Reducing the Dimensionality of Data with Neural Networks

Autoencoders

- Hidden Layer lowers dimensionality of input
- Non-linear reduction
- Reconstruct data from the middle layer
- Can perform better than PCA
Autoencoders - Problems

Problems

- Vanishing gradient problem for multiple layers
- Bigger NNs requires good initial weights
- How to initialize the weights?
Autoencoders - Pretraining

- Train each layer individually in an unsupervised way
- Composed by stacks of Restricted Boltzmann Machines (RBM)
- The input vector is binary for explanation purposes
RBMs - Pretraining

- **The idea**: model the input $P(X)$ better and later focus on optimizing $P(Y|X)$

- Each layer extract features of the previous

- It removes unimportant variations in the data
RBMs - Pretraining

\[
\frac{\partial \log p(v)}{\partial w_{ij}} = \langle v_i h_j \rangle_{data} - \langle v_i h_j \rangle_{model}
\]
RMBs - Pretraining

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\]
RBMs - Pretraining

\[ \Delta w_{ij} = \epsilon (\langle v_i h_j \rangle_{\text{data}} - \langle v_i h_j \rangle_{\text{model}}) \]

\[ p(h_j = 1 \mid v) = \sigma(b_j + \sum_i v_i w_{ij}) \]

\[ p(v_i = 1 \mid h) = \sigma(a_i + \sum_j h_j w_{ij}) \]
Deep Autoencoder

- Train each RBM separately
- "Unfold" the NN to form decoder part
- BP for fine-tuning
Datasets and Results

20000 training and 10000 testing images.

In order: original data, 6-dimensional autoencoder, “logistic” PCA with 6 components, 18 components and standard PCA with 18 components.
Datasets and Results

MNIST dataset

Random test image, 30-dim deep autoencoder, 30-dim logistic PCA, 30-dim PCA

784-1000-500-250-30
Datasets and Results

Fig. 3. (A) The two-dimensional codes for 500 digits of each class produced by taking the first two principal components of all 60,000 training images. (B) The two-dimensional codes found by a 784-1000-500-250-2 autoencoder. For an alternative visualization, see (B).

MNIST Dataset
2-dim LSA and autoencoder
Datasets and Results

Olivetti Dataset

Random samples of dataset, 625-2000-1000-500-30 autoencoder and 30-dim PCA
Datasets and Results

The Reuters Corpus Volume 2

2000-500-250-125-2 autoencoder and 2-dim LSA
References


http://cl.naist.jp/~kevinduh/a/deep2014/