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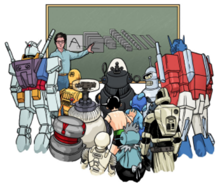

Training Artificial Neural Networks

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Introduction

Insert here your abstract text.

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1. Basic Concepts

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

1.1. Which Function ?

An ANNs classifier that is trained with cross-entropy loss approximates the conditional probability distribution function. More specifically, for an input data, the output of the classifier is a probability distribution for the classes. The cross-entorpy loss function is a measure between the predicted probability distribution and the true distribution. The form of the loss function is decreasing, smooth and differentiable, which makes it easier to optimize using gradient-based methods. This form is also known as the negative log-like function.

1.2. Gradient Computation

1.3. Some Training Parameters and Basic Parameter Calculations

1. The batch refers to a subset of the training data that is used to compute the weights for one iteration. More specifically, the batch size is the number of training samples in a batch. The epoch on the other hand refers to the number of times the entire training data is used to update the weights. In training, there are generally multiple epoch iterations where the weights are updated with different batches/subsets of the training data.
2. For the N number of training samples, the number of batches per epoch is N/B, where B is the batch size. A little side note that the solution is rounded up to the higher integer if N/B is not an integer.
3. For the loss calculation iterations, such as SGD, for E number of epochs, the total number of iterations is $E \times N/B$. Again, a practical side note states that the N/B is rounded up to the higher integer.

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1.4. Computing Number of Parameters of ANN Classifiers

1. Starting from the initial layer of the MLP, we have D_{in} number of input neurons and H_1 number of neurons in first hidden layer. Also there are biases associated with each neuron. Therefore, the number of parameters of the each layer is,

$$\begin{aligned}
\text{Input Layer} &= D_{in} \times H_1 \ + \ H_1 \\
\text{Hidden Layers} &= H_1 \times H_2 + H_2 \\
&\dots \\
\text{More Hidden Layers} &= H_{k-1} \times H_k + H_k \\
\text{Output Layer} &= H_k \times D_{out} \ + \ D_{out}
\end{aligned}$$

   The total sum can be written as, where K is the number of hidden layers.

$$\text{Total Number of Parameters} = D_{in} \times H_1 + \sum_{k=2}^{K} (H_{k-1} \times H_k + H_k) + H_k \times D_{out} + D_{out}$$

2. CNN structure is more complicated. The number of parameters of a CNN layer is calculated as follows:
   For the input layer, the number of parameters is,

$$\text{Input Layer} = (H_{in} \times W_{in} \times C_{in} \times C_1) + C_1$$

   where H_{in} and W_{in} are the height and width of the input image, and C_{in} is the number of channels of the input image. Each input of layer is the output of the previous layer. For the convolutional layers, the number of parameters is calculated as,

$$\text{Convolutional Layer} = H_k \times W_k \times C_{k-1} \times C_k + C_k$$

   Combination of all layers is,

$$\text{Convolutional Layers} = \sum_{k=2}^{K} H_k \times W_k \times C_{k-1} \times C_k + C_k$$

   Here all the parameters are summed up. The output is assumed to be the last index of the array. The final equation for the total number of parameters is,

$$\text{Total Number of Parameters} = (H_{in} \times W_{in} \times C_{in} \times C_1) + C_1 + \sum_{k=1}^{K} H_k \times W_k \times C_{k-1} \times C_k + C_k$$

2. Implementing a Convolutional Layer with NumPy

The section involves implementing conv2d function using NumPy for forward propagation and testing it on a small batch of MNIST dataset. We downloaded and loaded input and kernel files, and created an output image using the part2Plots function. The implementation code can be found in the appendix named my_conv2d.py. We confirmed the correctness of our implementation by the output image.

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Fig. 1. (a) first picture; (b) second picture.

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$$\begin{aligned} X_r &= \dot{Q}''_{rad} \Big/ \left(\dot{Q}''_{rad} + \dot{Q}''_{conv} \right) \\ \rho &= \frac{\vec{E}}{J_c(T = \text{const.}) \cdot \left(P \cdot \left(\frac{\vec{E}}{E_c} \right)^m + (1 - P) \right)} \end{aligned} \tag{1}$$

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References

[1] Filippini, Massimo, and Lester C. Hunt. (2011) "Energy demand and energy efficiency in the OECD countries: a stochastic demand frontier approach." *Energy Journal* **32** (2): 59–80.

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[4] Saunders, Harry (2009) "Theoretical Foundations of the Rebound Effect", in Joanne Evans and Lester Hunt (eds) *International Handbook on the Economics of Energy*, Cheltenham, Edward Elgar

[5] Sorrell, Steve (2009) "The Rebound Effect: definition and estimation", in Joanne Evans and Lester Hunt (eds) *International Handbook on the Economics of Energy*, Cheltenham, Edward Elgar

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