Deep Learning for Pattern Recognition

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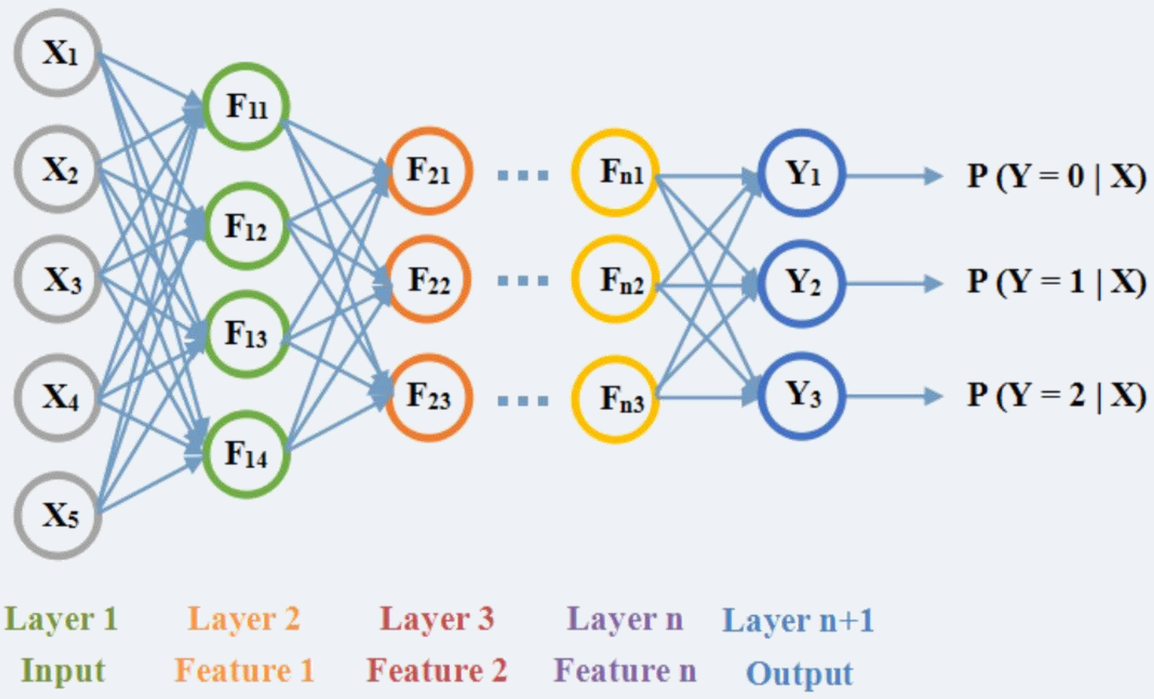
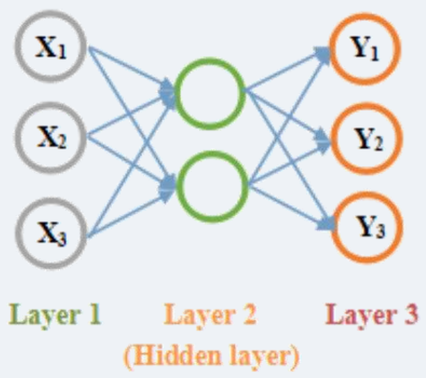
What is Deep Learning?

The idea of deep learning is to use neural network models that are composed of multiple layers to learn representations of data with multiple levels of abstraction. Each layer of the neral network computes a non-linear transformation of the previous layer.



This is an example of a deep neural network model, which consists of a stacked **auto-encoder** with n-1 hidden layers and a final **softmax classifier** layer.

Auto-encoder



The figure on the left is an example of an auto-encoder neural network, which applies back-propagation algorithm to set the target values to be as equal as possible to the inputs:

$$Yi = Xi \quad (i = 1,2,3)$$

Auto-encoder is an **unsupervised learning algorithm** that automatically learn features from unlabelled data. It only requires unlabelled data for training, which is less expensive and more approachable comparing to labelled data. This enables us to abstract better features by analysing massive amount of unlabelled data.

Softmax classifier

Softmax regression is a **supervised regression**. It is an extension of logistic regression, which can be used for classification problems where the class label may take on more than two possible values. It can also be used in conjunction with unsupervised feature learning framworks in solving problems such as handwritten digits classification.

Application on pattern recogntion

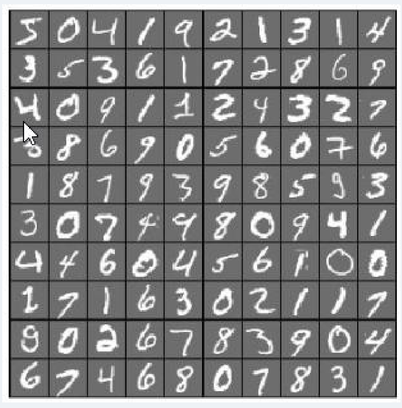
Deep learning (DL) related techniques present a strong ability in the filed of pattern recognition. Specifically, this technique are widely used for image detection, text and speech recognition, signal processing, natural language understanding and translation, financial data analysis, and other domains such as medical researches, autodrive and the game of Go.

The main **superiority of DL** comparing to other machine learning methods is that the feature extraction process of DL is not designed by feature engineering but are automatically learned under a certain learning procedure. This characteristic of DL enables it to extract different types of features in a wide range of fields. In this way, novel applications could be constructed much faster and more progress in the domain of artificial intelligence are expected to be made in the near future by applying DL.

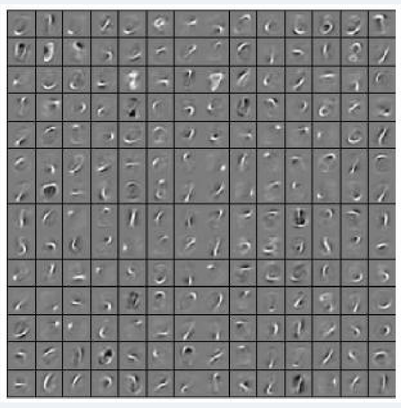
Reference: NVIDIA CES 2015 press conference
AlphaGo - Lee Sedol game video

Handwritten digits recognition

Dataset: MNIST database
Steps:
1. Train an auto-encoder on an unlabeled training dataset (29404 digits) which contains handwritten digits from 5 to 9.
2. Extract features from a labeled dataset (15298 digits) which contains handwritten digits from 0 to 4 by using the well trained auto-encoder.
3. These extracted features are used as inputs to train a softmax classifier.
4. As the whole self-taught learning network is well trained, another 15298 digits from 0 to 4 are used for testing the accuracy of this digit classifier.
Test accuracy: 98.29%



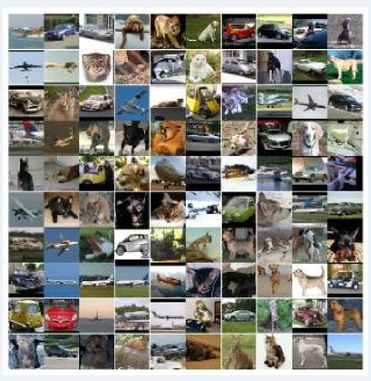
The first 100 input digits



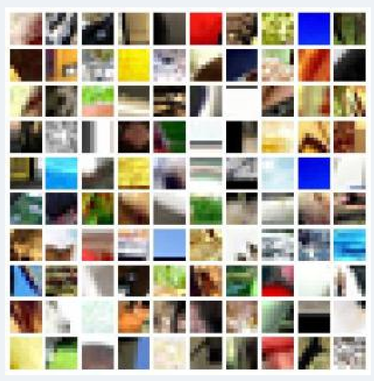
Learnt features

Image classification

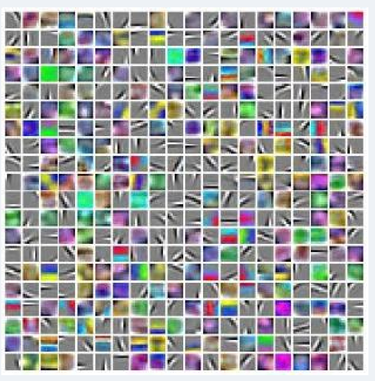
Dataset: STL-10 database
Steps:
1. Subsample the original images to 100,000 small 8 × 8 patches.
2. Learn 400 features from these 8 × 8 patches.
3. Implement convolution to a labeled STL-10 dataset. Four classes of 64 × 64 images are presented in this dataset. These classes include 2000 images of airplane, car, cat and dog.
4. Implement mean pooling to the convolved output images of step 3 to obtain 3 × 3 pooled output images.
5. Use pooled features to train a softmax classifier to map the features to the class labels.
6. Use 3200 test images to test the performance of this convolution neural network.
Test accuracy: 80.25%



Images expected to be classified



8 × 8 patches



Extracted features

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