深度學習於醫學影像分析—Deep learning in medical image analysis
Fall 2024

Homework 2, due on 2024/10/28

1. This homework is for analyzing single photon emission computed tomography (SPECT) images from individuals with Parkinson's disease (PD), who are divided into three stages (1, 2, 3) according to illness severity.

   The goal is to predict patients' PD illness stages by using their SPECT images. Since each image can only belong to one of the 3 disease stages, this is a **multi-class classification** problem.

2. The zipped file "**hwk02_data.zip**", which can be downloaded from e3 (https://e3.nycu.edu.tw/) under "Homework 2", contains all datasets for this homework.

   The file "**train.csv**" can be used to build up your prediction models and the file "**test.csv**" is for testing models' accuracy. Please read the file "**README.pdf**" first for the meaning of each data item in "**train.csv**" and "**test.csv**".

3. To build the prediction models for multi-class classification using SPECT images, you are asked to perform the following analyses:

   a. Each SPECT image (the DICOM file) is the three-dimensional (3D) stereo image, which can be seen as a list of slices (2D images). Please first select a single slice that contains the clearest striatum shape as the target data for subsequent analysis. Or, you can do the selection based on the "index" data item in both "**train.csv**" and "**test.csv**", which is our suggested slice to be analyzed for each 3D stereo image.

      Because most of the images consist of a black background and only the middle section contains the brain image, you can further crop the image at the center 50×50 pixels. The cropped image contains a complete brain image with only a small portion of the black background.

      These preprocessing procedures for 3D SPECT images are depicted in the following Figure 1.

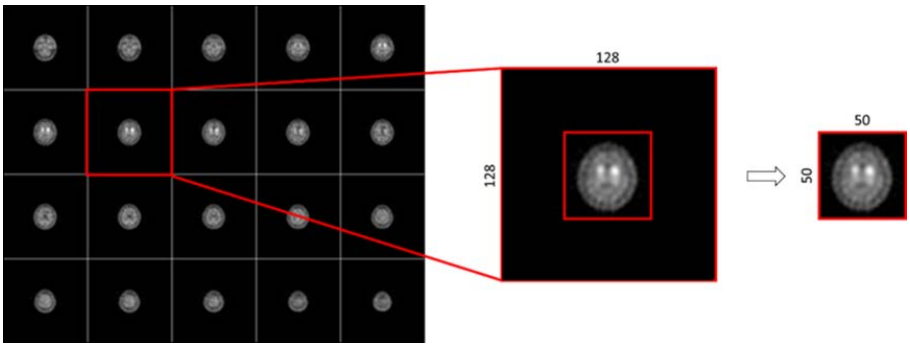

Figure 1. Preprocessing procedure for 3D SPECT images.

b. Use convolutional neural networks (CNNs) to extract features in these images. Utilize transfer learning to adopt the pre-trained model whose weights are trained from **ImageNet** to improve prediction accuracy.

Perform the analysis under a CNN architecture (e.g., VGGNet, ResNet, DenseNet, …) or a Transformer architecture (e.g., ViT, Swin Transformer, …). Output the prediction results for the test dataset based on your selected architecture.

Pre-trained CNN/Transformer architectures (e.g., VGGNet, ResNet, DenseNet, ViT, Swin Transformer,…) require input images with three channels (e.g., color). Our input data are grayscale medical imaging, and you thus can represent three channels for VGG16 and ResNet50 inputs, either with the same selected (2D) image, with the three consecutive images above and below the selected one, or any other approach you can think of.

c. Epidemiological studies have shown that there are gender differences in Parkinson's disease: the incidence and prevalence in males are higher than in females. This disease is also related to age: the incidence rates rise rapidly after the age of 60.

Patients' age and gender are provided. Please take them into consideration during training process.

4. Load your created prediction models with the test images and generate their predicted probabilities for 3 disease stages and predicted disease stages.

Upload a file "**test.res.csv**" for prediction results based on your fitted model. In "**test.res.csv**", columns 1 is the patient id and column 2 is for the predicted disease stages.

Please also upload the Python codes of your solution (saved as a .ipynb file) and its compiled html file.

5. Kaggle submission
   a. Kaggle link:
      ??
   b. Display team name: <studentID>
   c. The scoring metric is accuracy.
   d. You can submit at most 5 times each day.

6. Report submission
   a. How did you select the slice to be analyzed in Q3a (5 pts)?
   b. How did you incorporate age and gender into the model you used (Q3c) (5 pts)?
   c. Reproductivity of the results (4 pts)
   d. Number of parameters (2 pts)
   e. The difficulty during training (8 pts)
   f. Explain model architecture (6 pts)
   g. You should submit compile HTML file and ipynb notebook with name prefix to e3 platform.
      - {studentID}.ipynb {studentID}.html {studentID}.pdf
   h. Note: make sure your ipynb file print out the number of parameters of the model.

7. Grading policy
   a. Kaggle (70 pts)
      The public leaderboard is calculated with approximately 50% of the test data. The final score will be based on the other 50% (private leaderboard), so the final scorings may be different.
      - Basic score (40 pts):
        Over baseline: 40 pts
      - Ranking score (30 pts):

        Accuracy: $\left(1 - \frac{\text{rank}-1}{\text{num\_participated}}\right) \times 20$ pts (the larger the accuracy, the

higher the ranking)

Number of parameters: $\left(1 - \frac{\text{rank}-1}{\text{num\_participated}}\right) \times 10$ pts (the smaller the number of parameters, the higher the ranking)

b. Report (30 pts)

8. Error submission

If you submit the wrong format of files to e3, your score may be reduced.

a. Team name error: 0 pts

b. Late submission: -10 pts per day