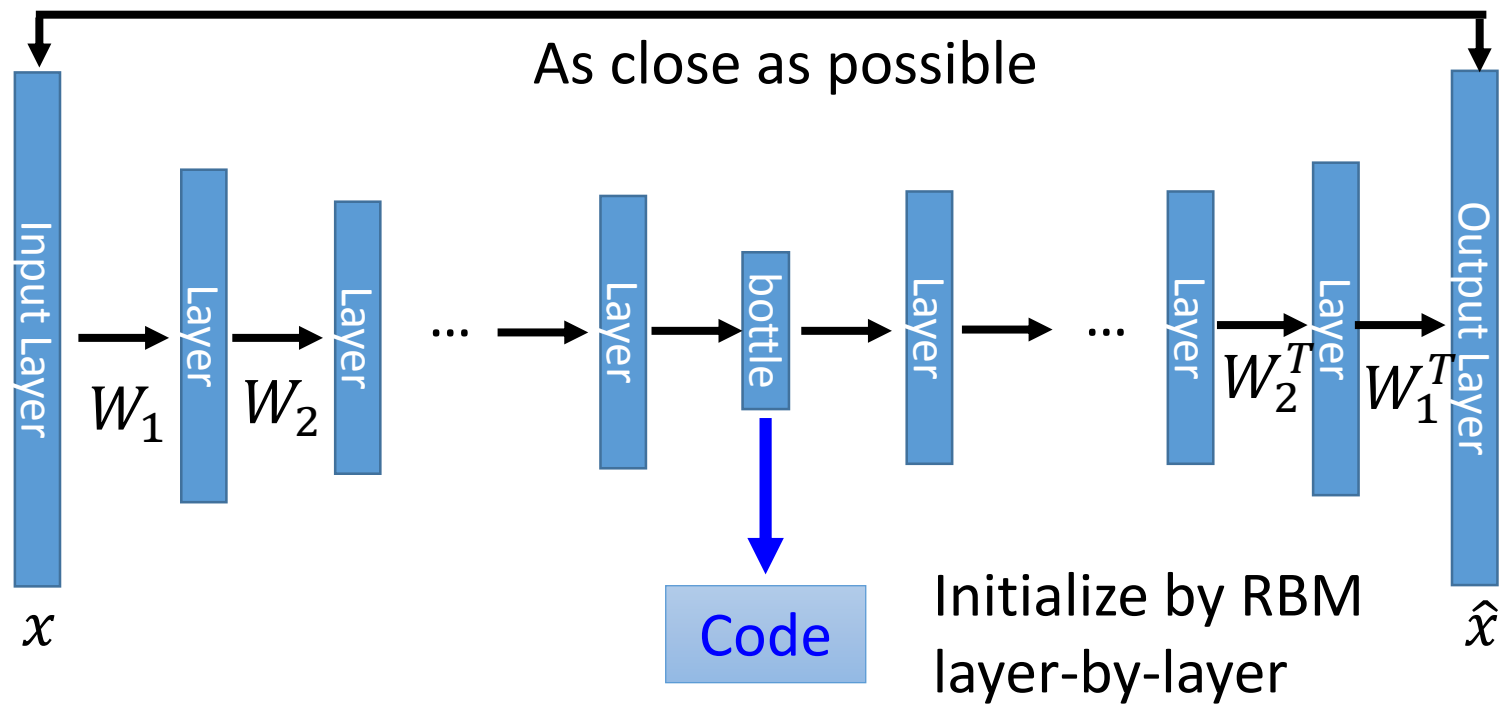


Output of the hidden layer is the code

Deep Auto-encoder

Symmetric is not necessary.

- Of course, the auto-encoder can be deep



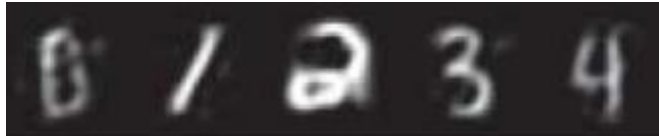
Reference: Hinton, Geoffrey E., and Ruslan R. Salakhutdinov. "Reducing the dimensionality of data with neural networks." *Science* 313.5786 (2006): 504-507

Deep Auto-encoder

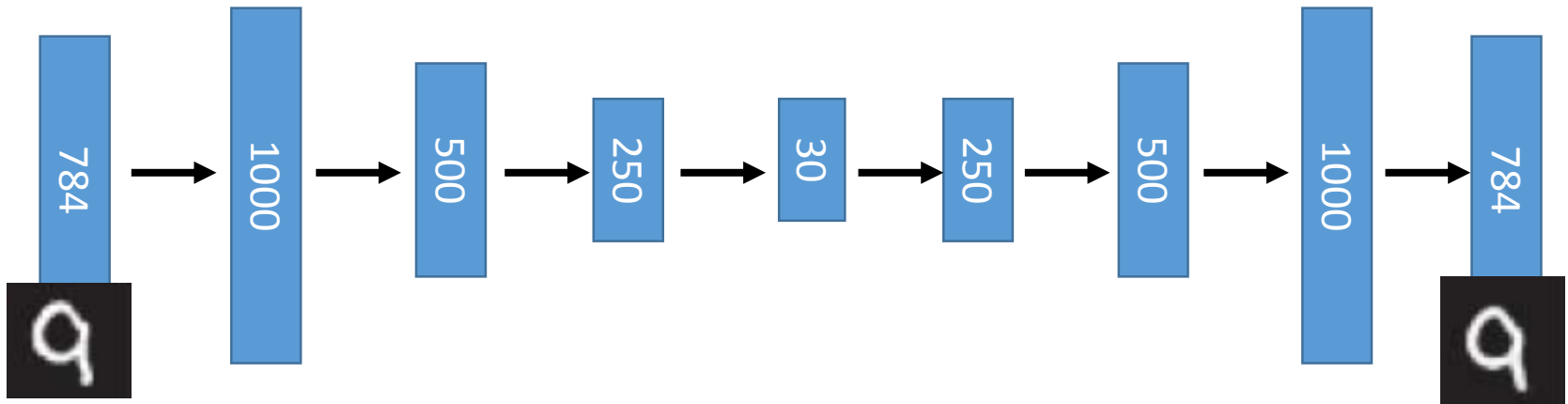
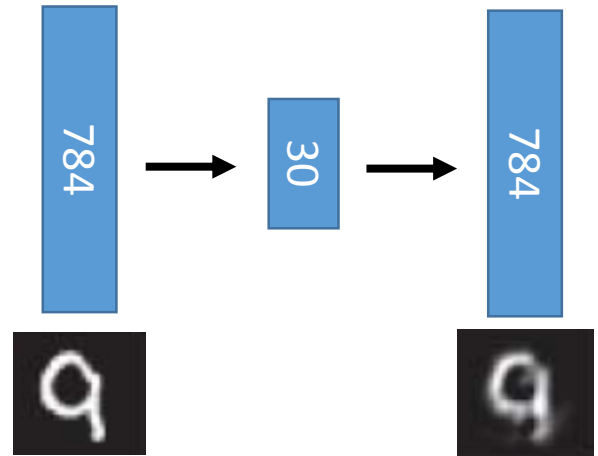
Original
Image

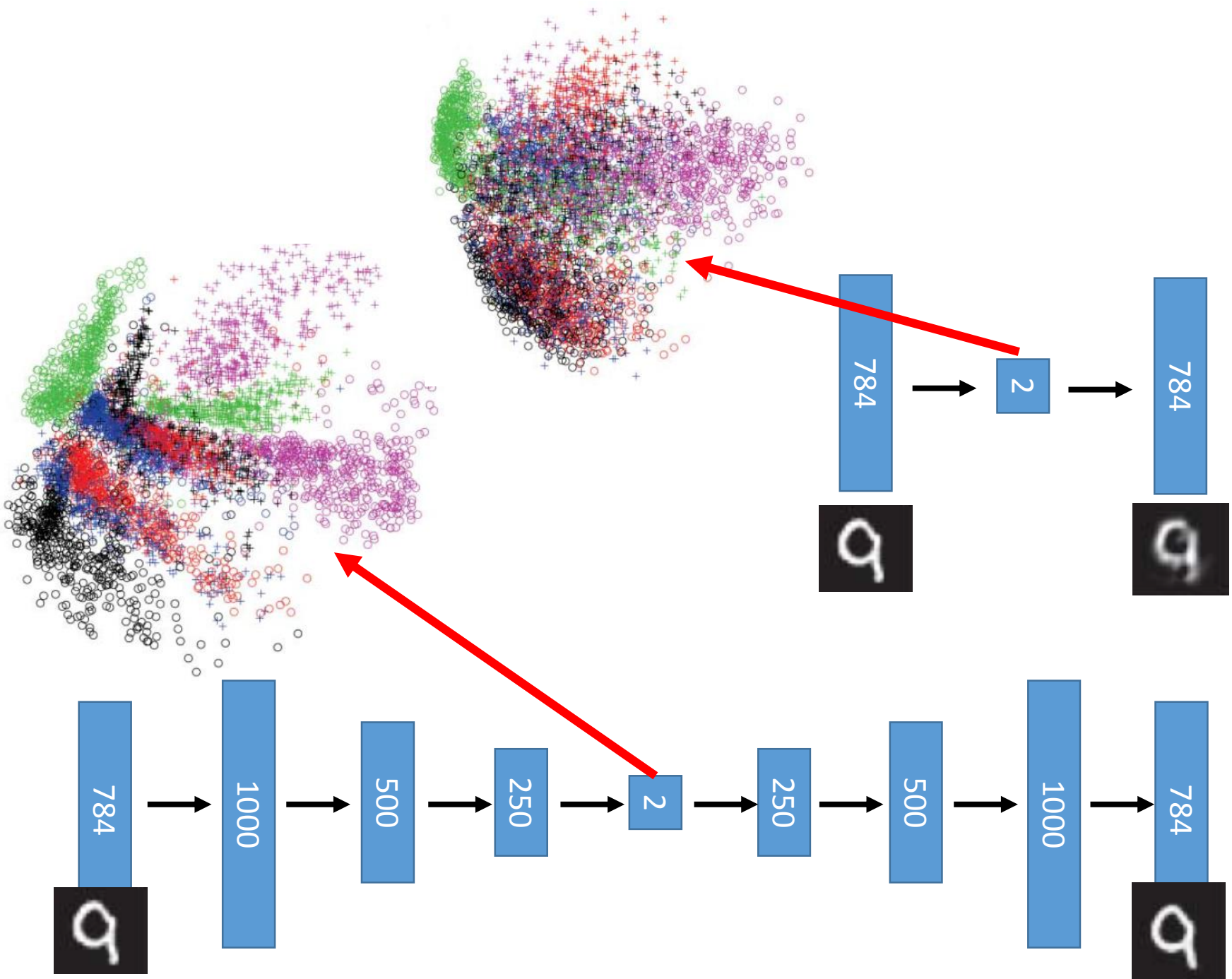


PCA



Deep
Auto-encoder



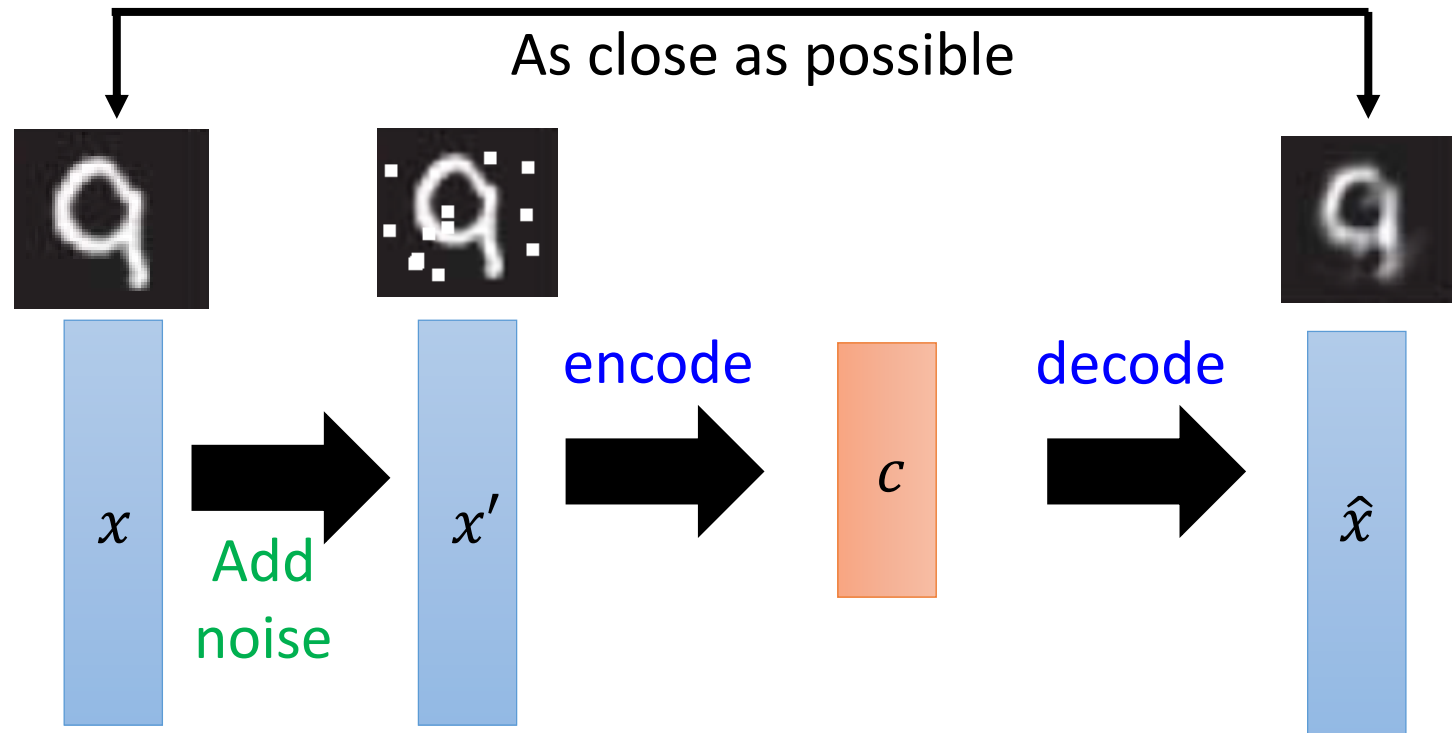


More: Contractive auto-encoder

Auto-encoder

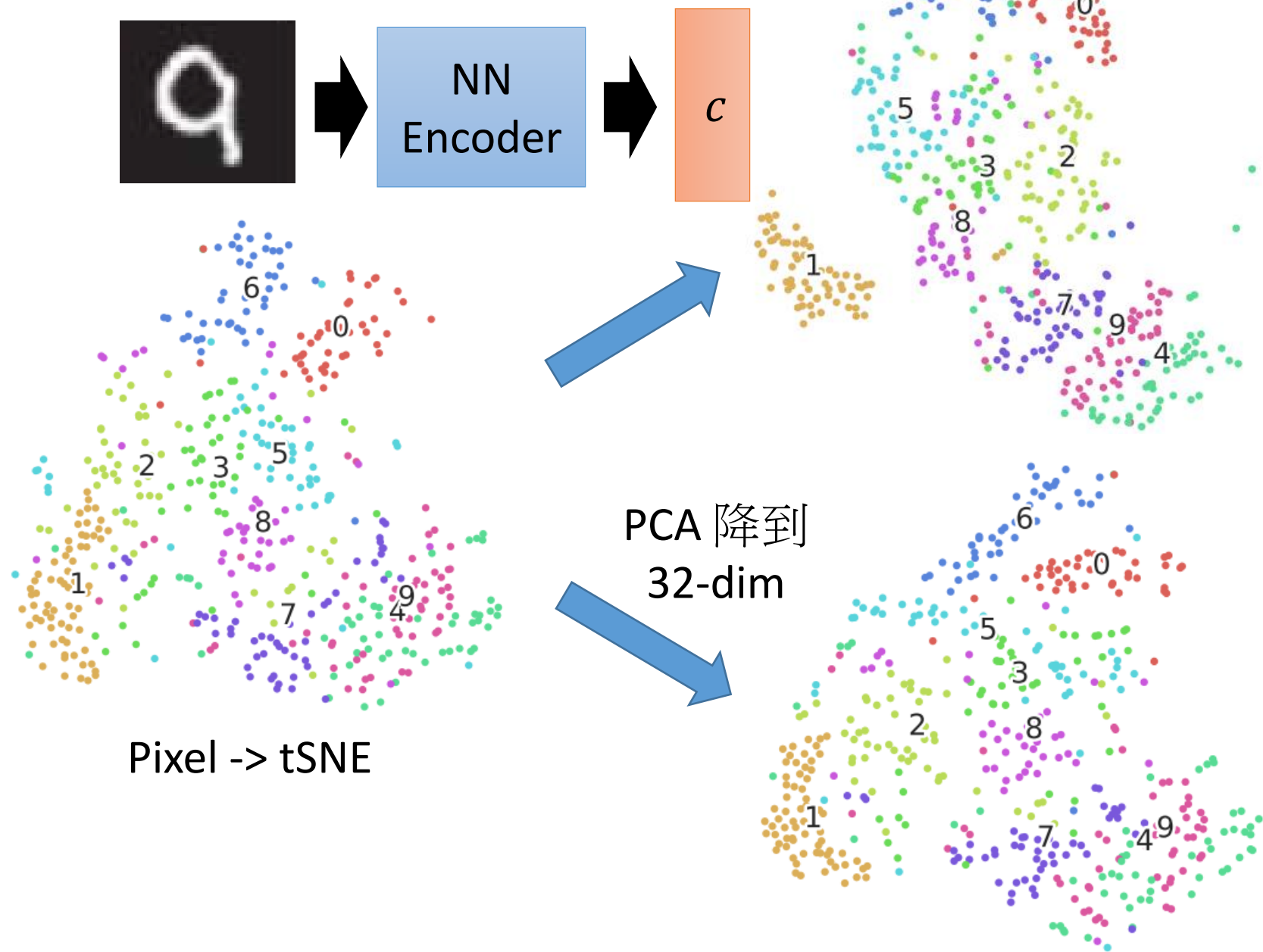
Ref: Rifai, Salah, et al. "Contractive auto-encoders: Explicit invariance during feature extraction." *Proceedings of the 28th International Conference on Machine Learning (ICML-11)*. 2011.

- De-noising auto-encoder



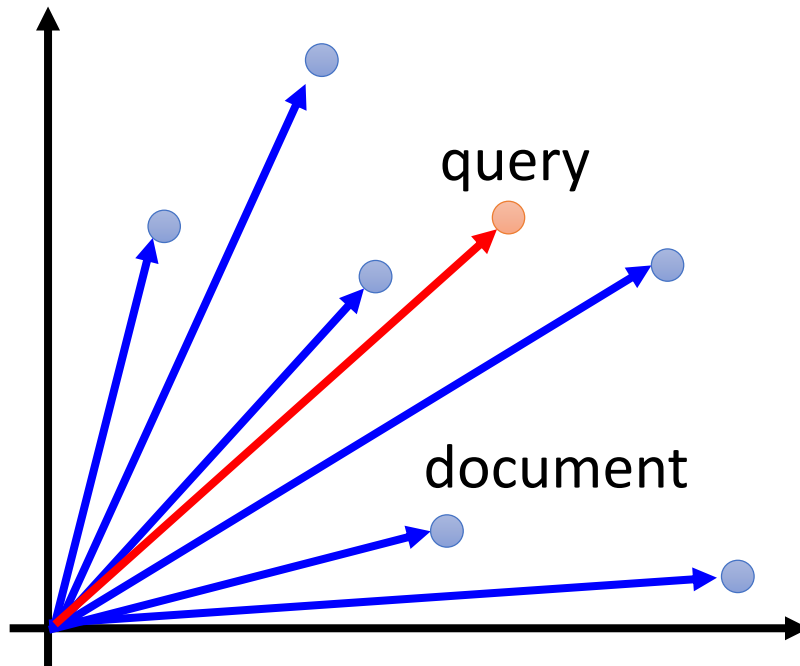
Vincent, Pascal, et al. "Extracting and composing robust features with denoising autoencoders." *ICML*, 2008.

Deep Auto-encoder - Example



Auto-encoder – Text Retrieval

Vector Space Model



Bag-of-words

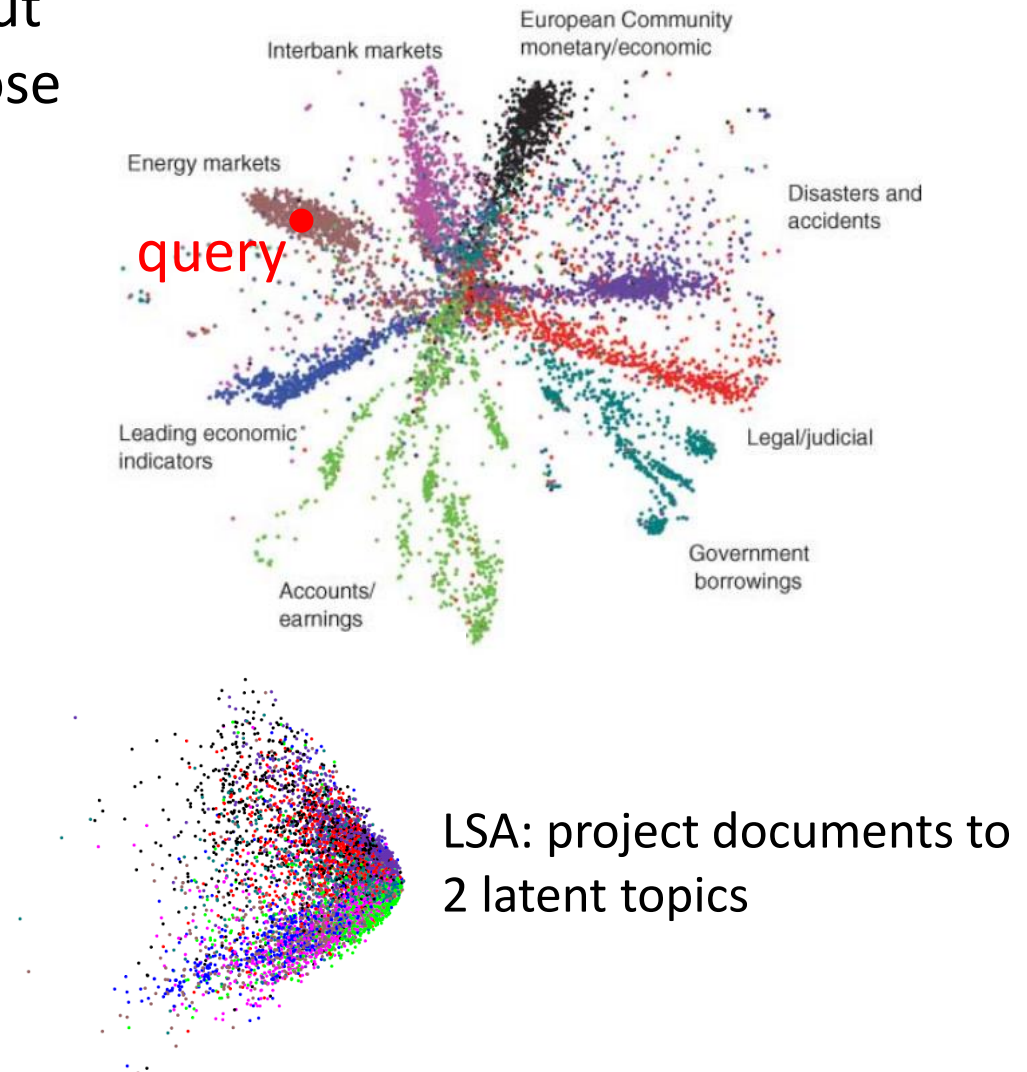
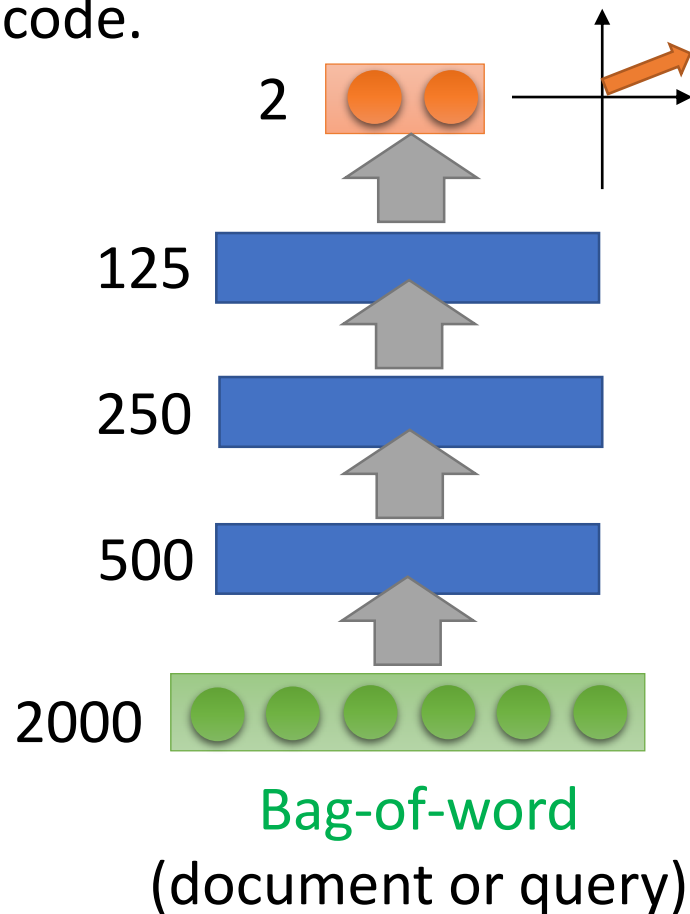
word string:
"This is an apple"

this	●	1
is	●	1
a	●	0
an	●	1
apple	●	1
pen	●	0
⋮	●	

Semantics are not considered.

Auto-encoder – Text Retrieval

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



Auto-encoder – Similar Image Search

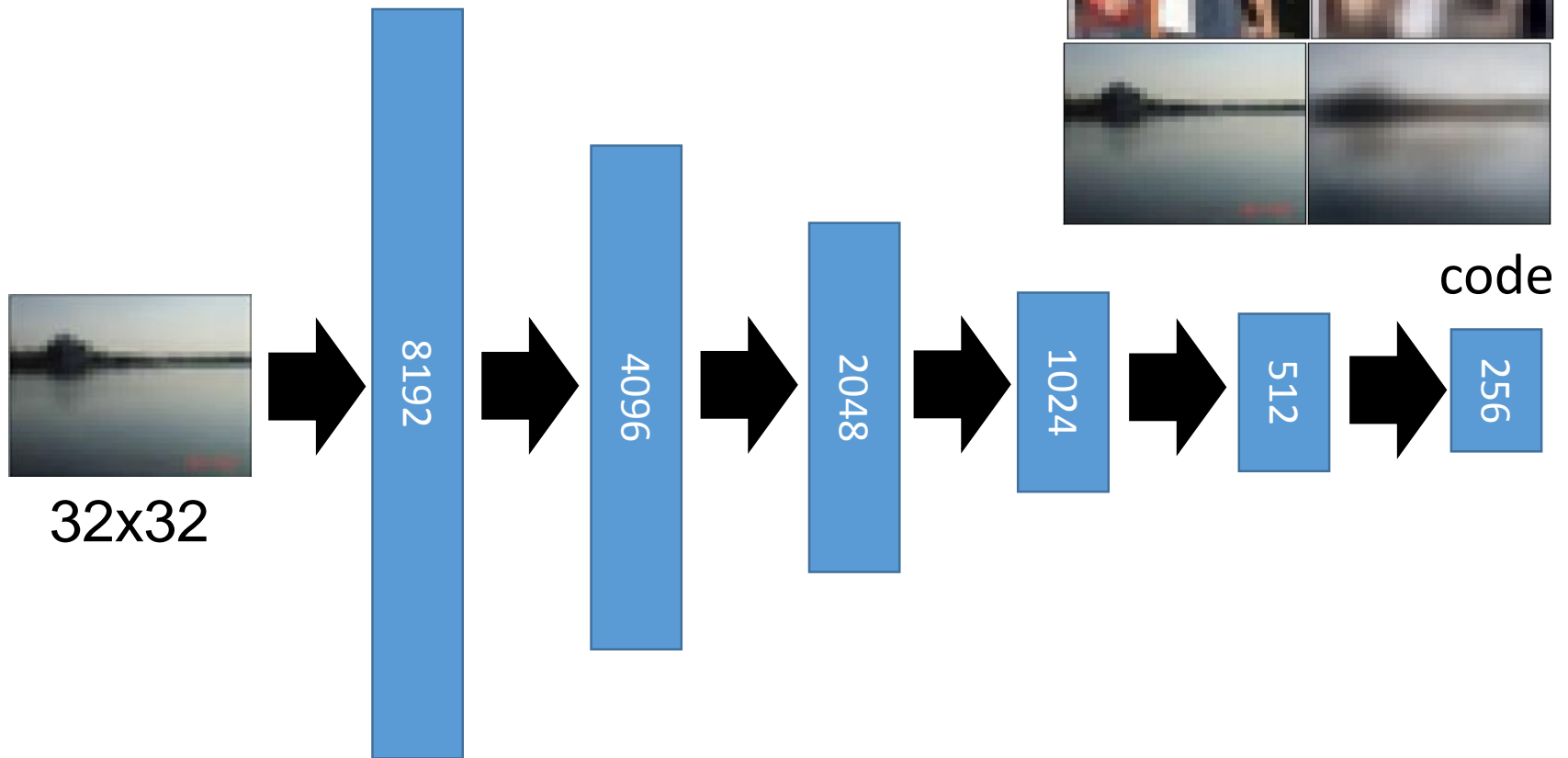
Retrieved using Euclidean distance in pixel intensity space



(Images from Hinton's slides on Coursera)

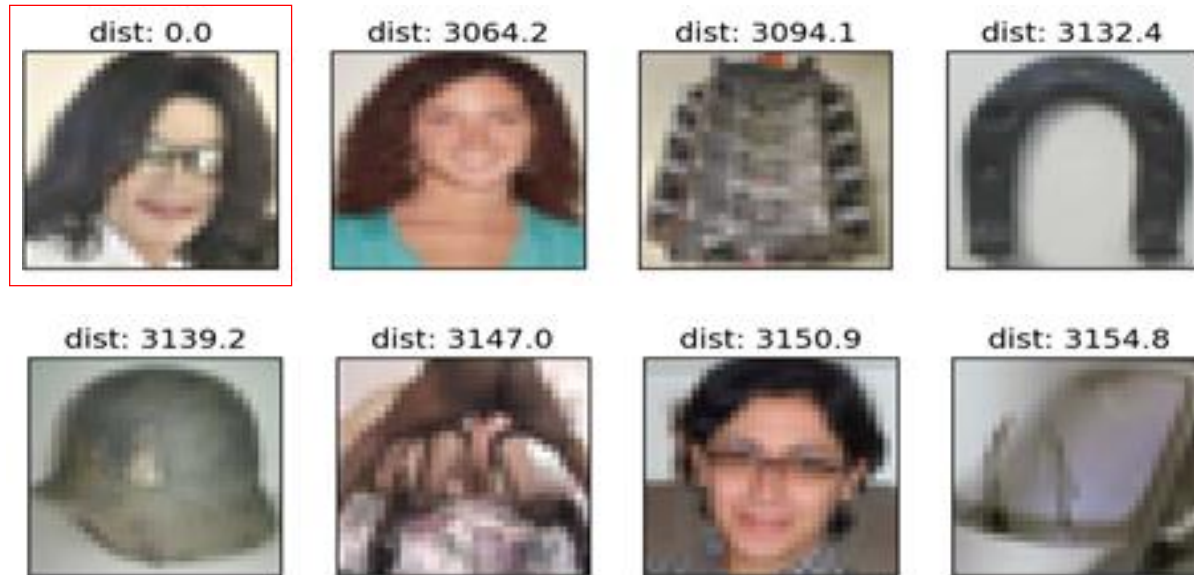
Reference: Krizhevsky, Alex, and Geoffrey E. Hinton. "Using very deep autoencoders for content-based image retrieval." *ESANN*. 2011.

Auto-encoder – Similar Image Search



(crawl millions of images from the Internet)

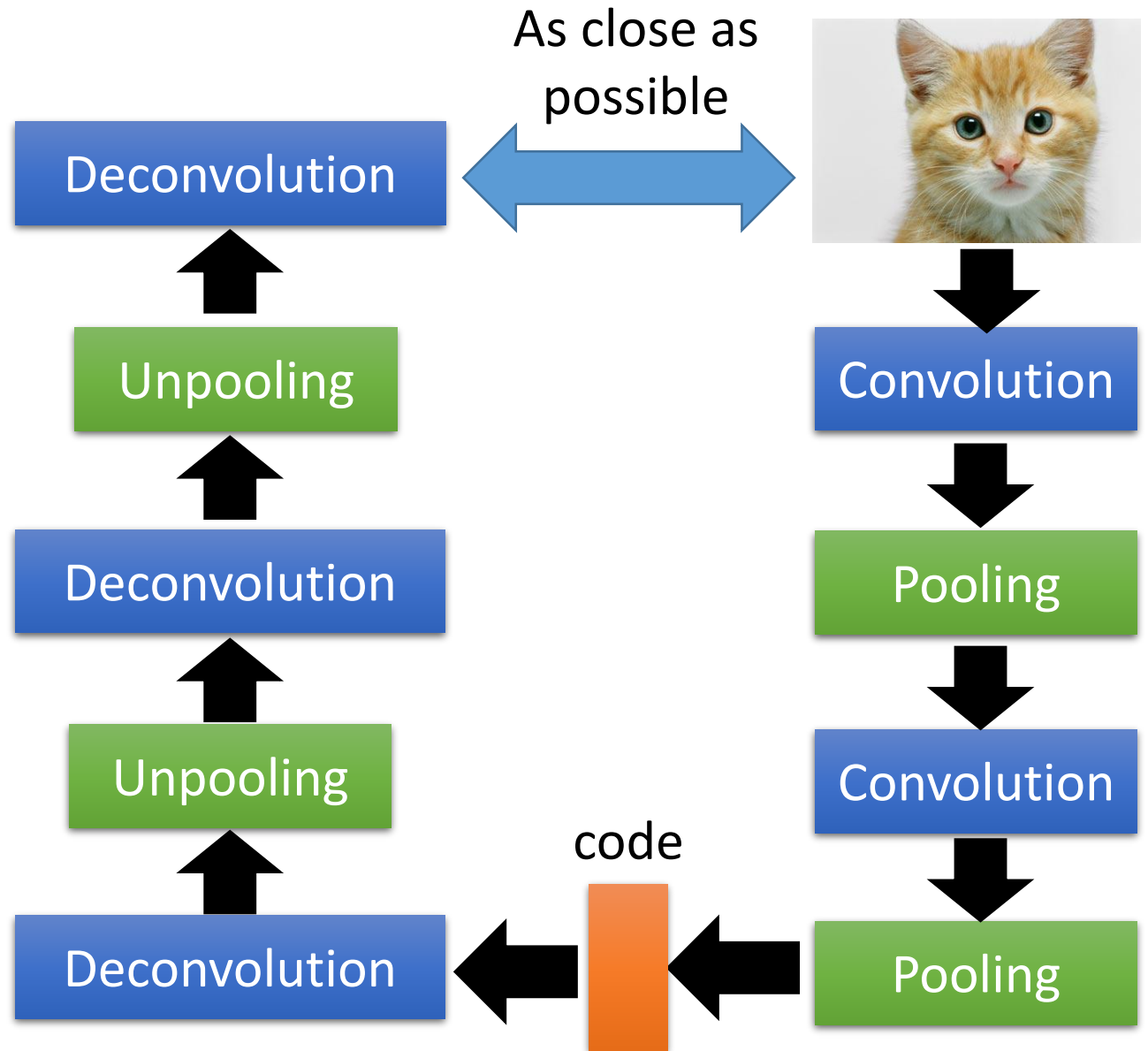
Retrieved using Euclidean distance in pixel intensity space



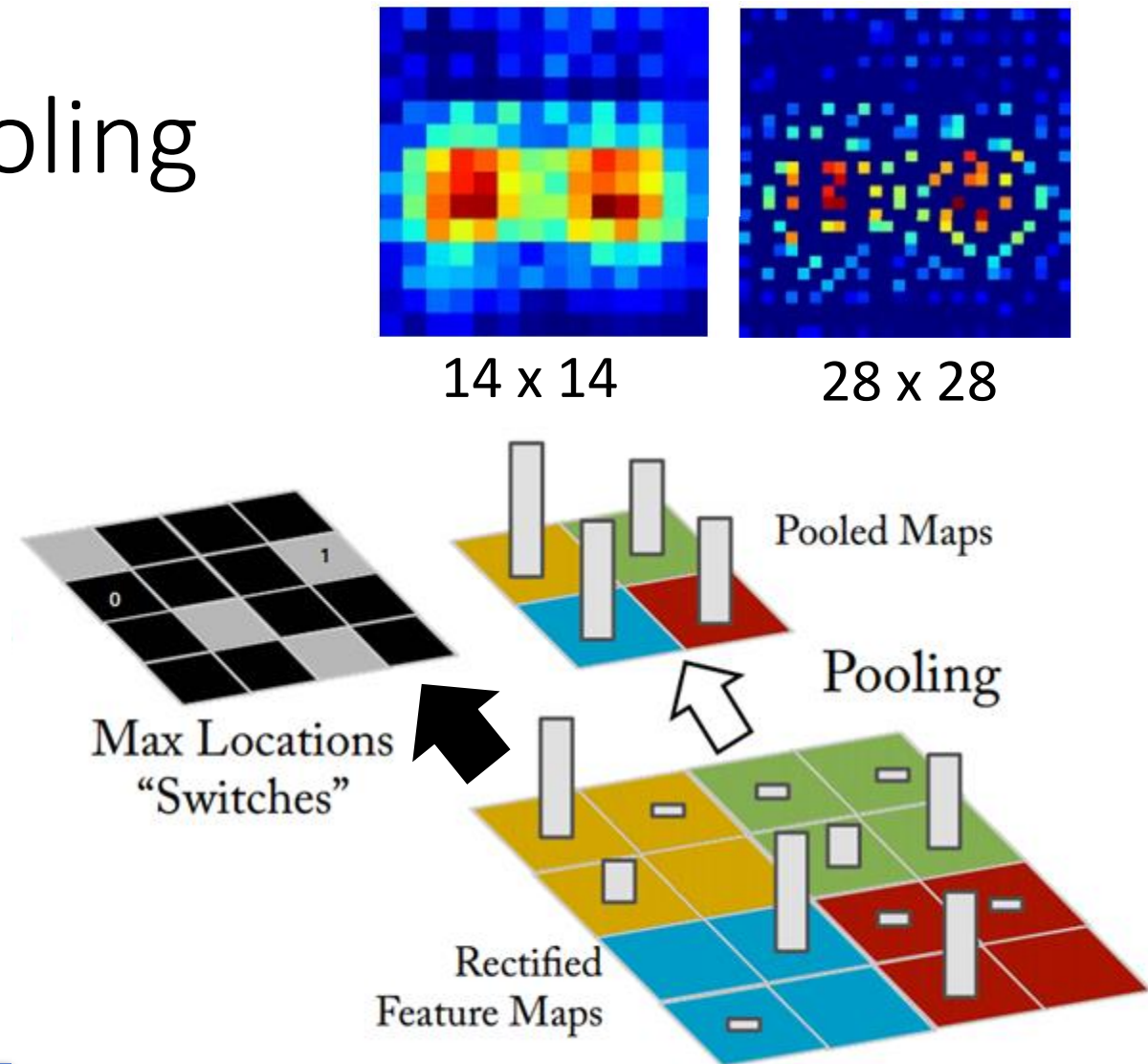
retrieved using 256 codes



Auto- encoder for CNN



CNN -Unpooling



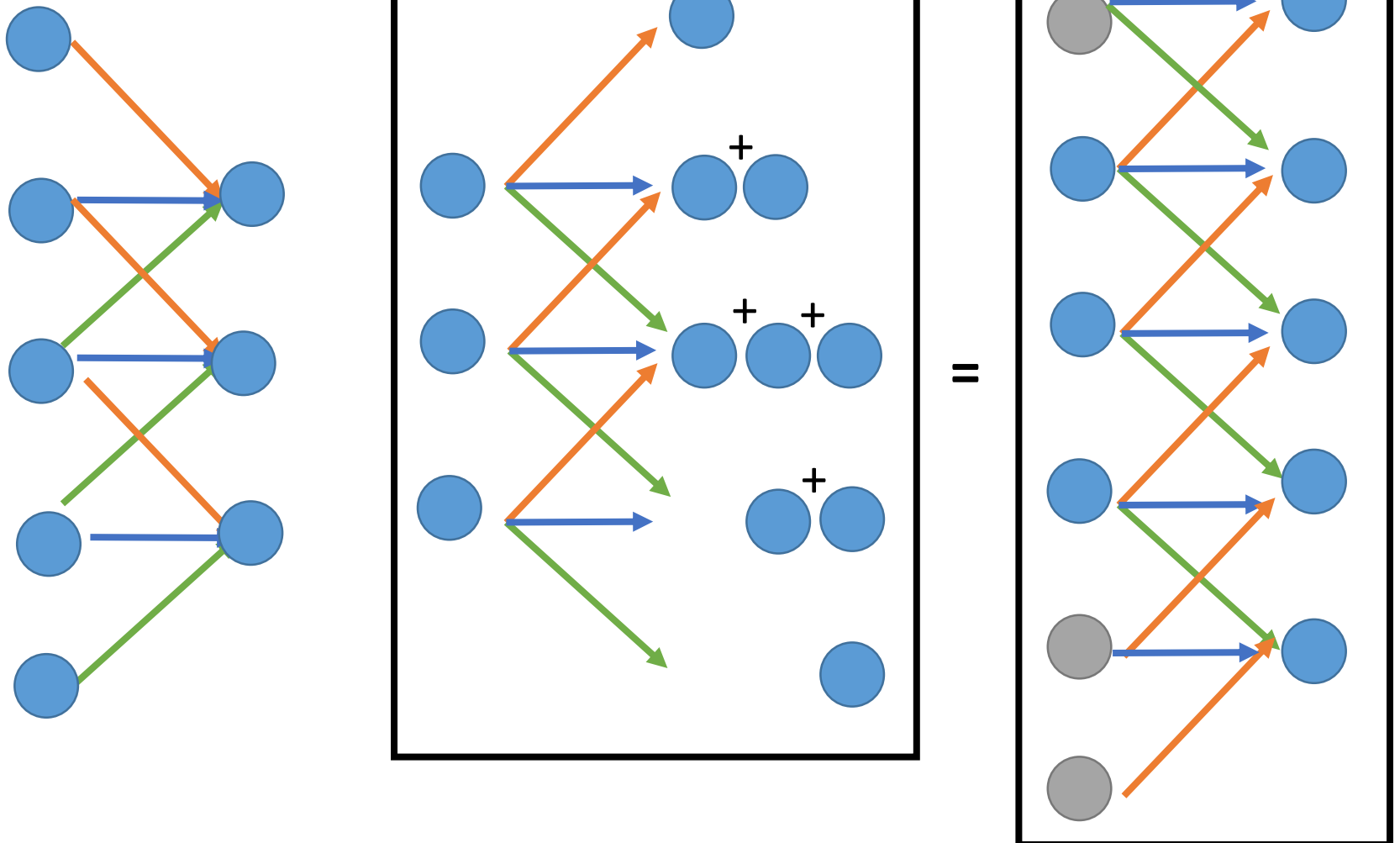
Alternative: simply
repeat the values

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

Actually, deconvolution is convolution.

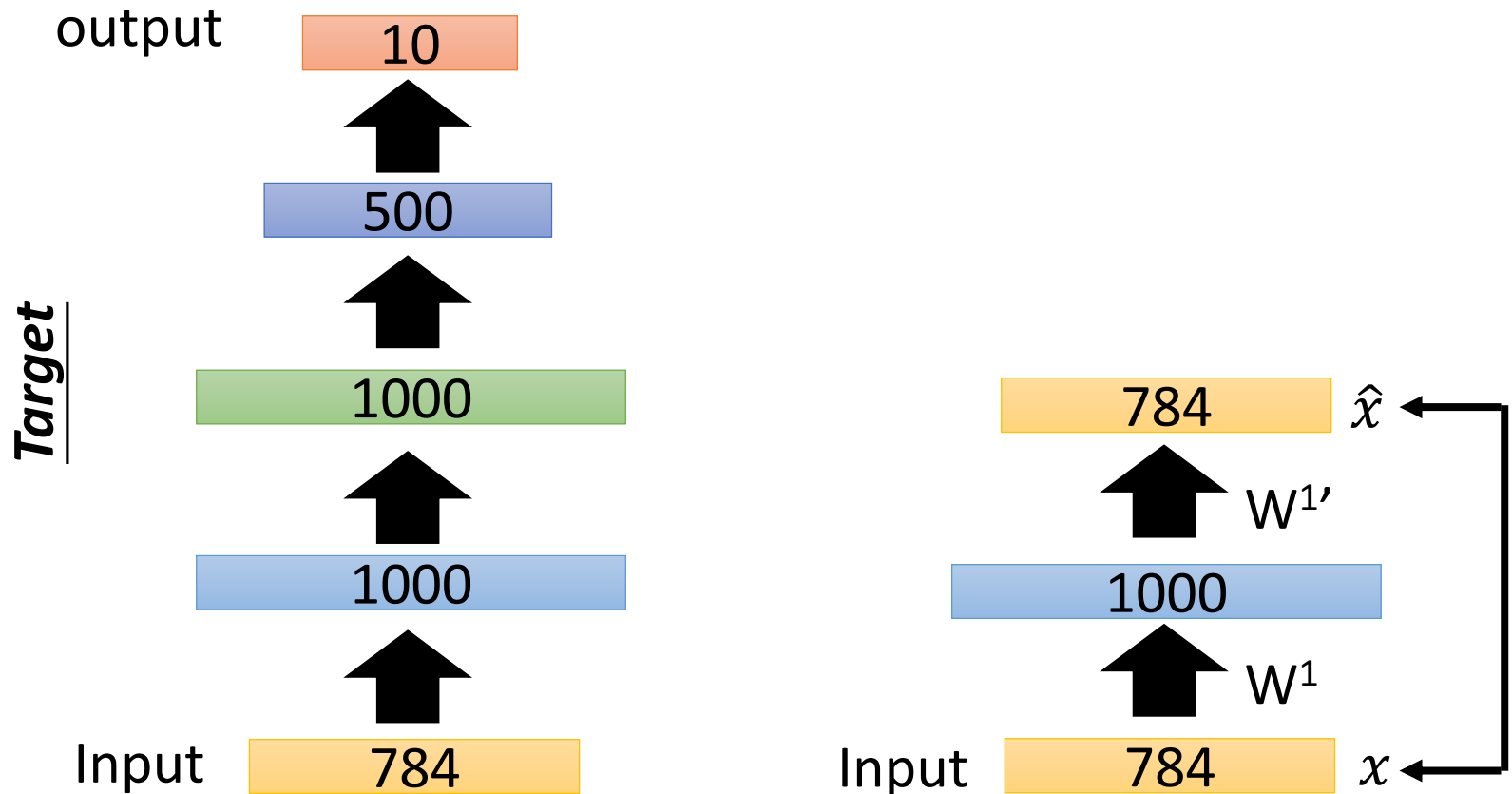
CNN

- Deconvolution



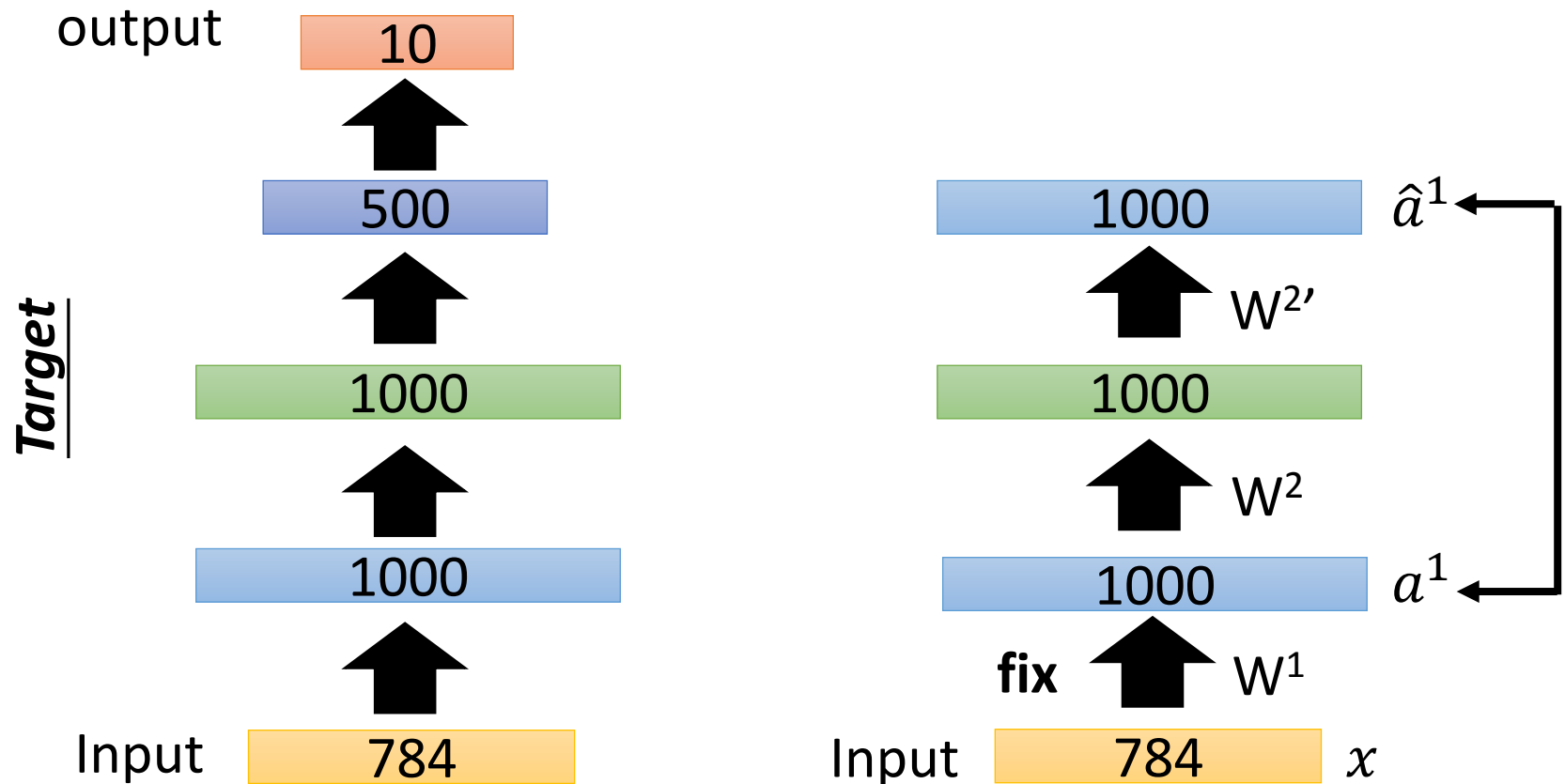
Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



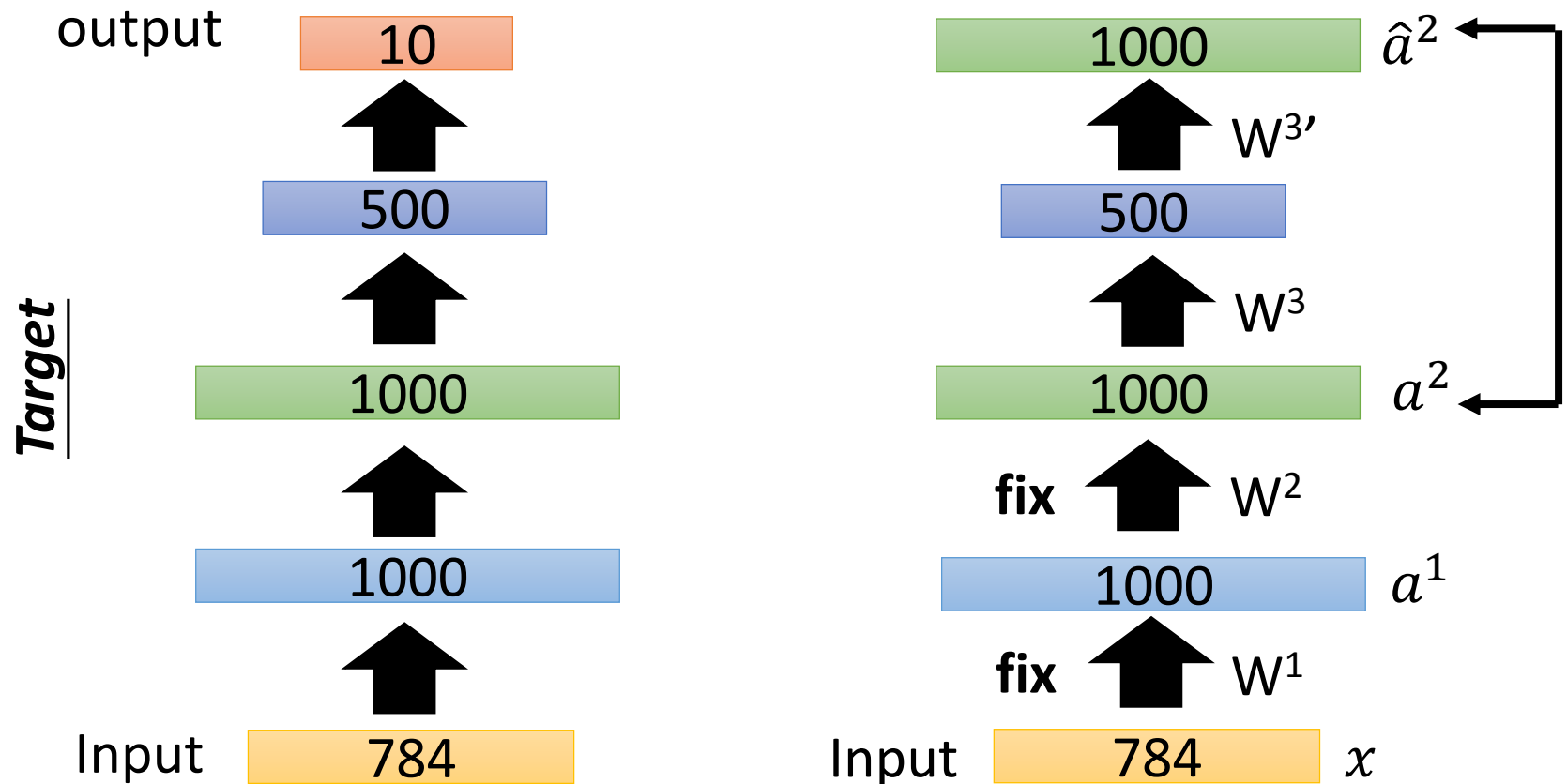
Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



Auto-encoder – Pre-training DNN

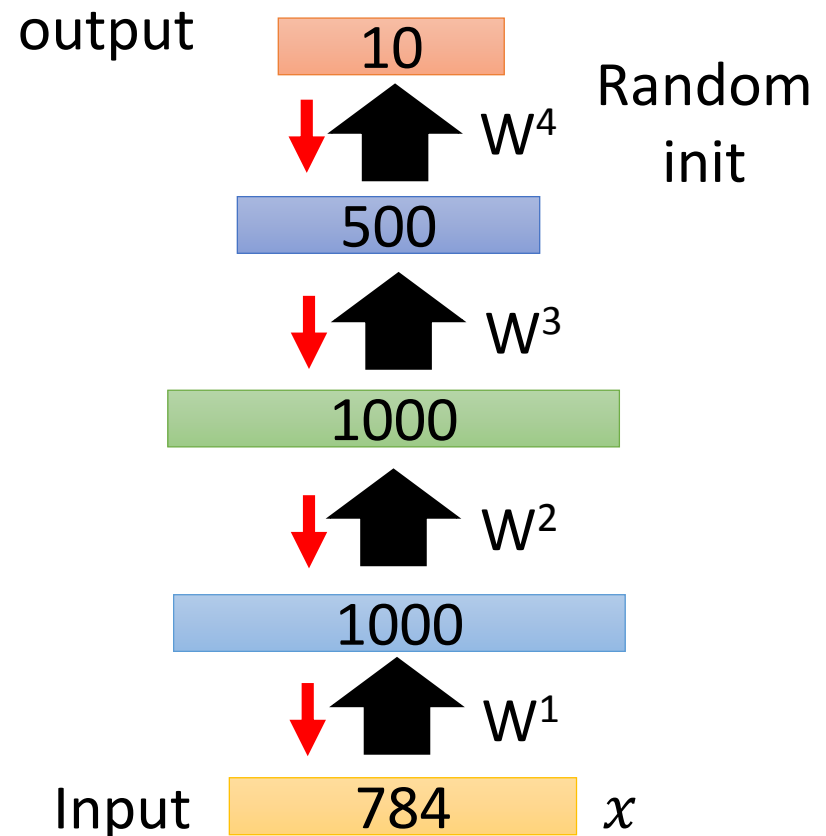
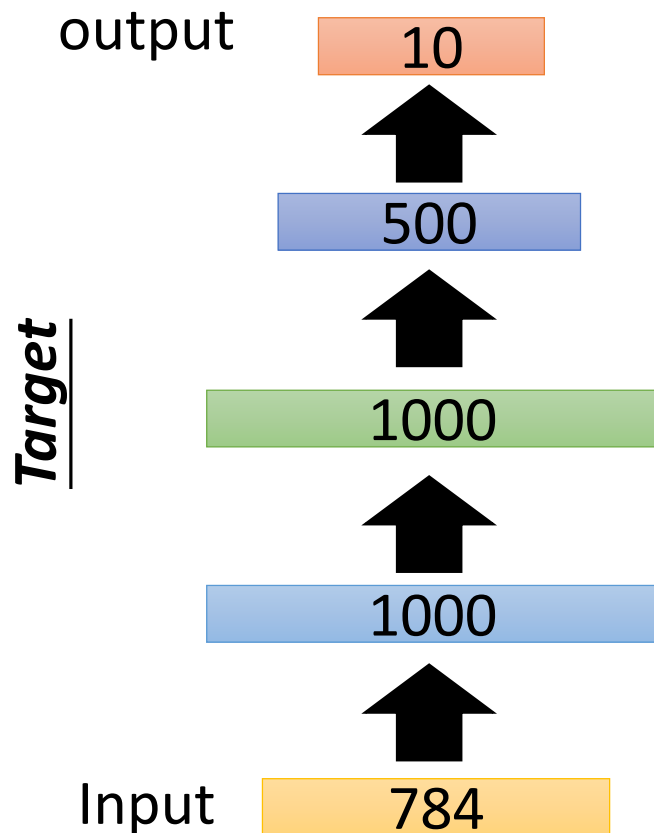
- Greedy Layer-wise Pre-training *again*



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

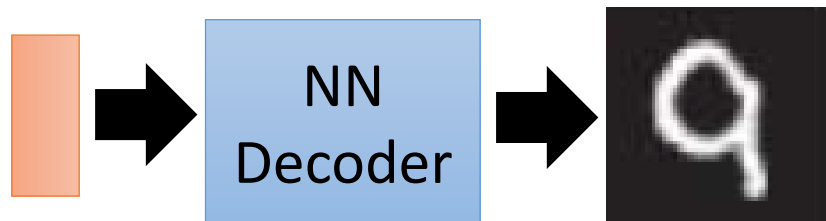
Learning More

- Deep Belief Network

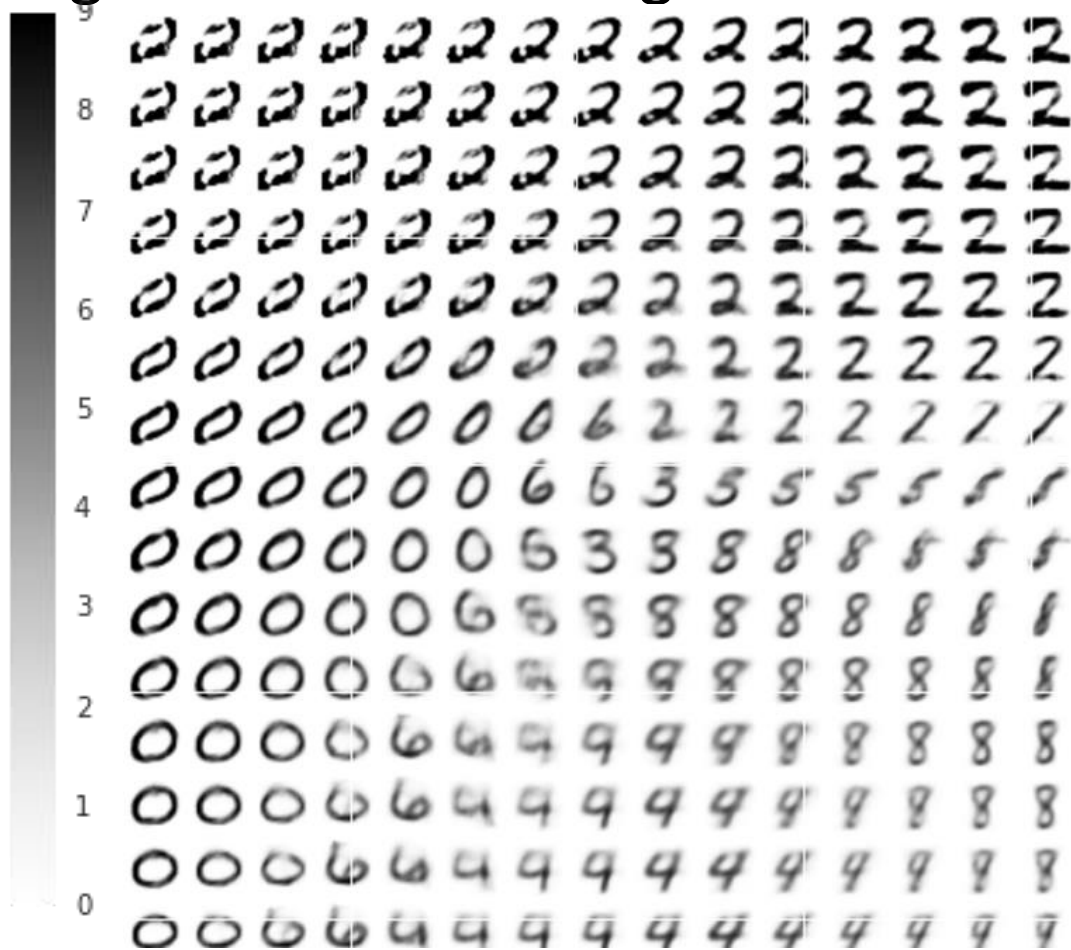
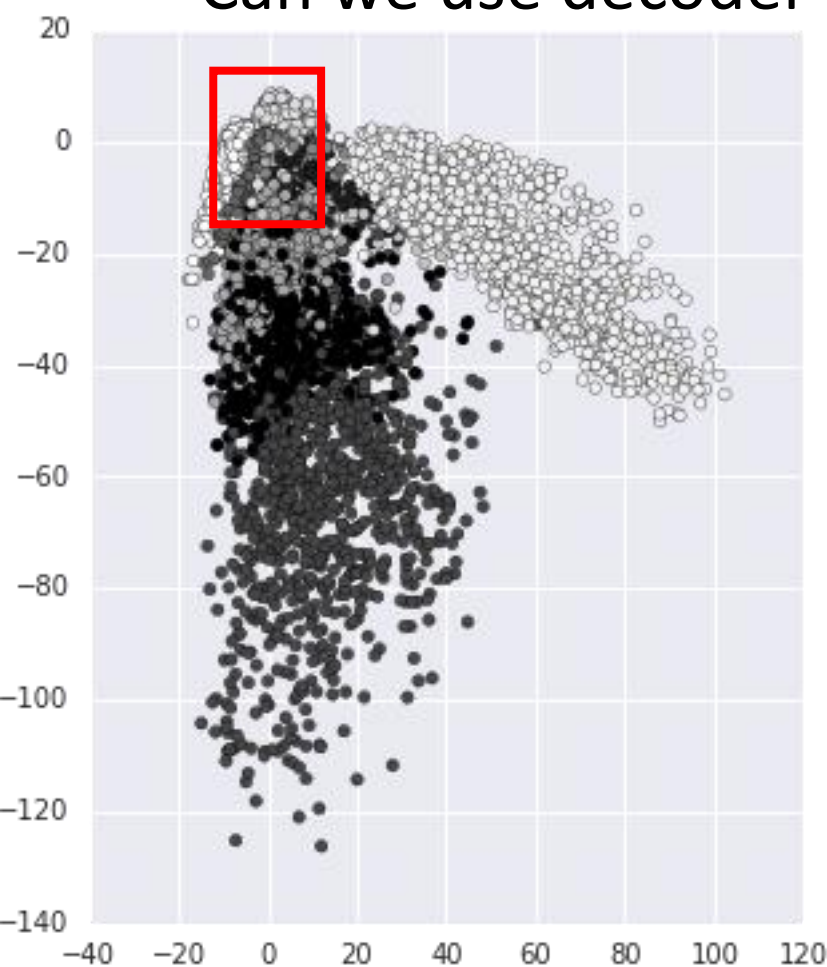
- Neural networks [7.7] : Deep learning - deep belief network
 - <https://www.youtube.com/watch?v=vkb6AWYXZ5I&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=57>
- Neural networks [7.8] : Deep learning - variational bound
 - <https://www.youtube.com/watch?v=pStDscJh2Wo&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=58>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

Next

code

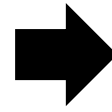


- Can we use decoder to generate something?

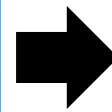


Next

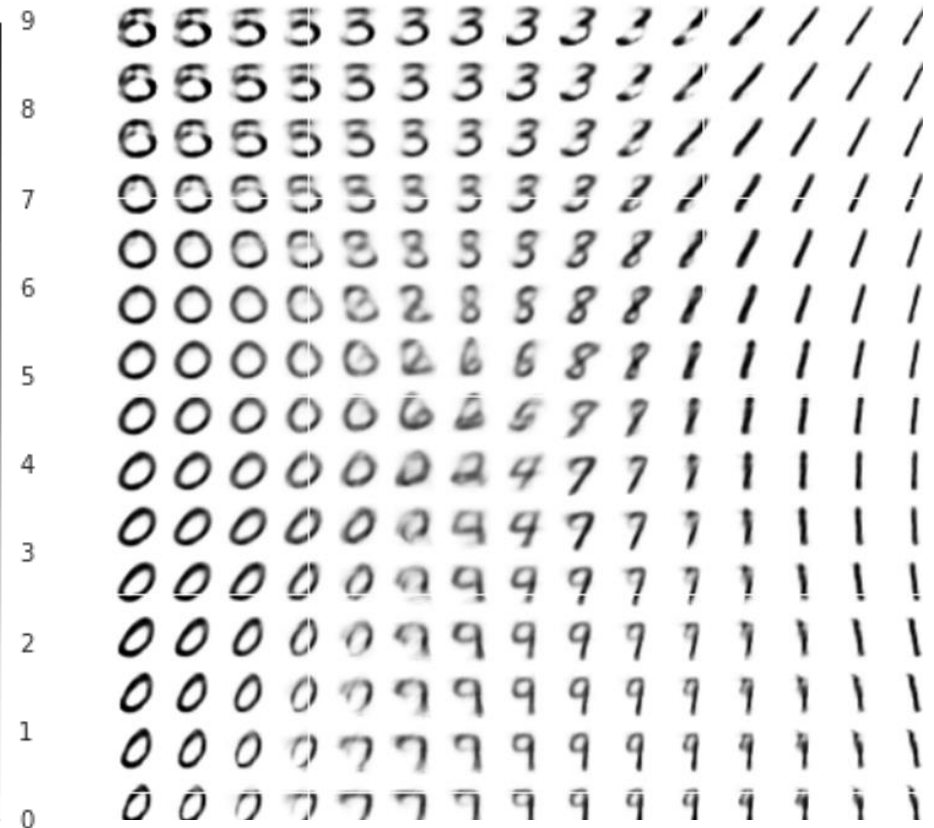
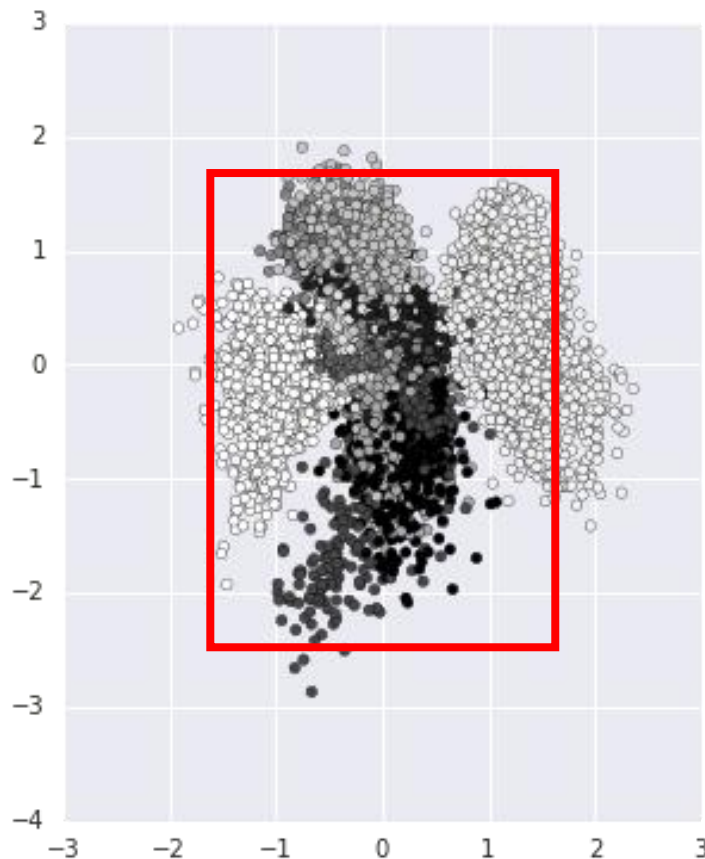
code



NN
Decoder



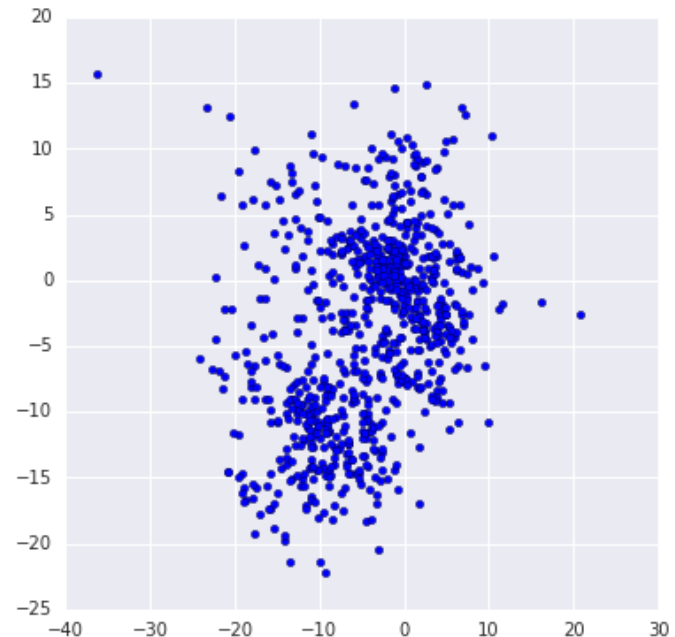
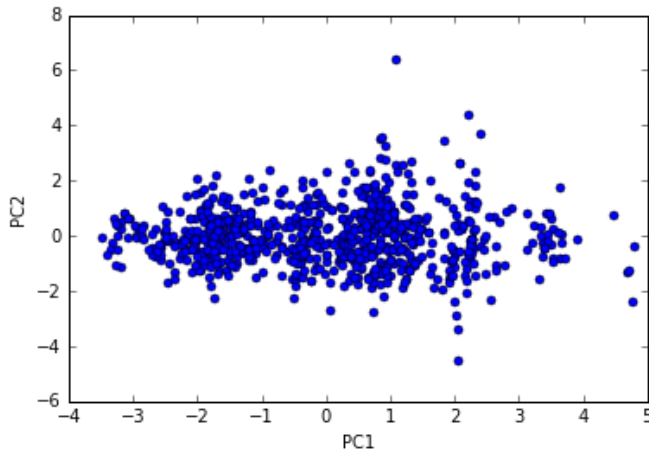
- Can we use decoder to generate something?



Appendix

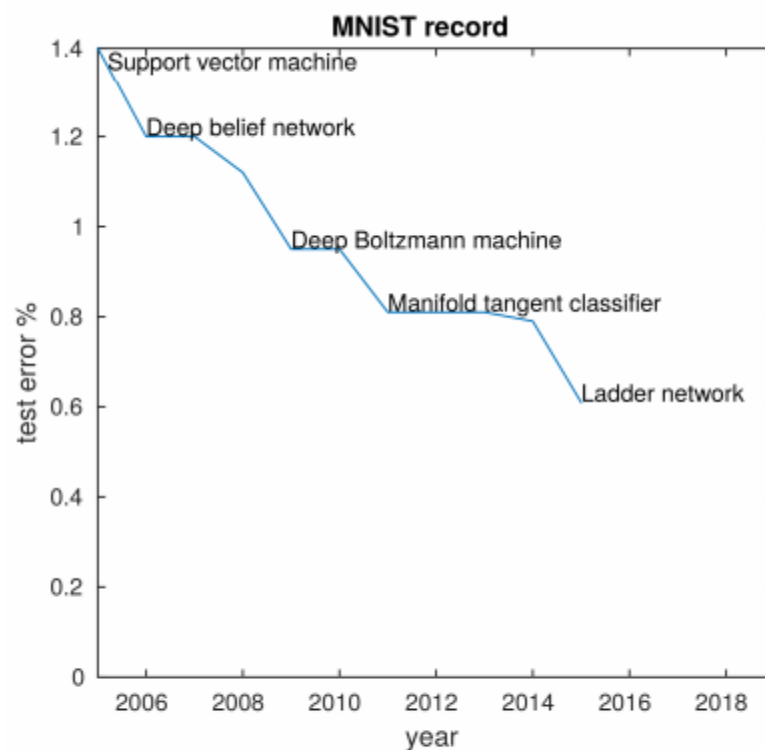
Pokémon

- <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.