ADRL 2023 - Assignment 1

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1. **Problem 1:** Construct a GMM by implementing the EM algorithm, on all the images in the dataset. Experiment with 3 different numbers of mixtures. Plot the likelihood curve as the EM iteration progresses. Post training, Generate and plot 100 images in a grid of 10 by 10 with all three GMMs separately and record your observations. Perform posterior inference with all three GMMs, compute and report Normalized Mutual Information (NMI).

2. **Problem 2:** Implement a vanilla VAE with MSE for conditional likelihood. Experiment with a single and multiple sample of z during training that goes at the input to the decoder. Plot 10 by 10 grids of both reconstructions and generations. Plot the loss curves for likelihood, KL, and the combined terms. Build a CNN-based classifier for 3 classes using the images in the training part of the dataset and report the accuracy on the validation part. Now, using the VAE trained, perform a posterior inference on all the images and use the thus obtained latent vectors with an MLP for classification. Quantify and document your observations on the advantages/disadvantages of using latent space, in terms of classification accuracy and network size.

3. **Problem 3:** Implement a beta-VAE with 4 different values of beta and plot 10 by 10 grids of generated and reconstructed data. Document your observation in terms of change in results with varying beta. For one of the VAEs, perform posterior inference for a pair of images and plot the generated images in the path of linearly interpolated latents (10 points along the line joining the corresponding latents) for 10 pairs.

   Problem 4: Implement a vanilla Auto-encoder with MSE loss. Perform posterior inference on all the images, post-training. Build a classifier with these latent vectors and calculate the accuracy. Compare it with the latents in problem 2. Fit a GMM on the vectors from the latent space obtained via posterior inference. Subsequently, sample new latents from the GMM, pass it through the decoder, and plot a grid of 10 by 10 images, comparing them with the GMM.

General Instructions:

1. We use only one dataset for this assignment.
2. The animal face dataset can be found here - data
3. The dataset consists of 16,130 images of 3 animal faces at 512×512 resolution.
4. You need to downsize all images to 128x128 pixels before implementing.
5. Use Google collab with Jupiter notebook for all the computing.
6. You are supposed to submit a single Jupiter notebook with all the solutions made into separate blocks.
7. Use Pytorch for building neural networks. You are supposed to directly use the off-the-shelf functions for the models asked.
8. A report has to be submitted that would list all the experiments, results, and observations. This should be embedded in the Jupiter notebook itself.
9. Use matplotlib for plotting.
10. The final evaluation **does not** depend on the accuracy metrics but is based on the **quality of your experiments and observations thereof**.
11. We will run a plagiarism check on the codes. Any suspicion of copying would lead to a harsh penalty from negative marks in the assignment to a failing grade in the course, depending upon the severity. Therefore, kindly refrain from copying others' codes and/or reports.