Deep (Structured) Learning

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What is Deep Learning? [1]

- A wide class of machine learning techniques and architectures
- Using many layers of non-linear information processing that are hierarchical in nature.
- Inspired from Human information processing mechanisms
  - Example: human speech production and perception systems are both equipped with clearly layered hierarchical structures in transforming the information from the waveform level to the linguistic level

General Challenges of Deep Learning

- Pervasive presence of local optima in non-convex objective function in deep networks
- Great computational demand due to the size of the deep network
- Traditional Back-Propagation used for training the non-deep ANN do not work well, beyond few hidden layers

3 Categories of Deep Learning Models

1. Deep supervised models

2. Deep unsupervised model
   - Discriminative deep networks
3. Hybrid models
   - Use **unsupervised learning models** to improve the training of a supervised learning models

Deep Learning today..

- Google
- Microsoft
  - Voice translator: english to chinese in realtime
- Facebook

Some Deep Learning Architectures

- **Deep neural networks** [2]
  - An ANN with multiple hidden layers of units between the input and output layers.
  - Extra layers enable modeling complex data with fewer units than a similarly performing shallow network

Some Deep Learning Architectures

- **Deep neural networks (cont'd)**
  - Can be trained using Back propagation or gradient descent with:
    - Mini-batching to enhance computation time
      - computing the gradient on several training examples at once rather than individual examples
    - A lot of learning algorithms to find initial weights
      - Because sweeping space is not practical
    - Techniques to prevent overfitting
      - L1 regularization in training to enforce sparsity
      - Dropout regularization: randomly dropping units from hidden layers during training, to break rare dependencies that can occur in training data

Some Deep Learning Architectures

- **Convolutional Neural Networks [3][4]**
  - Very good results in speech and image recognition
  - Designed to take advantage of the 2D structure of an input image (or other 2D input such as a speech signal).
    - Achieved with local connections and tied weights followed by some form of “pooling” which results in translation invariant features.

Some Deep Learning Architectures

- **Convolutional Neural Networks [3][4] (cont'd)**
  - There are at least 3 types of layers: convolution, pooling and fully connected layers. There can be more than one layer of each of these types.
    - **Convolution layer**:
      - Each neurons in this layer processes (as input) a certain region in the image. Result is a convolution operation.
      - The **convolution kernel is actually learnt as part of the weight learning process**.
        - » For e.g. some neurons will learn a certain edge detection convolution kernel.
      - Also Multiple neurons process each region, which leads to several filters applied on each region of the image.
      - Usually weights are shared between neurons which process different regions, for example the same "learnt" edge detection kernel will be applied to all the regions in the image.

Some Deep Learning Architectures

- **Convolutional Neural Networks [3][4] (cont'd)**
  - Pooling layer:
    - it subsamples the result of the previous layer, for example it can perform a max operation on every 2 neighboring values in the results of the convolution (subsampling).
    - Objective is to reduce the size of the representation and achieve translation invariance.
    - This is a fixed layer and does not need training, because it performs a fixed function (e.g average or max)
- Fully connected layer:
  - this is the normal layer that we know from traditional neural networks.

Some Deep Learning Architectures

- **Convolution Neural Networks [3] (cont'd)**
  - Easier to train and have many fewer parameters than fully

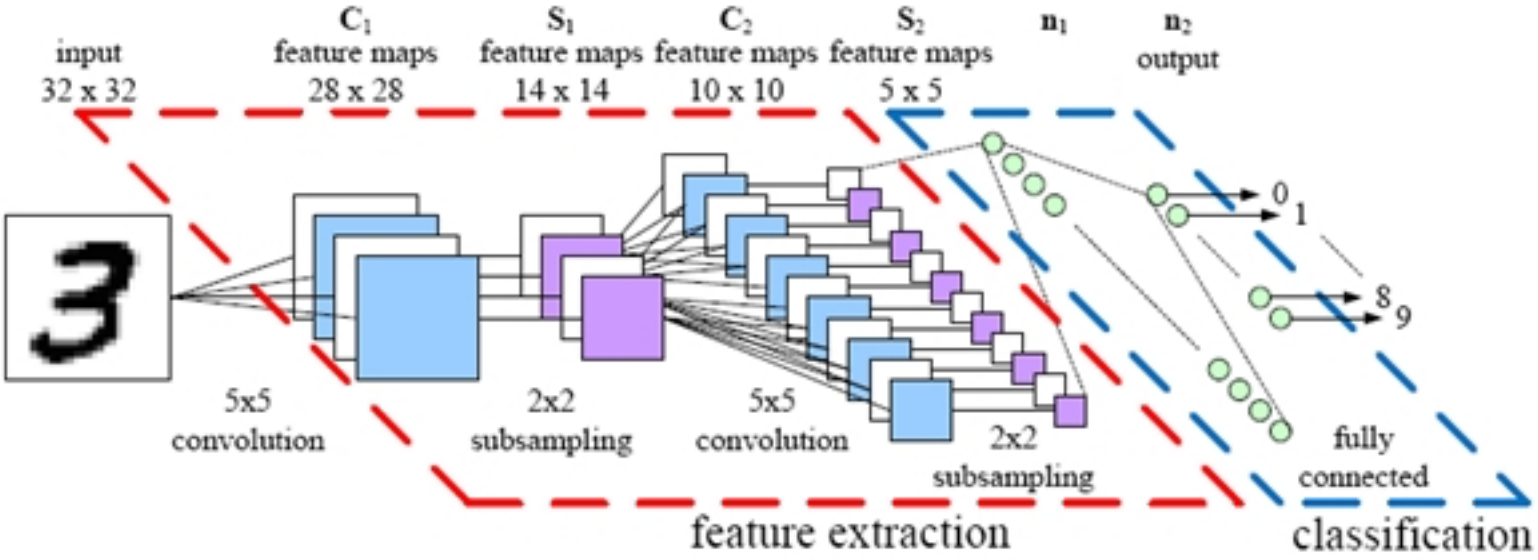

Image source: http://parse.ele.tue.nl/education/cluster2

References

[1] Li Deng and Dong Yu; Deep Learning Methods and Applications; Foundations and Trends in Signal Processing; Vol.7; 2014

[2] https://en.wikipedia.org/wiki/Deep_learning

[3] http://ufldl.stanford.edu/tutorial/supervised/ConvolutionalNeuralNetwork/

[4] http://cs231n.github.io/convolutional-networks/