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.”

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

28 x 28 = 784

Compact representation of the input object

Learn together

Can reconstruct the original object
Recap: PCA

Minimize \((x - \hat{x})^2\)

As close as possible

Input layer

\(x\)

\(W\)

encode

hidden layer (linear)

\(c\)

\(W^T\)

decode

output layer

\(\hat{x}\)

Bottleneck later

Output of the hidden layer is the code

\(q\)
Deep Auto-encoder

- Of course, the auto-encoder can be deep

Symmetric is not necessary.

Initialize by RBM layer-by-layer

Deep Auto-encoder

Original Image

PCA

Deep Auto-encoder

0 / 2 3 4

0 / 2 3 4

784 → 30 → 784

784 → 1000 → 500 → 250 → 30 → 250 → 500 → 1000 → 784

q
Auto-encoder

• De-noising auto-encoder

More: Contractive auto-encoder

Deep Auto-encoder - Example

Pixel -> tSNE

NN Encoder

PCA 降到 32-dim

$c$
Auto-encoder – Text Retrieval

**Vector Space Model**

- query
- document

**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.

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)

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

As close as possible

Deconvolution

Unpooling

Deconvolution

Unpooling

Deconvolution

code
CNN - Unpooling

Alternative: simply repeat the values

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

Actually, deconvolution is convolution.
Auto-encoder – Pre-training DNN

- Greedy Layer-wise Pre-training *again*

![Diagram of auto-encoder and pre-training process](image_url)
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

Input: 784

Output: 10

W^1

W^2

W^3

W^4

Random init
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=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 \[\xrightarrow{}\] NN Decoder \[\xrightarrow{}\] 

• 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/pca.html)
- [http://140.112.21.35:2880/~tlkagk/pokemon/auto.html](http://140.112.21.35:2880/~tlkagk/pokemon/auto.html)
- The code is modified from
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
Yearly progress in permutation-invariant MNIST.
A. Rasmus, H. Valpola, M. Honkala, M. Berglund, and T. Raiko.