



UNIVERSITY OF ARKANSAS

CSCE 5563: Introduction to Deep Learning

Homework Assignment #3

Submission Deadline: 11:59PM, 11/19/2022

What to submit:

- **1 pdf file** contains your solution and your name. Please don't submit the screenshot/scan of your handwritten solution. Exception is made for hand-drawn graphs. Grading rule: If it's unreadable, I won't grade. Confusing answer gets no point.
- **source code folder** that contains your code. The source code contains readme file on how to run the code.
- Put all the to-be-submitted files into a folder with the name format as:

$\{LASTNAME\}-\{FIRSTNAME\}.homework1$

What else to note:

- A.. If you don't understand the question, ask the TA immediately at khoavoho@uark.edu or visit AICV Lab (JBHT #447) on Tuesday 1:45PM-2:45PM.
- B.. You can discuss with your classmates, **DO NOT COPY** and please submit your own work.
- C.. Solution for this homework is provided within 1-2 weeks after submission deadline or extended deadline, whichever comes later.

Question 1. (20 points): Self-attention vs. Cross-attention

(5 points) From what you have learnt about general attention mechanism, explain how and when would it become self-attention.

(5 points) Similarly, please explain how and when attention would become cross-attention.

(10 points) For each of the above attention mechanisms, please find a research paper that utilize it. Please (a) provide a link to the paper, then (b) shortly describe the reason why they use such attention mechanism in their work.

Question 2. (20 points): Soft-attention vs. Hard-attention

Attention mechanisms can be categorized into soft-attention and hard-attention. Each of the mechanisms have both pros and cons. However, soft-attention is much more popular than hard-attention.

(10 points) Please find and declare pros and cons of each attention mechanism.

(5 points) Give an example of a task in which hard-attention is superior to soft-attention and vice versa.

(5 points) Explain why soft-attention is recognized by the community more than hard-attention.

Question 3. (20 points): Autoencoder vs. Variational Autoencoder

(10 points) Autoencoder (AE) is an popular neural network scheme that is trained in unsupervised manner for various applications, e.g., dimensionality reduction, image denoising, image compression, etc. Variational Autoencoder (VAE) is firstly introduced in 2014. Please explain the advantages of VAE over AE.

(10 points) Please list 2 applications of VAE and briefly describe how it is used (trained and deployed) in each application.

Question 4. (40 points): Image Denoising Implementation

Autoencoder is popular for its ability to denoise images. In this question, we will try to implement a denoising system based on autoencoder neural network.

Please download and work on the homework notebook from [this link](#).

In this question, you are required to complete 4 TODO's:

TODO1 (10 pts): Complete `def apply_noise(self, im)` to add a Gaussian noise of $\mathcal{N}(0, 0.5)$ (mean of 0 and standard derivative of 0.5).

TODO2 (10 pts): Create an Autoencoder with an encoder and a decoder that are MLPs following the below descriptions:

- Encoder: 3 linear layers of 512, 128, 128 perceptrons. The first two layers having ReLU activation function, and the last layer do **NOT** have activation function.
- Decoder: 4 linear layers of 128, 512, 2828 perceptrons. The first two layers having ReLU activation function, and the last layer do **NOT** have activation function.
- The Encoder will process the noisy input image of size 28x28 from MNIST and encode it into a 128-dimension vector.
- Then, the Decoder will process the 128-dimension vector from Encoder and decode it into 28x28 image.

TODO3 (10 pts): Implement the training, validating and testing processes. The network should be trained on training set following below descriptions:

- Number of epochs: 100
- Learning rate: 0.0001
- Optimizer: AdamW
- Loss function: L1 Loss

After each epoch, evaluate the model on validation set and save the best performed model to a checkpoint. Eventually, please load the best checkpoint and test it on testing set.

Finally, please plot a graph showing the training progress, which should include two line plots for training loss and validation loss at every epoch.

TODO4 (10 pts): Change loss function to L2 Loss (Mean squared error).

Then, please follow the training and testing requirements as in ****TODO3****. Then, plot a graph showing the training progress, which should include two line plots for training loss and validation loss at every epoch.

Important Notice

1. You should use ipython notebook and Google Colab for **Question 4** to accelerate model training by GPU and have a clean, well-organized submission.

2. If you have any question, please feel free to contact TA (Khoa Vo) through email khoavoho@uark.edu, or visit AICV Lab (JBHT #447) on Tuesday 1:45PM-2:45PM.