Neural Networks and Deep Learning
Academic year 2020-21

Homework 2: Unsupervised Deep Learning

General overview: In this homework you will learn how to implement and test neural network models for solving unsupervised problems. For simplicity and to allow continuity with the kind of data you have seen before, the homework will be based on images of handwritten digits (MNIST). However, you can optionally explore different image collections (e.g., Caltech or Cifar) or other datasets based on your interests. The basic tasks for the homework will require to test and analyze the convolutional autoencoder implemented during the Lab practice. If you prefer, you can opt for a fully-connected autoencoder, which should achieve similar performance considering the relatively small size of the MNIST images. As for the previous homework, you should explore the use of advanced optimizers and regularization methods. Learning hyperparameters should be tuned using appropriate search procedures, and final accuracy should be evaluated using a cross-validation setup. More advanced tasks will require the exploration of denoising and variational architectures.

Additional information is provided in a Python notebook uploaded in the course Moodle.

Technical notes: The homework should be implemented in Python using the PyTorch framework. The student can explore additional libraries and tools to implement the models; however, please make sure you understand the code you are writing because during the exam you might receive specific questions related to your implementation. The entire source code required to run the homework must be uploaded as a compressed archive in a Moodle section dedicated to the homework. If your code will be entirely included in a single Python notebook, just upload the notebook file.

Final report: Along with the source code, you must separately upload a PDF file containing a brief report of your homework. The report should include a brief Introduction on which you explain the homework goals and the main implementation strategies you choose, a brief Method section where you describe your model architectures and hyperparameters, and a Result section where you present the simulation results. Total length must not exceed 6 pages, though you can include additional tables and figures in a final Appendix (optional).

Grade: The maximum grade for this homework will be **8 points**. Points will be assigned based on the correct implementation of the following items:

- 1 pt: implement and test (convolutional) autoencoder, reporting the trend of reconstruction loss and some examples of image reconstruction
- 1 pt: explore advanced optimizers and regularization methods
- 1 pt: optimize hyperparameters using grid/random search and cross-validation
- 1 pt: implement and test denoising (convolutional) autoencoder
- 1 pt: fine-tune the (convolutional) autoencoder using a supervised classification task
    (you can compare classification accuracy and learning speed with results achieved in homework 1)
- 1 pt: explore the latent space structure (e.g., PCA, t-SNE) and generate new samples from latent codes
- 2 pt: implement variational (convolutional) autoencoder or GAN

Deadline: The complete homework (source code + report) must be submitted through Moodle at least 10 days before the chosen exam date.