

# Unsupervised Learning:

## Deep Auto-encoder

# Unsupervised Learning

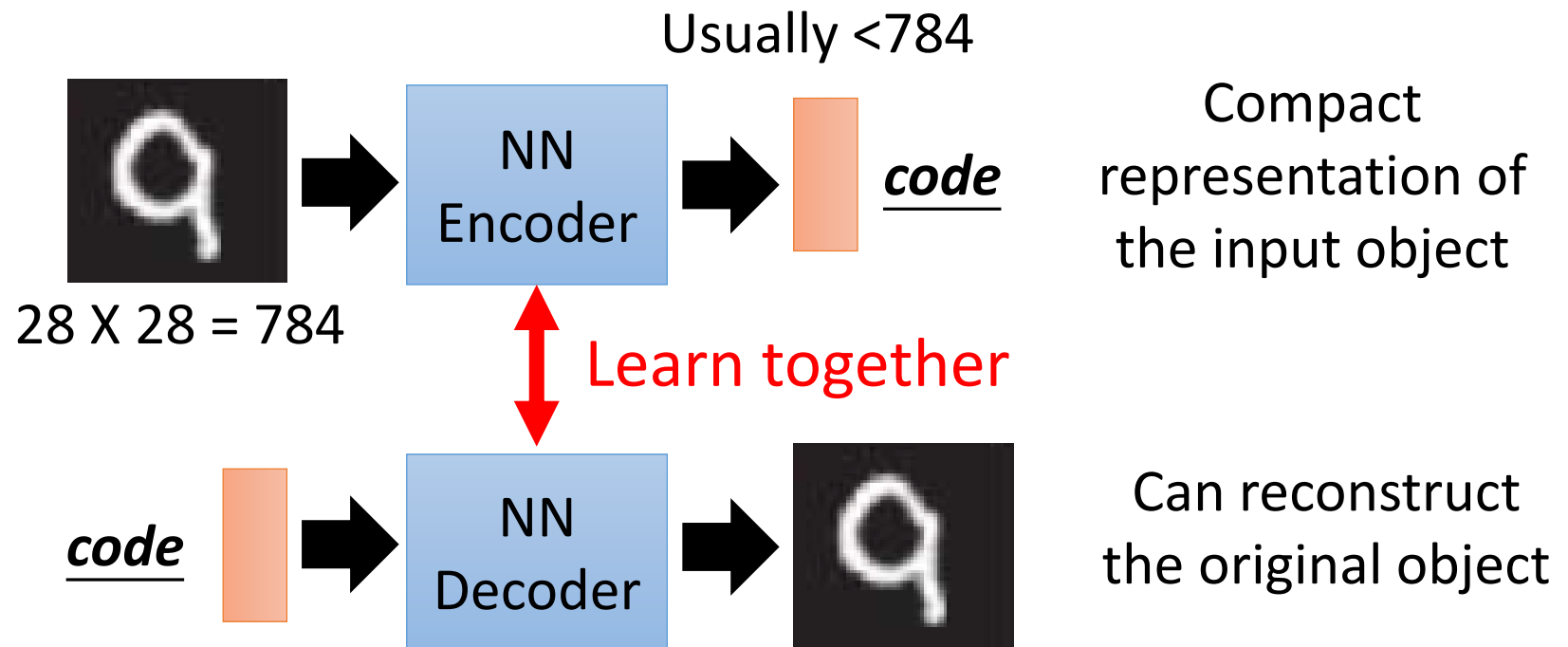
“We expect unsupervised learning to become far more important in the longer term. Human and animal learning is largely unsupervised: we discover the structure of the world by observing it, not by being told the name of every object.”

– LeCun, Bengio, Hinton, Nature 2015

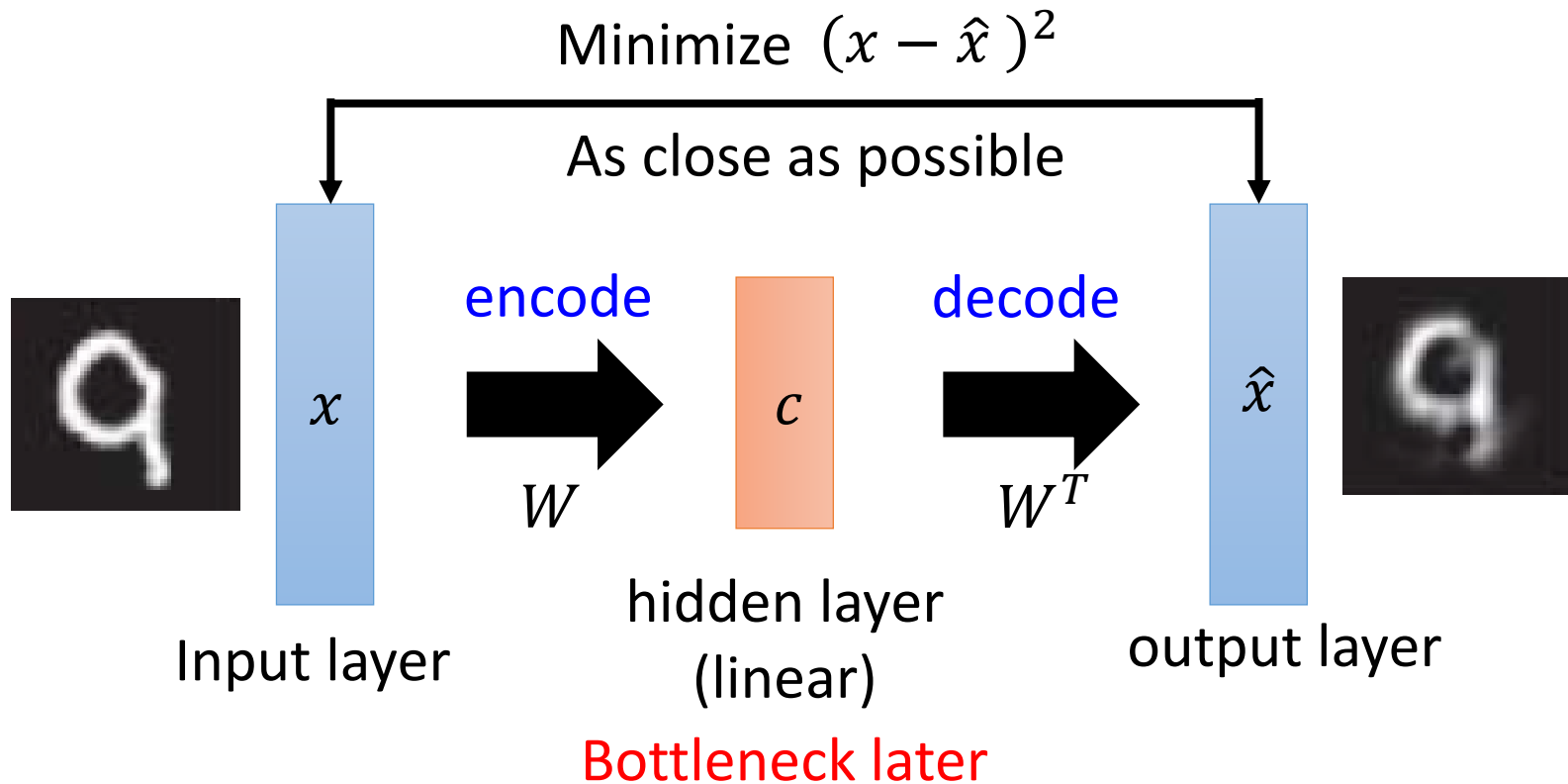
As I've said in previous statements: most of human and animal learning is unsupervised learning. If intelligence was a cake, unsupervised learning would be the cake, supervised learning would be the icing on the cake, and reinforcement learning would be the cherry on the cake. We know how to make the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

- Yann LeCun, March 14, 2016 (Facebook)

# Auto-encoder



# Recap: PCA

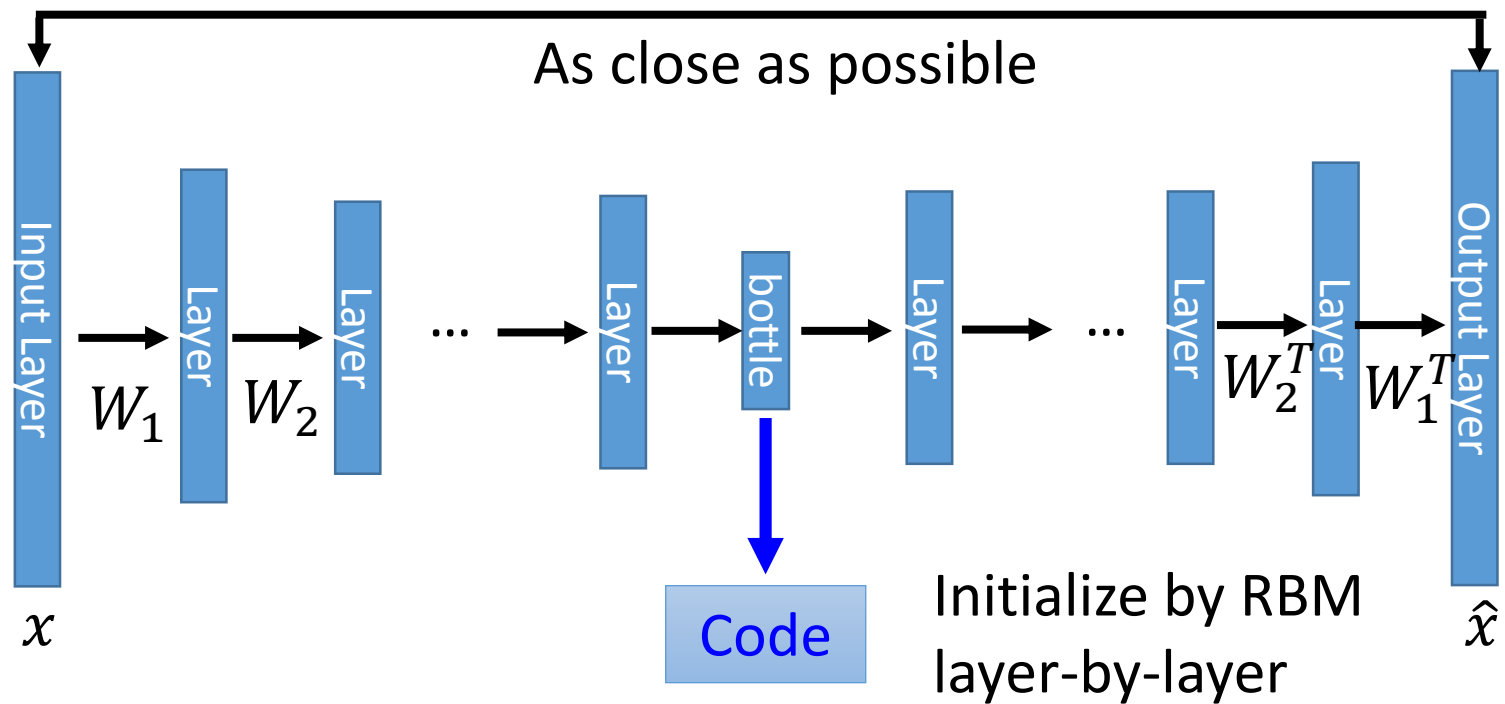


Output of the hidden layer is the code

# Deep Auto-encoder

Symmetric is not necessary.

- Of course, the auto-encoder can be deep



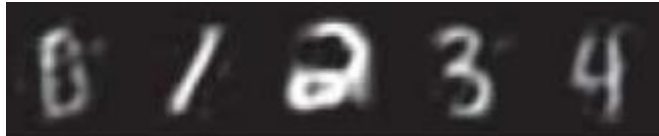
Reference: Hinton, Geoffrey E., and Ruslan R. Salakhutdinov. "Reducing the dimensionality of data with neural networks." *Science* 313.5786 (2006): 504-507

# Deep Auto-encoder

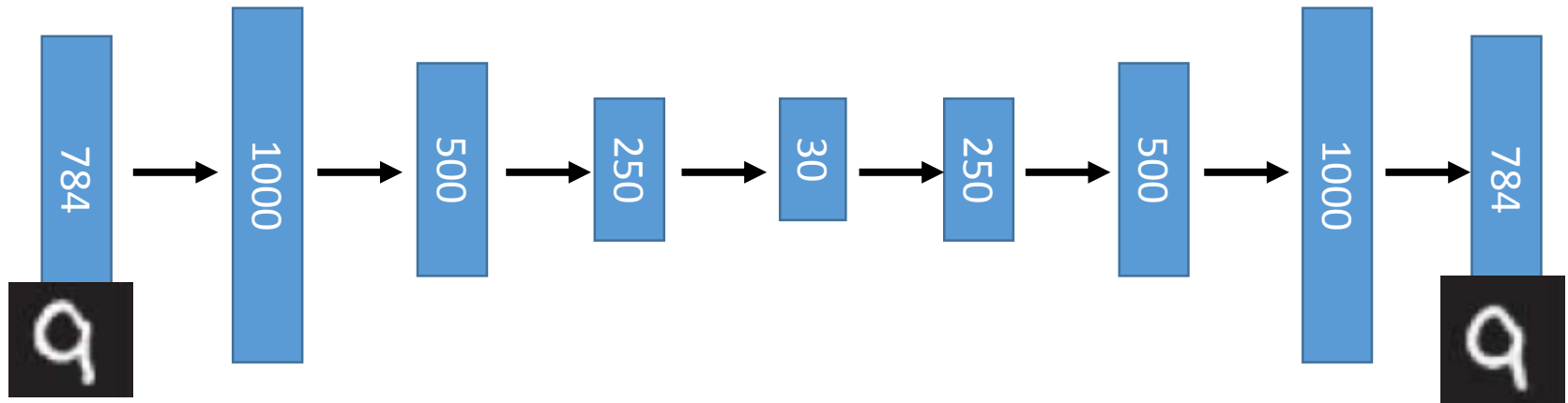
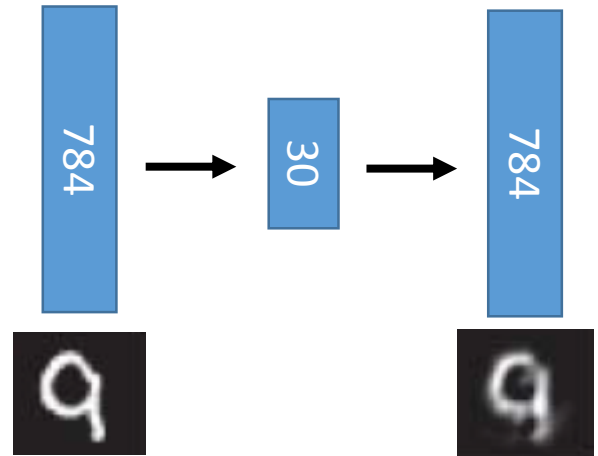
Original  
Image

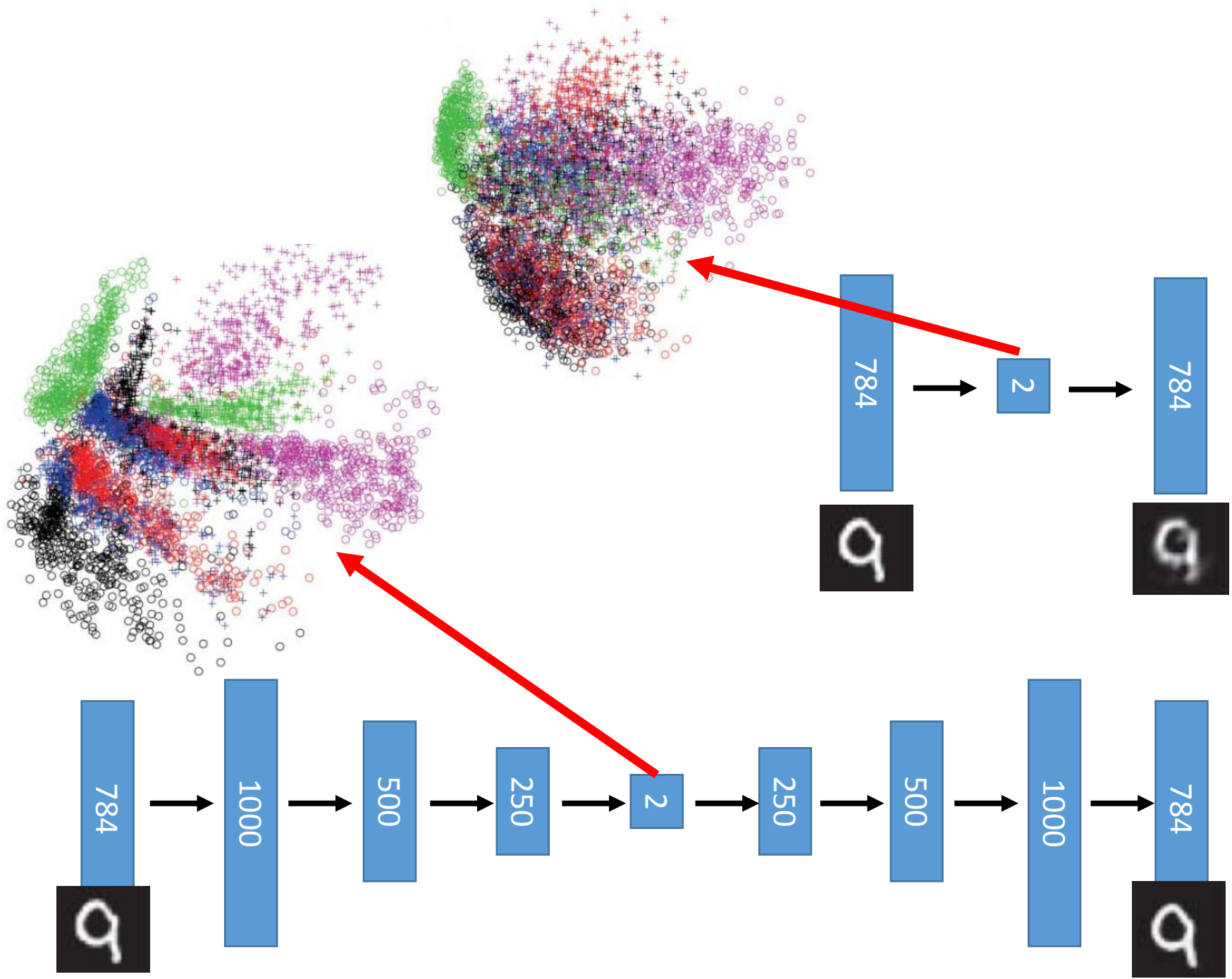


PCA



Deep  
Auto-encoder



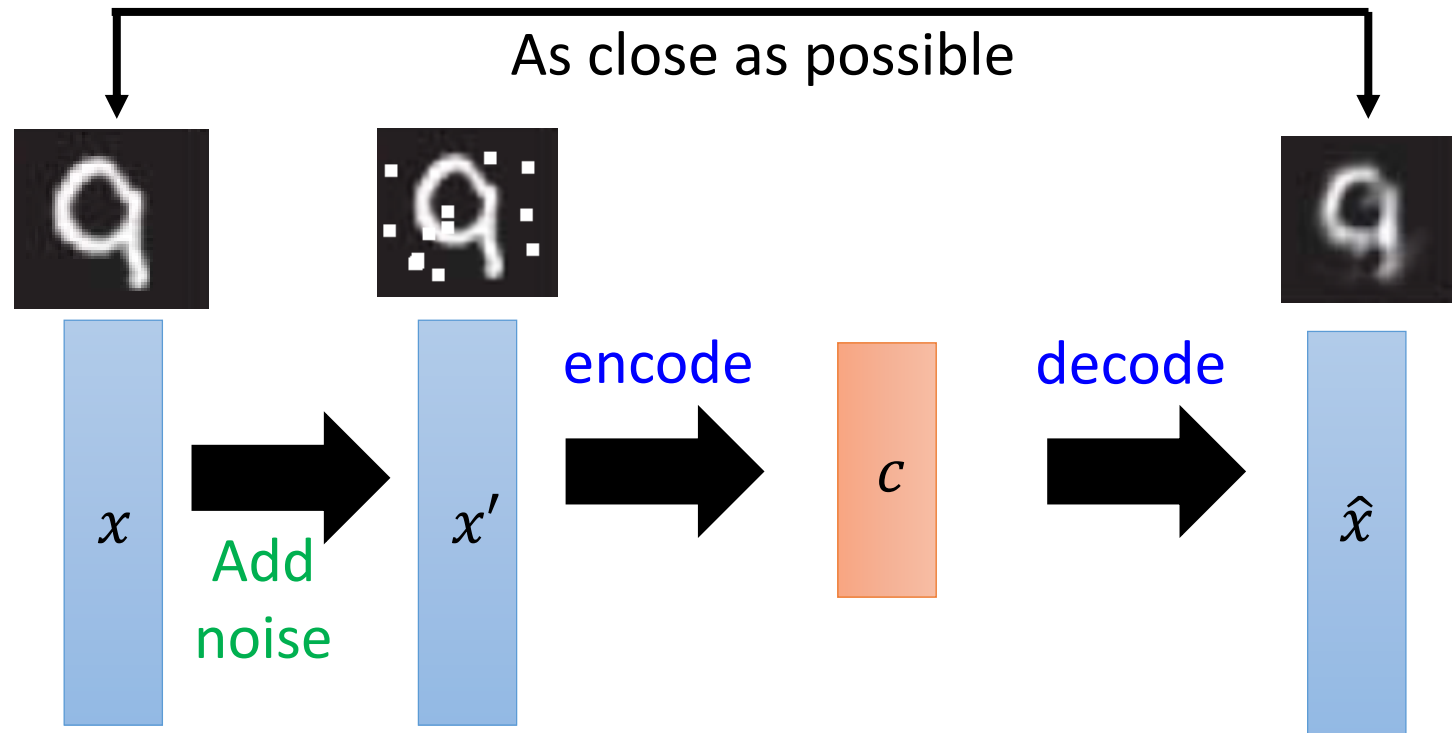


## More: Contractive auto-encoder

# 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.

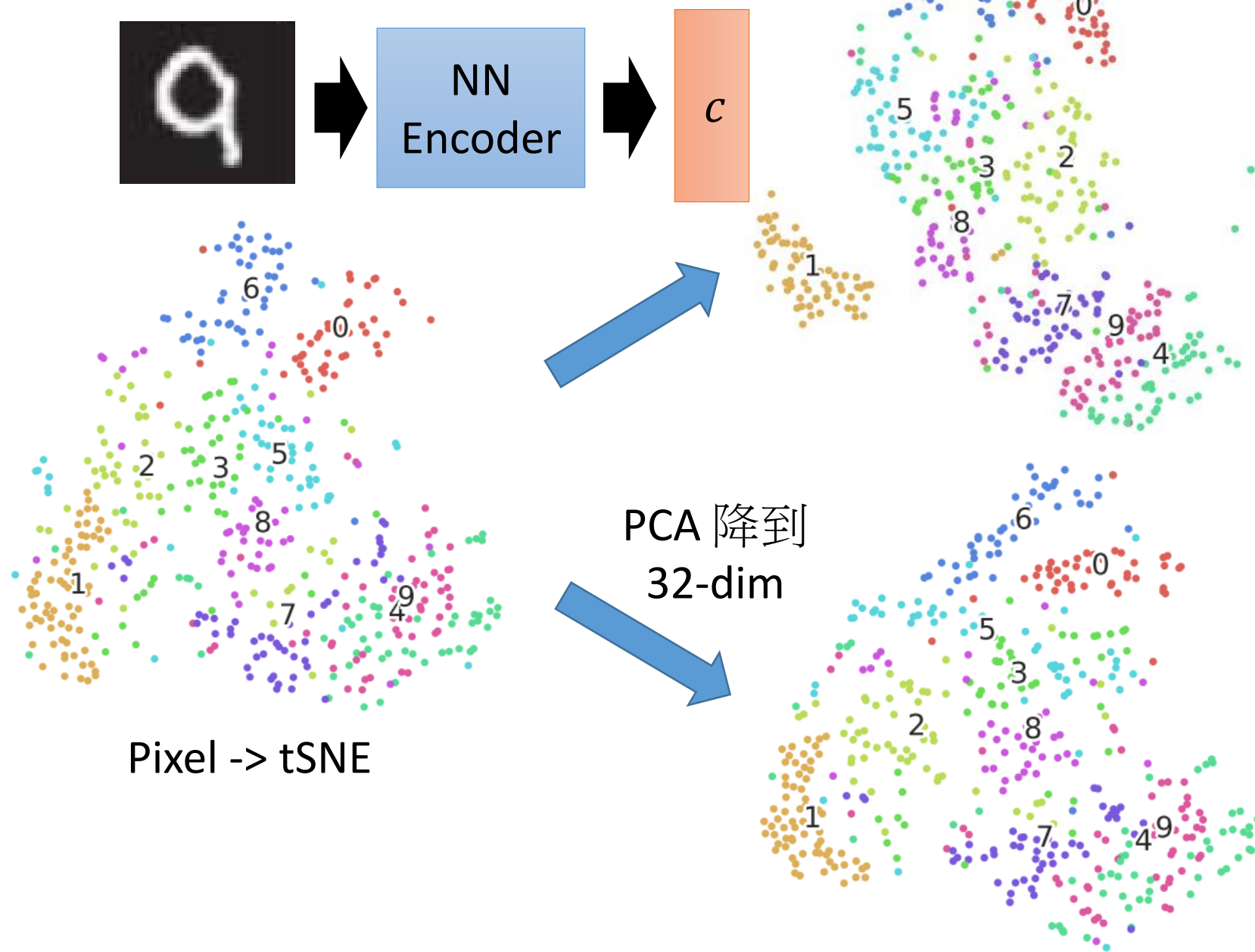
- De-noising auto-encoder



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

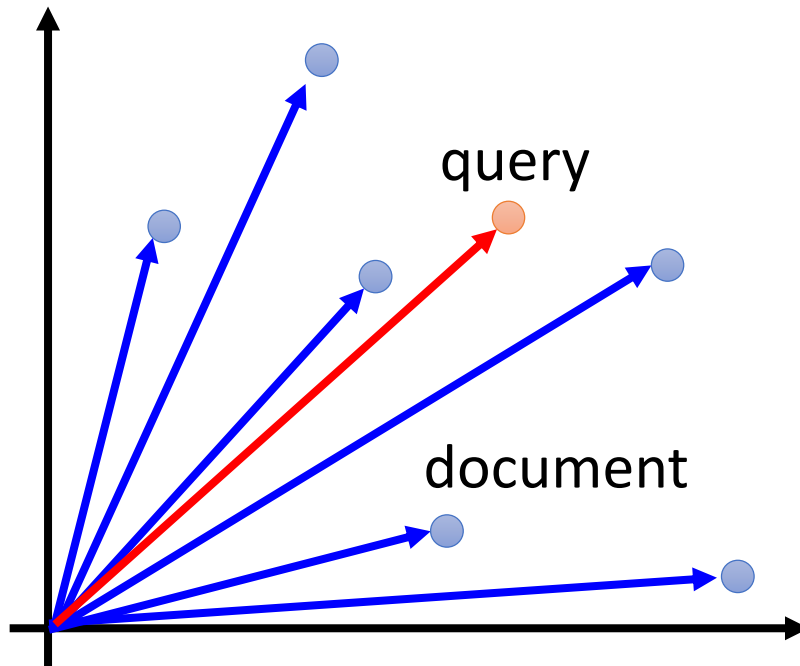


# Deep Auto-encoder - Example



# Auto-encoder – Text Retrieval

## Vector Space Model



## Bag-of-word

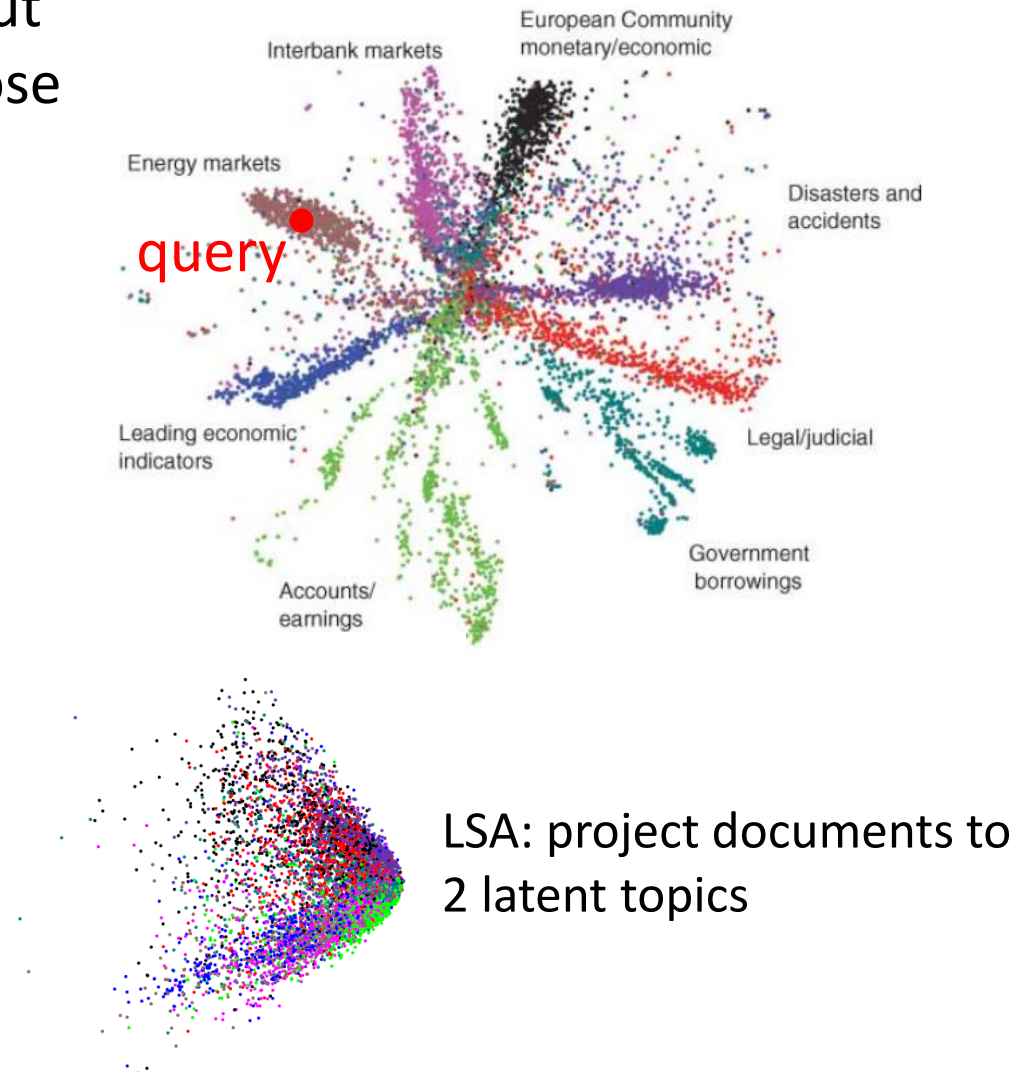
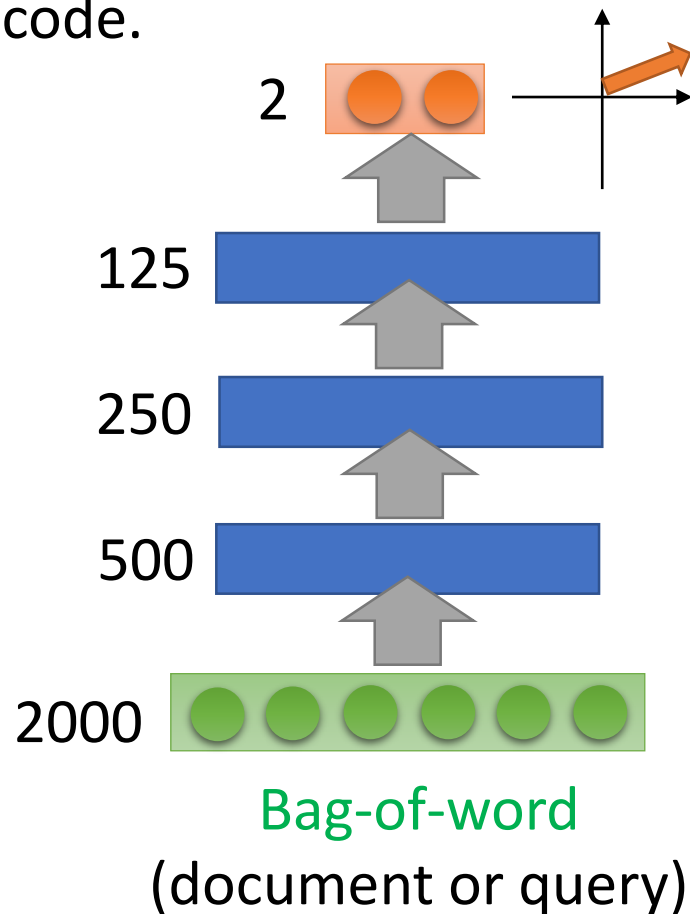
word string:  
"This is an apple"

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

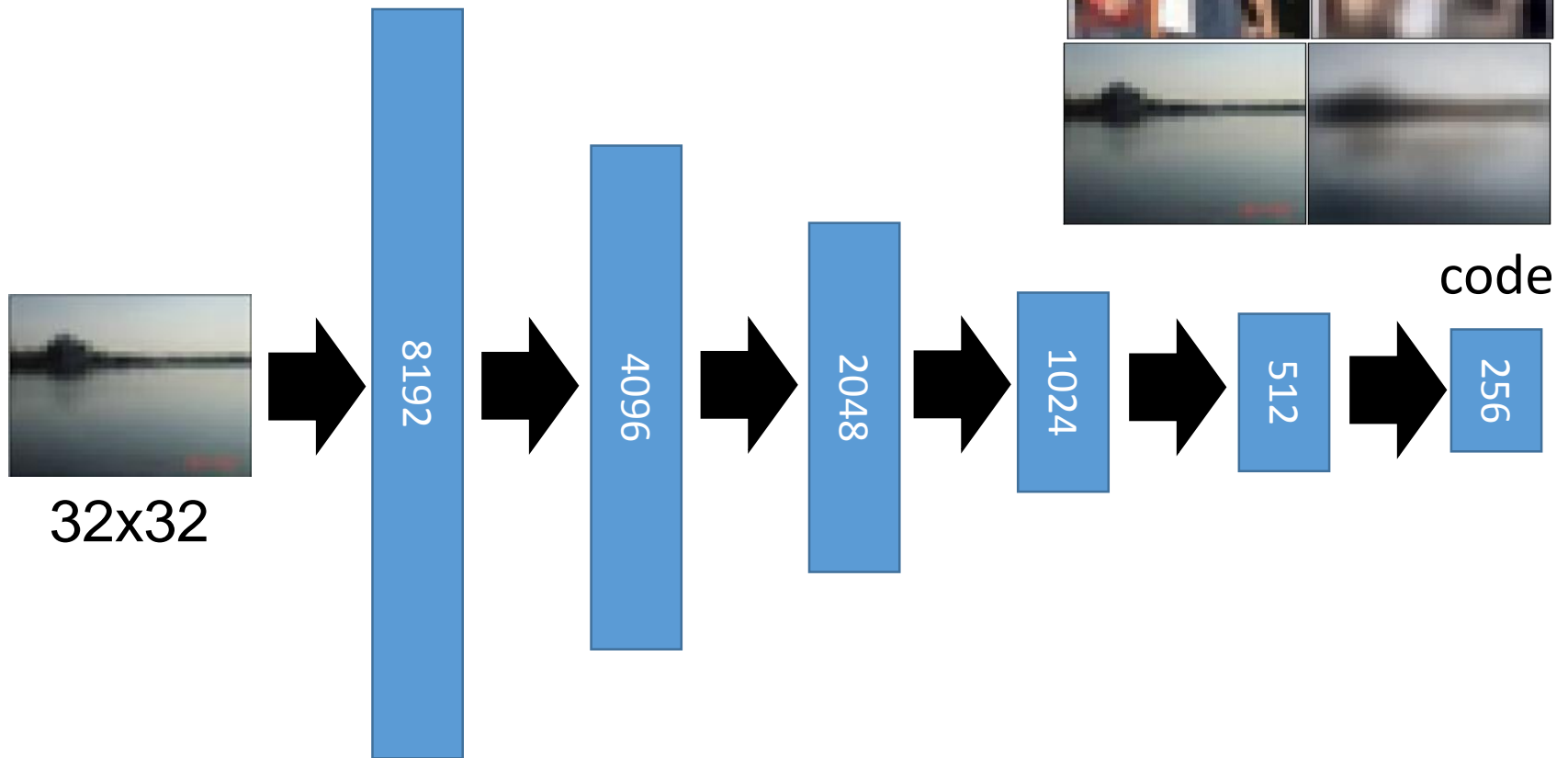
Retrieved using Euclidean distance in pixel intensity space



(Images from Hinton's slides on Coursera)

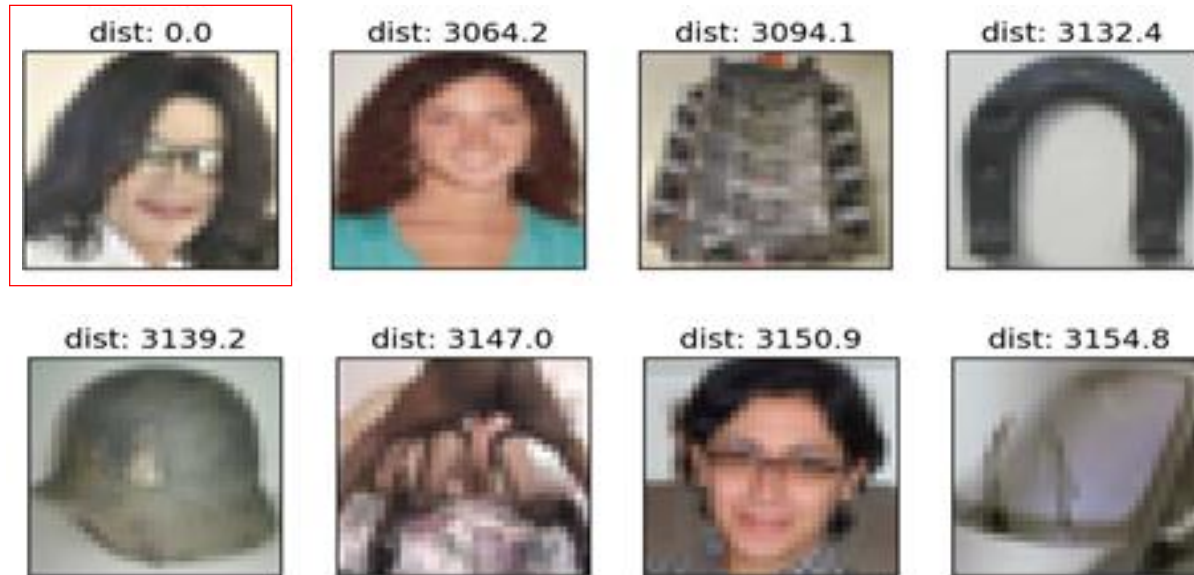
Reference: Krizhevsky, Alex, and Geoffrey E. Hinton. "Using very deep autoencoders for content-based image retrieval." *ESANN*. 2011.

# Auto-encoder – Similar Image Search



(crawl millions of images from the Internet)

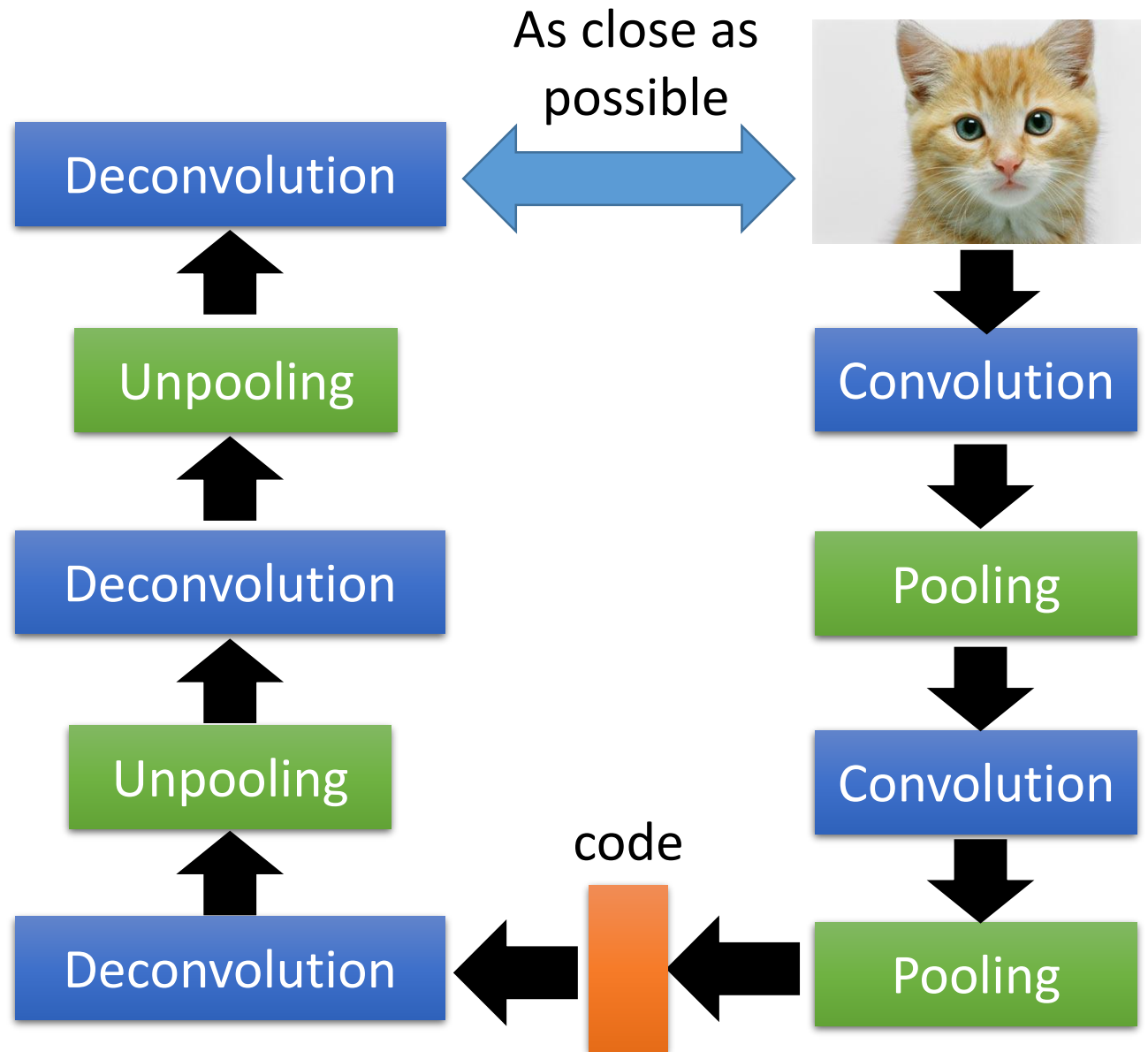
# Retrieved using Euclidean distance in pixel intensity space



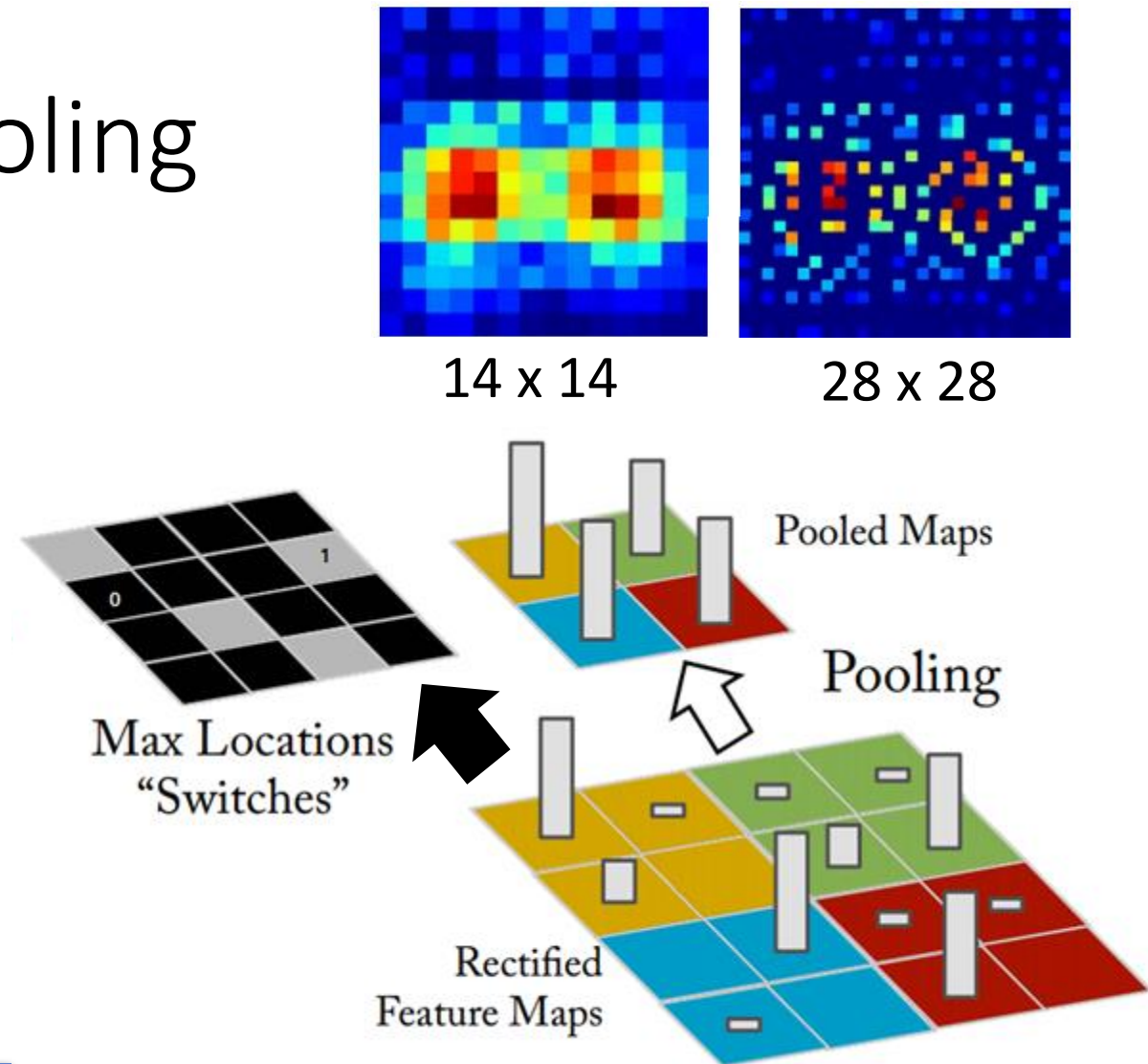
retrieved using 256 codes



# Auto- encoder for CNN



# CNN -Unpooling



Alternative: simply  
repeat the values

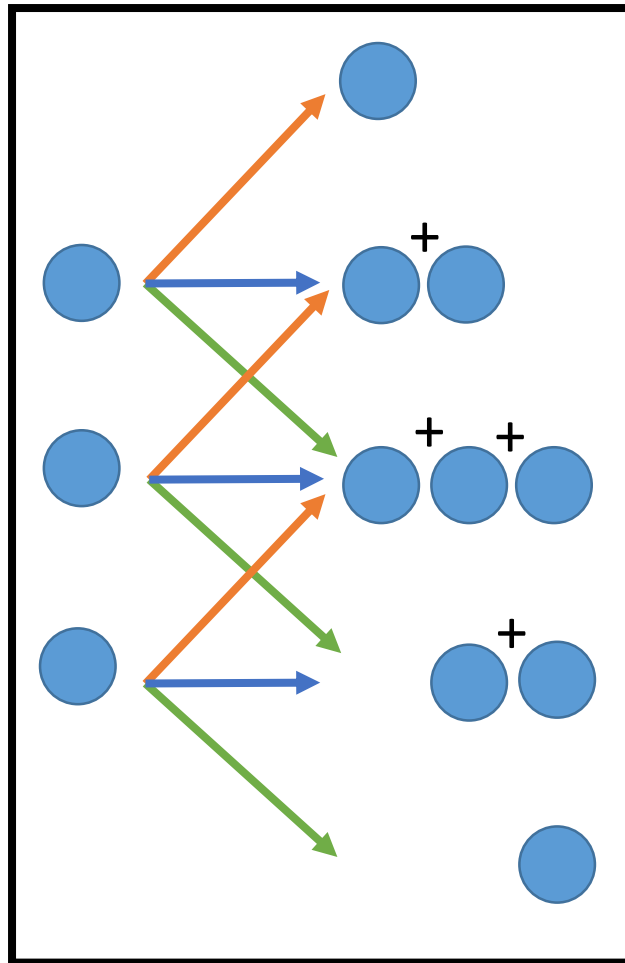
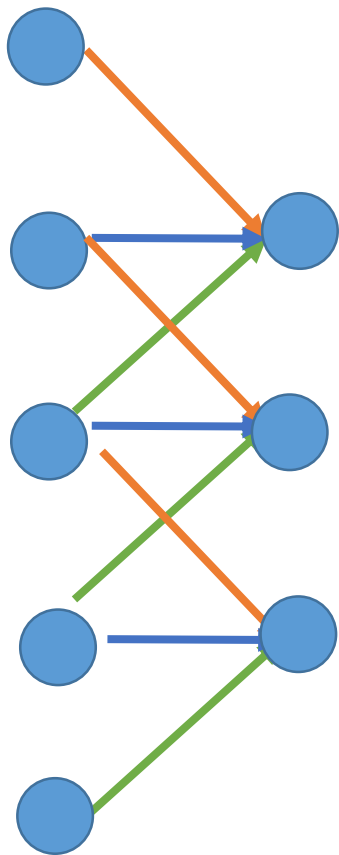
Source of image :  
[https://leonardoaraujosantos.gitbooks.io/artificial-intelligence/content/image\\_segmentation.html](https://leonardoaraujosantos.gitbooks.io/artificial-intelligence/content/image_segmentation.html)



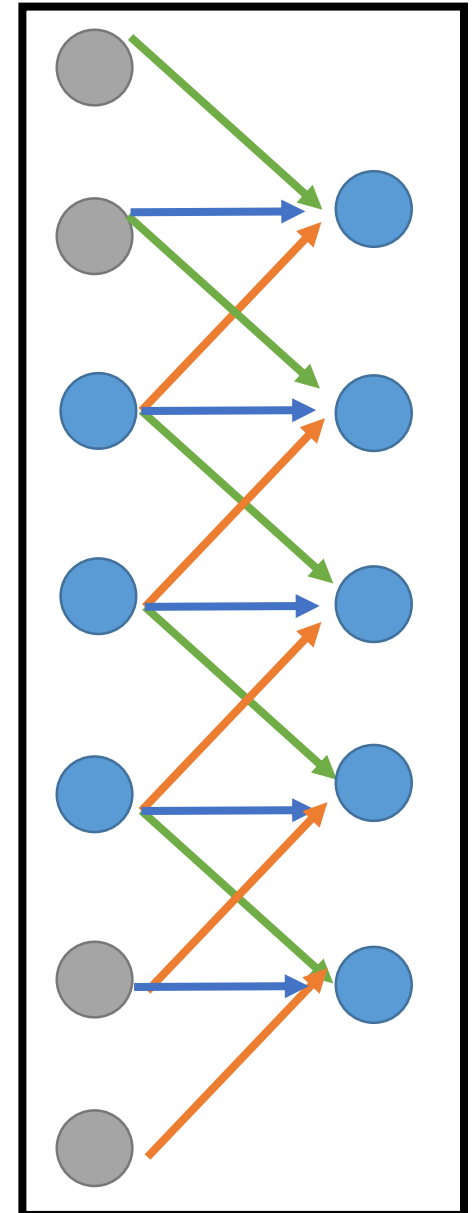
Actually, deconvolution is convolution.

# CNN

## - Deconvolution

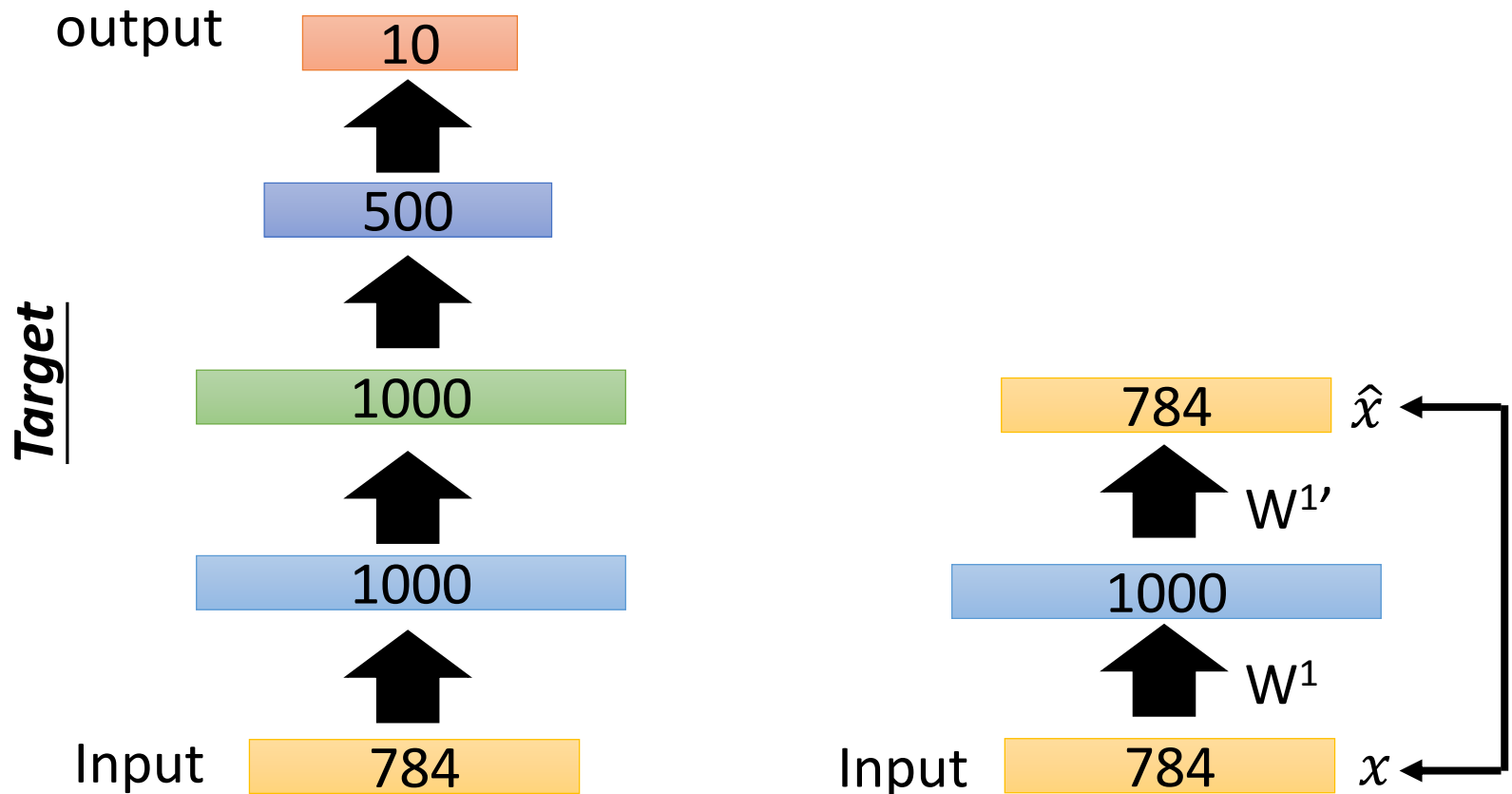


=



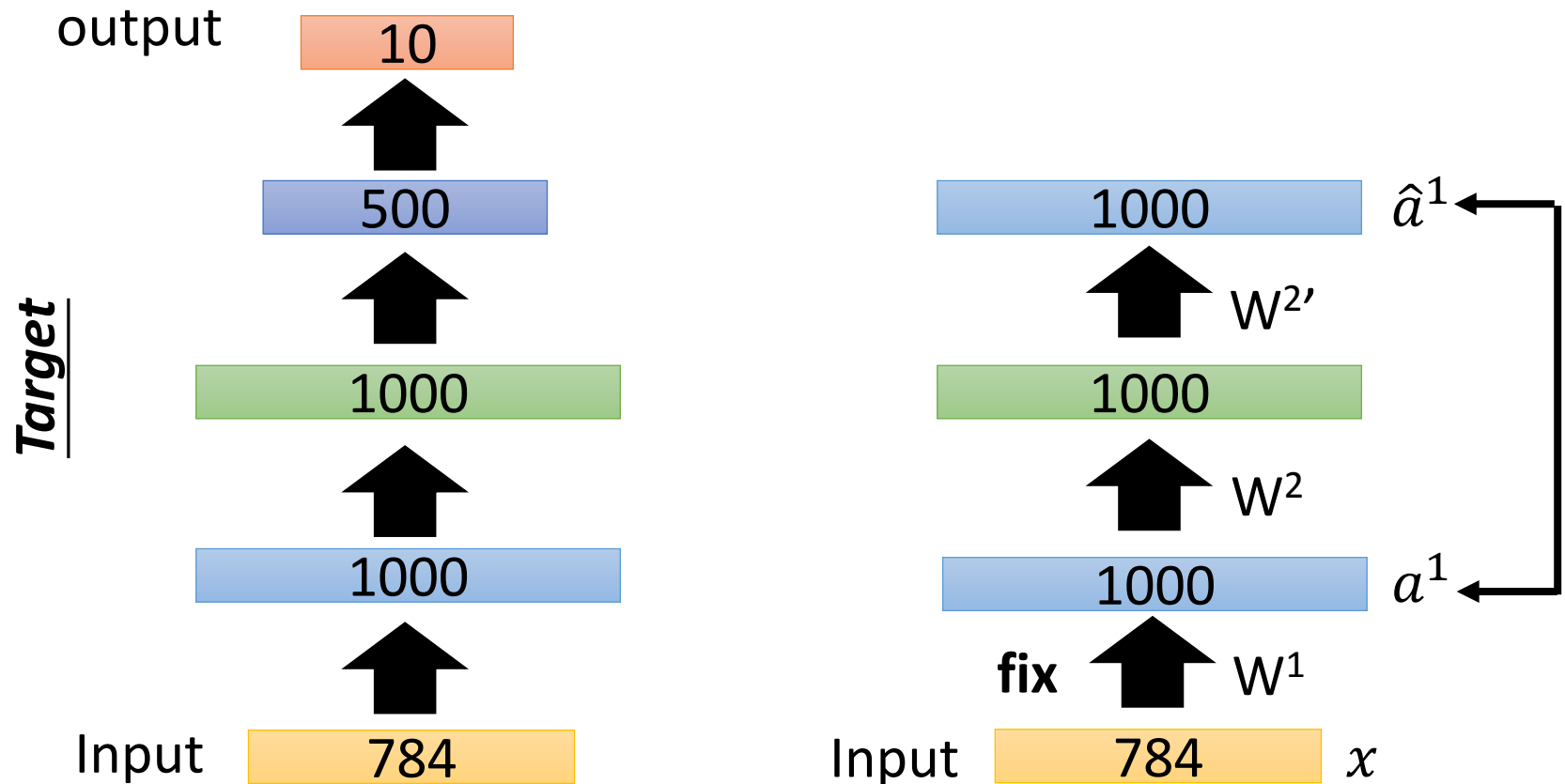
# Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



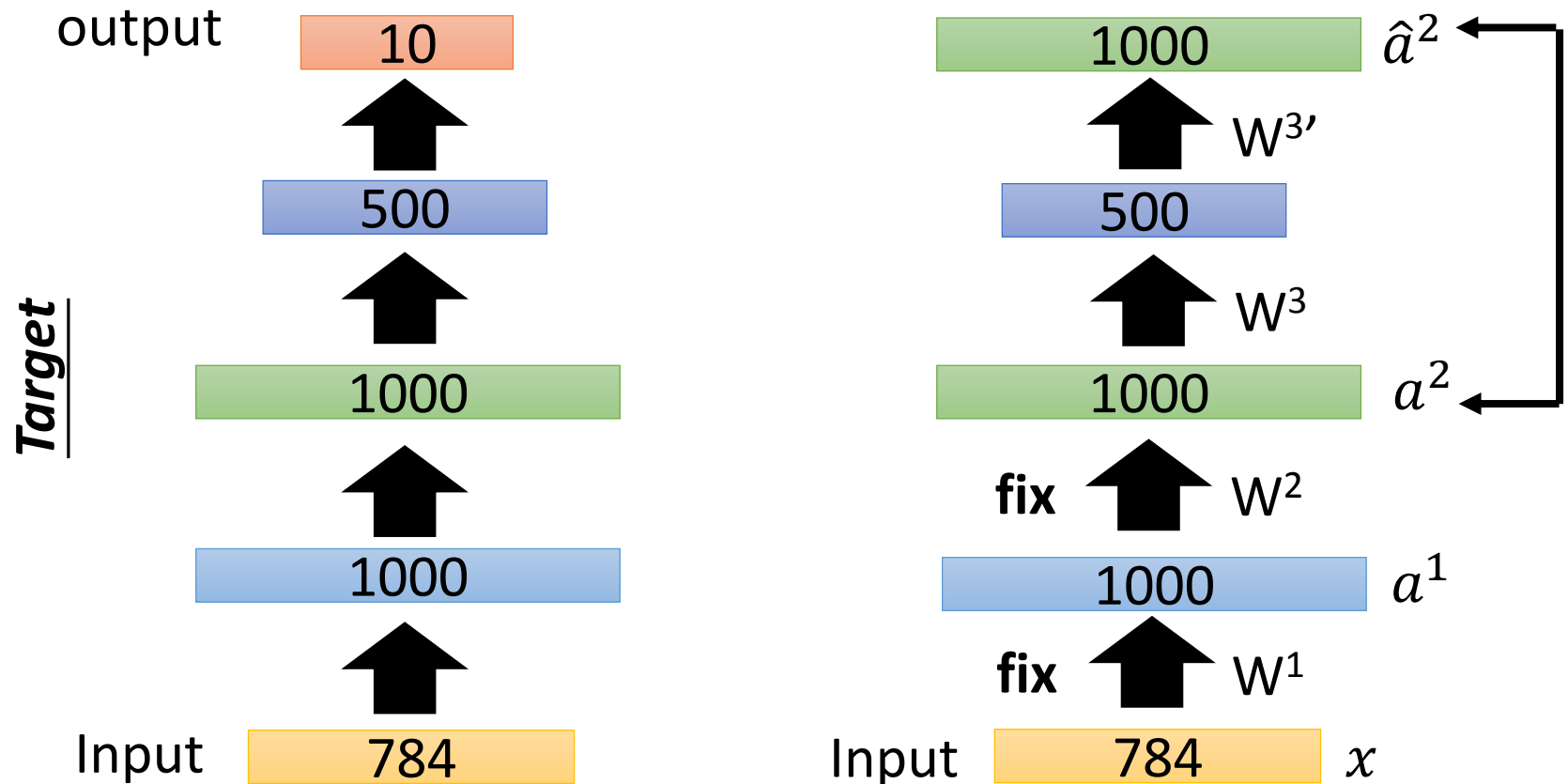
# Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*



# Auto-encoder – Pre-training DNN

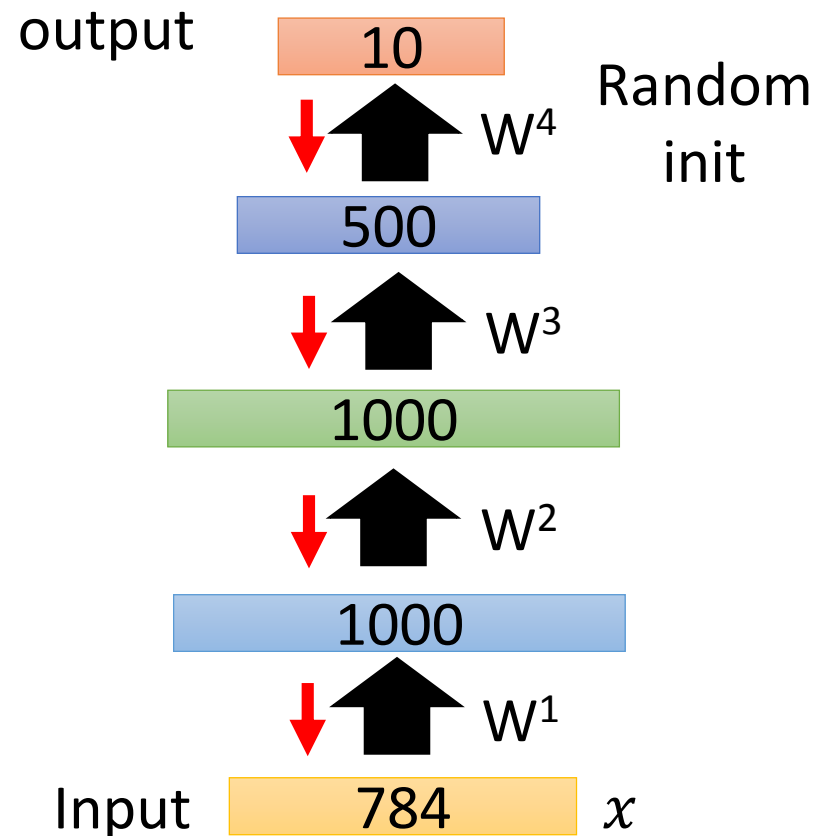
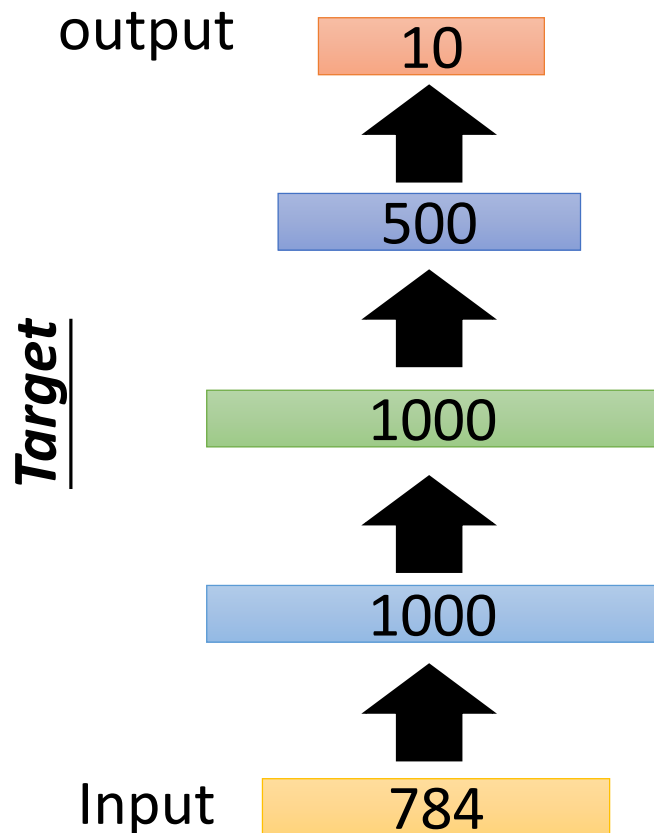
- Greedy Layer-wise Pre-training *again*



# 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](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](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](https://www.youtube.com/watch?v=e0Ts_7Y6hZU&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=38)

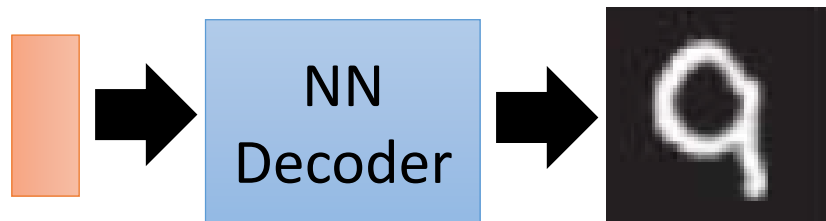
# Learning More

## - Deep Belief Network

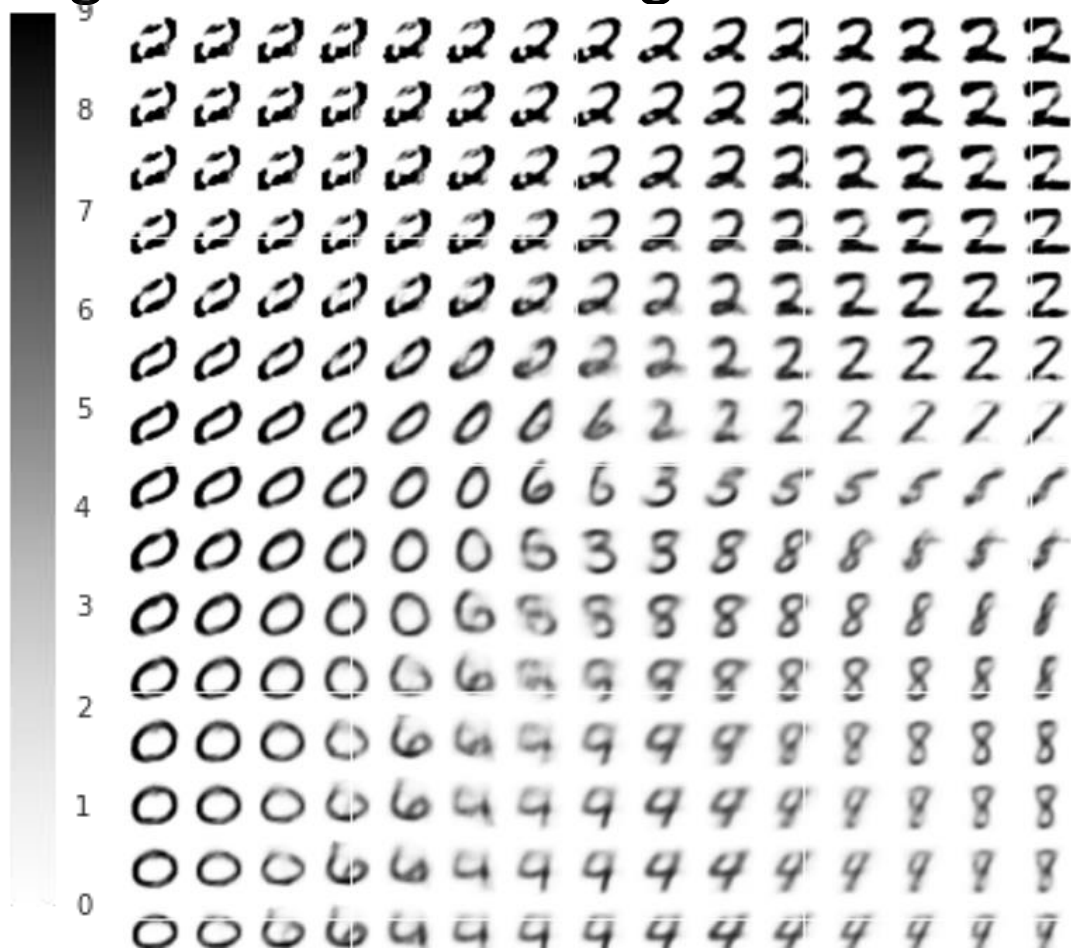
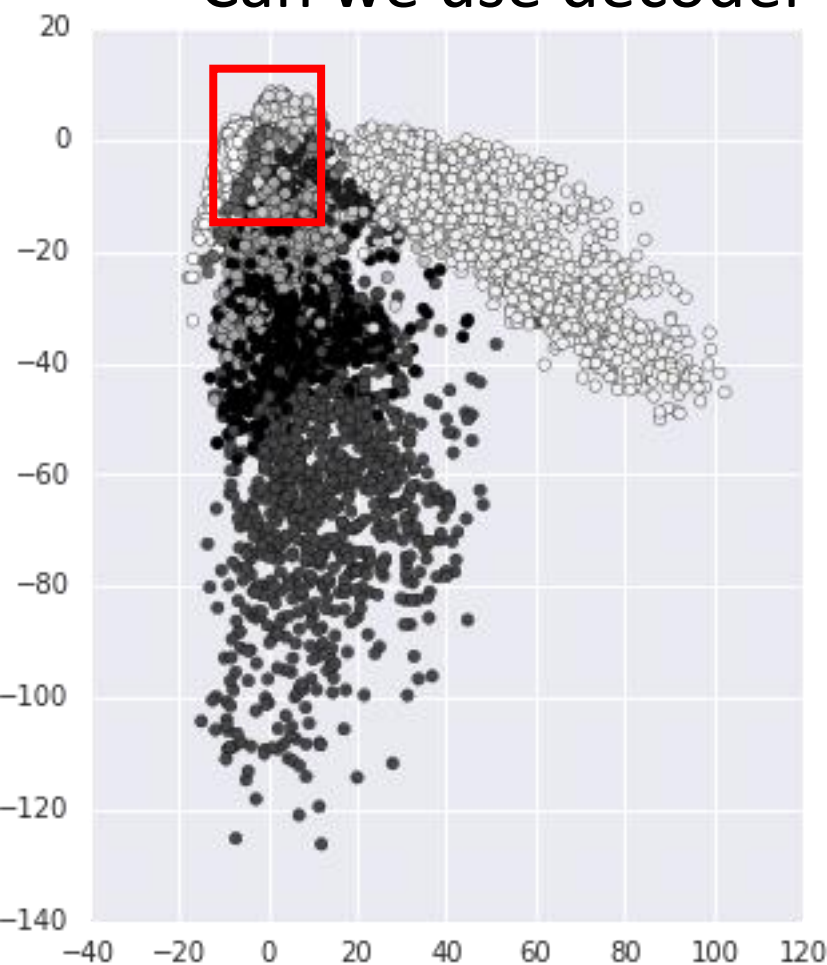
- Neural networks [7.7] : Deep learning - deep belief network
  - <https://www.youtube.com/watch?v=vkb6AWYXZ5I&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=57>
- Neural networks [7.8] : Deep learning - variational bound
  - <https://www.youtube.com/watch?v=pStDscJh2Wo&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH&index=58>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

Next .....

code



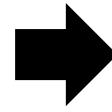
- Can we use decoder to generate something?



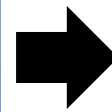


Next .....

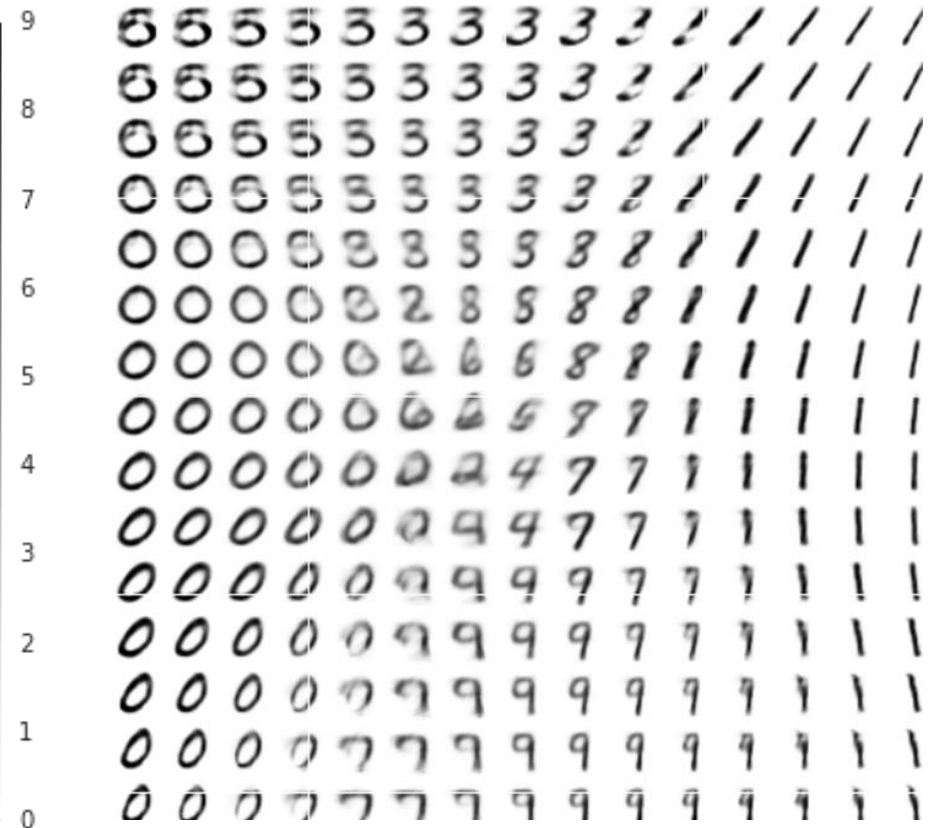
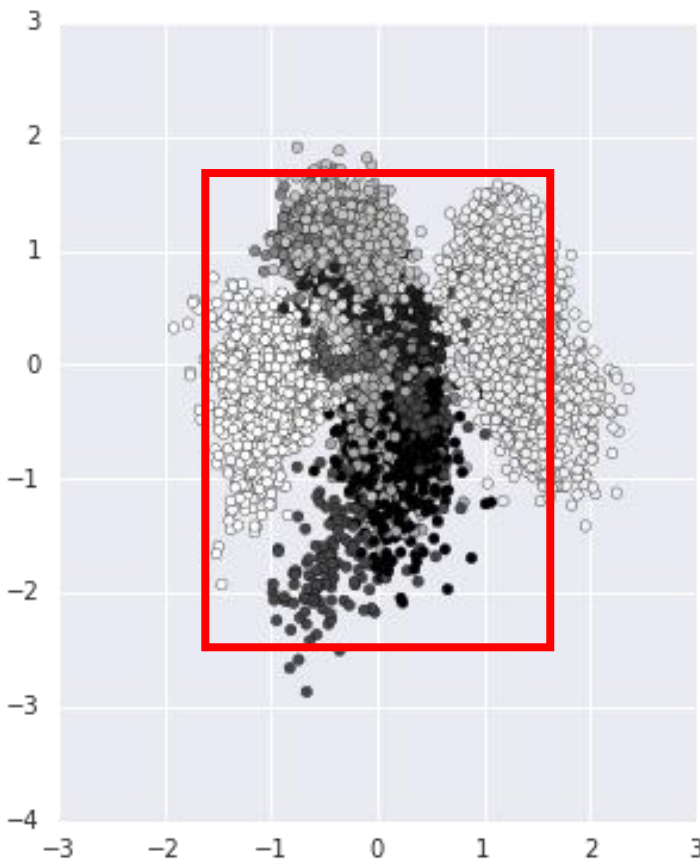
code



NN  
Decoder



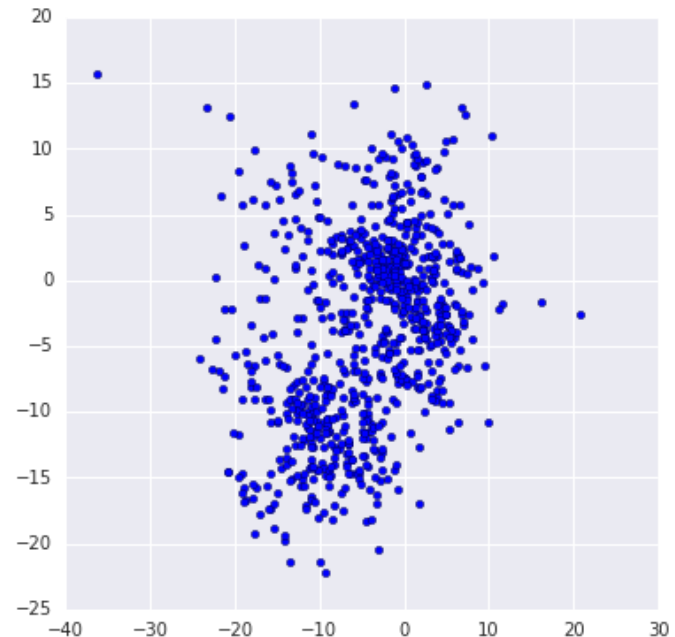
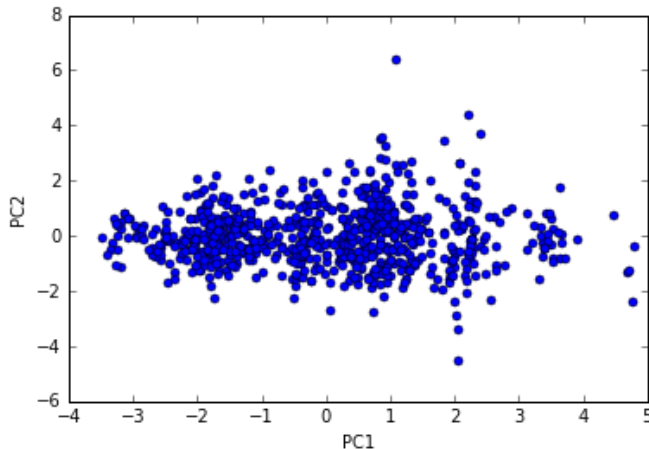
- Can we use decoder to generate something?



# Appendix

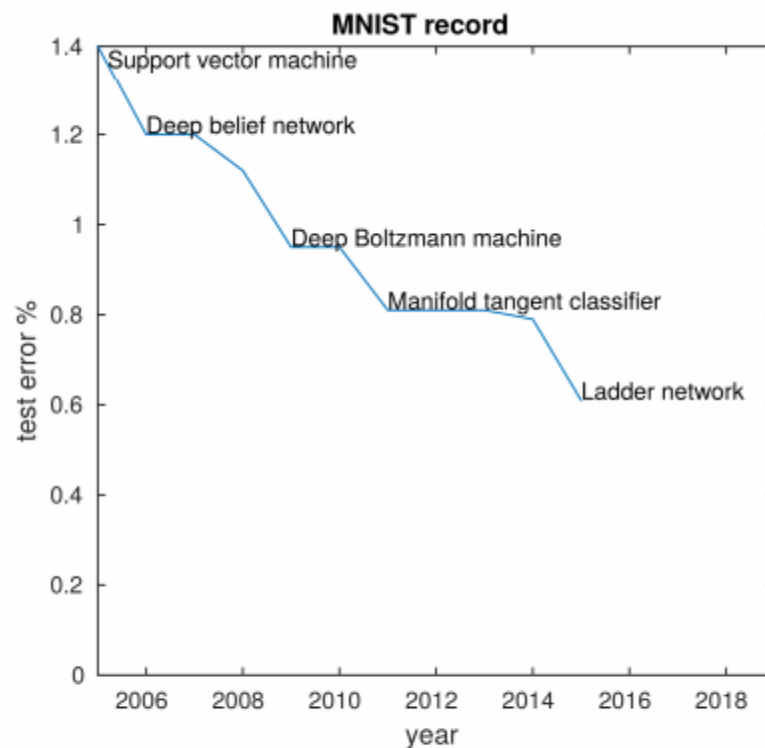
# Pokémon

- <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://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.