**IE643: Deep Learning : Theory and Practice** **Jul-Dec 2021**

Assignment 2: Due On 31$^{st}$ October 2021 (11:59 PM IST)

# 1 Instructions

Answer all questions. Write your answers clearly. All your answers for each exercise must be present in a single python notebook. Name your python notebook files as `IE643_YOURROLLNO_assignment2_Ex1.ipynb`, `IE643_YOURROLLNO_assignment2_Ex2.ipynb` and `IE643_YOURROLLNO_assignment2_Ex3.ipynb`.

Construct a folder named `IE643_YOURROLLNO_assignment2` which contains all the notebook files. Upload on moodle, a single zip file named `IE643_YOURROLLNO_assignment2.zip`, containing the folder with all the notebook files.

IMPORTANT NOTE: Make sure that your code can be run in Google colab as it is. Include the installation code for all relevant packages used in your code. No further installations should need to be performed by the TAs during evaluation.

You can score a maximum of 50 marks in this assignment.

There will be no extensions to the submission deadline.

# 2 Data set preparation

Download the data set `17flowers.tgz` from the link shared in moodle and teams. **Please use IITB SSO login to download the data**. Unzip the data into your computer (`e.g.` you can use `tar zxvf 17flowers.tgz` if you use linux).

The data set contains images containing different flowers belonging to 17 different categories (*e.g.* tulip, daffodil, daisy, sunflower, etc.) Note that there are exactly 80 images in each category. The file names are numbered such that the first 80 images belonging to the first flower category have names `image_0001.jpg`, `image_0002.jpg`, etc. upto `image_0080.jpg`. Similarly, the images belonging to the second flower category have names `image_0081.jpg`, `image_0082.jpg`, etc. upto `image_0160.jpg` and so on.

Choose a category $C$ of your choice and construct a data set $D$ containing 90% images from the category $C$ of the data. Construct a validation set $V$ using the remaining 10% images.

# 3 Questions

1. **[Use only Python]** The first question is about constructing a GAN to generate images similar to those in category $C$. Please note that you need to choose only a single flower category for this exercise. Answers containing all categories of flowers will not be considered.

   (a) Construct a CNN-GAN. You can use the demo code posted in the shared link (posted in moodle and teams) to construct your CNN-GAN.

(b) Train the CNN-GAN on the data $D$.

(c) Choose the best parameters for CNN-GAN (e.g. number of training iterations, learning rate, number of samples to train the discriminator and generator, etc.) using the validation set $V$.

(d) If needed, use heuristics from the paper [1] to improve training. You can use early stopping criteria and learning rate scheduling based on your choice.

(e) Clearly describe in your python notebook about the training heuristics used in your code and explain why they were useful.

(f) Prepare a plot of the training objective function value against the iterations.

(g) Prepare a plot to depict the discriminator objective function value and the generator objective function value and check if they converge.

(h) After training, display 10 images (in a $10 \times 1$ grid) generated using the generator of CNN-GAN. For each of the 10 images, display 5 original images from the training data $D$ closer to the generated image in a $10 \times 5$ grid. Comment on the quality of the generated images. Explain the similarity metric you used in the code and justify your choice.

2. For this question, choose a different category $K$ of flowers. construct a data set $D_1$ containing 90% images from the category $K$ of the data. Construct a validation set $V_1$ using the remaining 10% images. This question is about constructing a VAE to generate images similar to those in category $K$. Please note that you need to choose only a single flower category for this exercise. Answers containing all categories of flowers will not be considered.

   (a) Construct a VAE. You can use the demo code posted in moodle to construct your VAE.

   (b) Train the VAE on the data $D_1$.

   (c) Choose the best parameters for VAE (e.g. number of training iterations, learning rate, etc.) using the validation set $V_1$. You can use early stopping criteria and learning rate scheduling based on your choice.

   (d) Clearly describe in your python notebook about the training heuristics used in your code and explain why they were useful.

   (e) Clearly describe the objective used for VAE and your training and inference procedures.

   (f) Prepare a plot of the training objective value against the iterations.

   (g) After training, display 10 images (in a $10 \times 1$ grid) generated using the VAE. For each of the 10 images, display 5 original images from the training data $D_1$ closer to the generated image in a $10 \times 5$ grid. Comment on the quality of the generated images. Explain the similarity metric you used in the code and justify your choice.

3. Use the CNN-GAN to train on category $K$ and generate 10 images. Compare the quality of images generated using CNN-GAN and VAE for category $K$. Similarly, use VAE to train on category $C$ and generate 10 images. Compare the quality of images generated using VAE and CNN-GAN for category $C$. Explain your observations and the possible reasons for your observations.

[1] `https://arxiv.org/pdf/1511.06434.pdf`