DS 261: Artificial Intelligence for Medical Image Analysis

Assignment 2

Due Date: 25 Oct., 2025 - 11.59 pm IST

Important Notes:

1. **Use of ChatGPT, Gemini, Perplexity or any other LLM frameworks for assignment completion is strictly prohibited.**
2. **The assignment has to be attempted individually by each person. Group attempts are not allowed.**
3. **Students must submit the report discussing their observations and results for each question strictly in Latex in a legible manner. Failure to submit reports in LaTeX will be penalized.**
4. **Students are permitted to use up to 2 grace days in total across the 3 assignments; late submissions beyond that will not be graded. Hence, use your grace days judiciously.**
5. **Usage of Scikit-learn framework for solving ML-based questions is permitted for this assignment. For DL-based questions, one is permitted to use PyTorch only. Usage of other DL frameworks such as Tensorflow, JAX, Theano, etc., is not permitted.**
6. **Marks Distribution: Q1-15 Marks, Q2-15 Marks.**

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1. For this question, use Dataset 1. You have been provided with 2D DWI scans and their corresponding binary masks containing lesion information. Your tasks are:

   (a) Train a Naive Bayes Classifier, a K Nearest Neighbour (KNN) classifier, and a Random Forest Classifier to perform image segmentation. You may use the `scikit-learn` library.

   (b) Select a deep learning segmentation model of your choice (e.g., U-Net, Attention U-Net, etc.) and conduct the following experiments (using the `PyTorch` library):

      i. **Experiment 1:** Train the model using Binary Cross-Entropy (BCE) loss with the Adam optimizer.

      ii. **Experiment 2:** Train the model using a combination of Dice loss and weighted Cross-Entropy loss (eg: weights based on proportion of pixels in each class) with the Adam optimizer.

      iii. **Experiment 3:** Train the model using the better-performing loss function from Experiments 1 and 2, with Adam optimizer + a learning rate scheduler.

iv. **Experiment 4:** Train the model by varying the encoder depth (i.e., the number of levels in the encoder) to analyze its impact on segmentation performance.

(c) Evaluate the performance of all four experiments on the test set using metrics like Dice score, lesion-wise F1 score, and lesion-wise accuracy. Compare the results and discuss your observations for each experiment. Also, clearly describe and justify any preprocessing steps and data augmentations applied during training and testing.

2. For this question, you have been provided with two datasets; viz., `dataset_2` and `dataset_3`.

   (a) Train a segmentation model of your choice using `dataset_2` and evaluate its performance directly on the test split of `dataset_3`.

   (b) Next, apply one supervised and one unsupervised domain adaptation technique of your choice to improve the performance of the model trained on `dataset_2` when tested on `dataset_3`, making use of the train split of `dataset_3` for adaptation.

   (c) After adaptation, evaluate the models on `dataset_3` and report performance metrics, including Dice score, lesion-wise F1 score, and lesion-wise accuracy for each experiment conducted so far.

   (d) Additionally, perform statistical testing for all performance metrics for `dataset_3` for unsupervised and supervised domain adaptation with respect to the baseline unadapted model.

   (e) Finally, provide a comparative discussion on your observations, highlighting the differences in effectiveness between the unadapted baseline, supervised adaptation, and unsupervised adaptation approaches. Also, clearly describe and justify any preprocessing steps and data augmentations applied during training and testing.

Submission format: Submit the performance scores, experiment details, insights and observations as a LaTeX report. Submit your code in jupyter notebooks with one notebook per question with proper comments, viz., `Q1.ipynb` and `Q2.ipynb` files with cell outputs and sample predictions from the model. Ensure that your code is clean and free from bugs. Include a plot illustrating the training progress, showing the loss or accuracy curves for both the training and validation sets wherever possible.

Your directory structure must be as follows:

```
- Assignment2_{name}_{last_5_digits_SRNO}
    |-- Q1.ipynb
    |-- Q2.ipynb
    |-- report.pdf
```