

10910COM526000 Deep Learning

Homework 1: Neural Networks

Announced: October 13 at 01:00 pm

Deadline: November 2 at 11:59 pm (iLMS)

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Introduction:

There is a saying that goes “Great oaks from little acorns grow.” In this assignment, you need to build a shallow neural network as well as the **mini-batch SGD** training process on MNIST dataset from scratch using Python3. The performance of your model should surpass 95% accuracy on testing data.



Rules:

- Built-in machine learning libraries (Sklern, PyTorch, TensorFlow...) **are not allowed** to use for NN, you need to use basic mathematical operations in NumPy to define the behavior of each layer.
- You can use any libraries to read the data from the MNIST folder and to do result visualization which should be shown on your report.
- Please properly **comment your code** to let us understand your train of thought.
- Discussions are encouraged, but **plagiarism is strictly prohibited** and punishable!

Submission:

You should compress your code, dataset, report (**hw1report_studentID.pdf**) and **readme.txt** (explain how to run your code) into a ZIP file (**hw1_studentID.zip**), and submit it on iLMS before the due date. **Zero credit** for the submission after deadline.

Implementation [80%, 10% for each part]

1. *MNIST reading & splitting*: (<http://yann.lecun.com/exdb/mnist/> for details)
You need to split the original training data into validation data and training data. (proportion: 3/7)
2. *Dense neural layer*:
Every output neuron has full connection to the input neurons.
3. *ReLU layer*:
We add nonlinear **activation functions** after the neural layer **using ReLU**.
4. *Softmax output*: 
The final layer is typically a Softmax function which outputs the probability of a sample being in different classes.
5. *Cross-entropy loss calculation*: 
Use the output of a batch of data and their labels to calculate the CE loss.
6. *Backward propagation*:
Propagate the error backwards and update each parameter.
7. *Validation*:
Test the performance on validation data during each epoch.
8. *Testing accuracy*:
Reach 95% to get 10 points, 90~95% -> 7 points, 85~90% -> 5 points, zero otherwise.

Report [20%]

The format is not limited, but the following matters must be discussed in your report:

1. Show your model architecture and testing accuracy.
2. How do you implement feed forward and backward propagation? A brief explanation is fine.
3. Plot training loss and validation loss. (loss vs. epochs figure)
4. If we use a very deep NN with a large number of neurons, will the accuracy increase? Why or why not?
5. Why do we need to validate our model?
6. t-SNE results (optional, not included in 20%)

Bonus [10%]

Try to use t-SNE (read the document before you call function) to visualize the outputs of (1) validation data at different epochs and (2) testing data, then show the result on your report.