深度學習於醫學影像分析—Deep learning in medical image analysis
Spring 2021

Homework 2, due on 2021/5/10

1. This homework is for analyzing single photon emission computed tomography (SPECT) images from individuals with Parkinson's disease (PD), who are divided into four stages (0, 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 4 disease stages, this is a **multi-class classification** problem.

2. The zipped file "**hwk02_data_new.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.

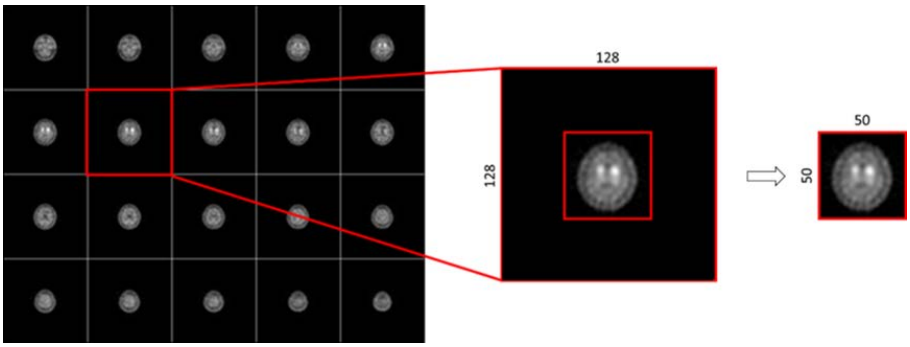

Figure 1. Preprocessing procedure for 3D SPECT images.

b. The distribution of our data over multiple PD stages (classes) is relatively imbalanced, which could result in a distortion of the classification model. Also, our data seem not large enough to construct a powerful image classifier. Please adopt appropriate approaches to address these issues.

c. 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 two CNN architectures: VGG16 and ResNet50. Output the prediction results for the test dataset based on each of the two architectures.

d. 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 4 disease stages and predicted disease stages.

   Use these predicted probabilities and predicted disease stages to fill in the file "**test.csv**", where variables "Stage 0", "Stage 1", "Stage 2", and "Stage 3" are for predicted probabilities of stages 0, 1, 2, and 3, respectively, and variable "Stage"

is for predicted disease stages. Upload two files "**VGG16.csv**" and "**ResNet50.csv**" for prediction results based on VGG16 and ResNet50 architectures, respectively. Please also upload the Python codes of your solution (saved as a .ipynb file) and its compiled html file.

5. 另外，繳交格式希望大家上傳壓縮檔(學號.zip)，裡面包含 VGG16.csv、ResNet50.csv、report.pdf、學號.ipynb、學號.html。

   其中 report.pdf 只需要回答：
   - 3a.中要分析的 slices，是自己選的?還是根據"index" data item 選的?
   - 3b.用什麼方法處理 imbalanced data、image augmentation 的問題?
   - 3d.怎麼加入 age 和 gender?可以用描述的也可以畫架構圖。
   - 怎麼決定最終輸出的期別(predicted disease stage)?