CAP 5516 - Medical Image Computing (Spring 2023)

Programming Assignment #2 (40 points)

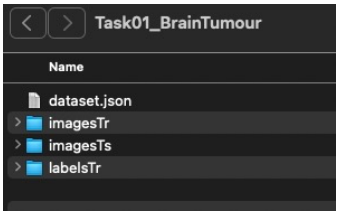
Due: 4/21/2023, 11:59 PM (EST)

Deep Learning-based Brain Tumor Segmentation Using MRI

1. Dataset

A subset of the data used in the 2016 and 2017 Brain Tumour Image Segmentation (BraTS) challenges [1-3] will be used for this programming assignment. A detailed description about the dataset can be found in [4] (Task01_BrainTumour). The dataset can be downloaded here: https://drive.google.com/drive/folders/1HqEgzS8BV2c7xYNrZdEAnrHk7osJJ--2 (Choose Task01_BrainTumour.tar)

Once you download the dataset, there are three folders and one json file (see the figure below). "dataset.json" provides an overview about the dataset (e.g., MRI modality, label information for segmentation, number of training and testing samples, etc.). "imagesTr" is the folder for training samples. "labelsTr" is the folder for segmentation masks (labels) of the training samples. We do not need the "imageTs" folder (testing samples) since no ground truth label is provided.



2. Task

1) Data visualization

Use ITK-SNAP software to visualize a few MRI samples and their corresponding segmentation masks.

2) Brain tumor segmentation using U-Net

Train 2D U-Net (process MRI slice by slice) or 3D U-Net for brain tumor segmentation. Do 5-fold cross validation on the training set ("imagesTr" folder) and report the segmentation results (Dice score and Hausdorff Dist.)

3. What to report

1) Present a visualization example (data and segmentation mask) using ITK-SNAP.
2) Implementation details of the network.
3) Use a table to list the segmentation results (Dice score and Hausdorff Dist.) for each fold, as well as the average results of 5-fold.

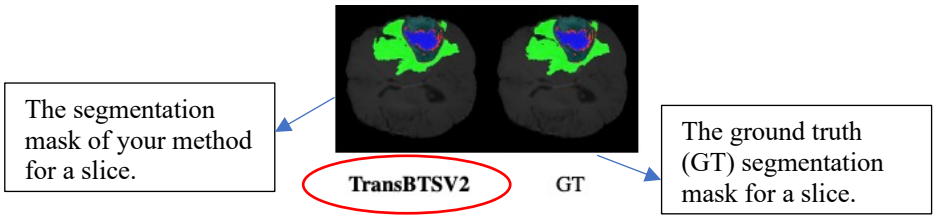
You can use this code to compute Hausdorf distance:
from medpy.metric import binary
https://loli.github.io/medpy/_modules/medpy/metric/binary.html#hd

```
def hd(result, reference, voxelspacing=None, connectivity=1):
    """
    Hausdorff Distance.

    Computes the (symmetric) Hausdorff Distance (HD) between the binary objects in two
    images. It is defined as the maximum surface distance between the objects.

    Parameters
    ----------
    result : array_like
```

Evaluation:
background (label 0), necrotic and non-enhancing tumor (label 1), peritumoral edema (label 2) and GD-enhancing tumor (label 4). The segmentation accuracy is measured by the Dice score and the Hausdorff distance (95%) metrics for enhancing tumor region (ET, label 4), regions of the tumor core (TC, labels 1 and 4), and the whole tumor region (WT, labels 1,2 and 4).
4) Present a few examples of your segmentation results (an example is given below) for qualitative analysis.



4. What to submit

(1) A report for this assignment. The quality of the report is important.
(2) Clean code and clear instructions (e.g., a readme file) to reproduce your results. If you choose to host the code on GitHub, please provide the GitHub link.

Code Examples

1. TransBTS for brain tumor segmentation: https://github.com/Wenxuan-1119/TransBTS
2. Brain tumor 3D segmentation with MONAI: https://github.com/Project-MONAI/tutorials/blob/master/3d_segmentation/brats_segmentation_3d.ipynb
3. https://github.com/Project-MONAI/tutorials

References

[1] Bakas, S., Reyes, M., Int., E. & Menze, B. Identifying the Best Machine Learning Algorithms for Brain Tumor Segmentation, Progression Assessment, and Overall Survival Prediction in the BRATS Challenge. arXiv preprint arXiv:1811.02629 (2018).
[2] Bakas, S. et al. Advancing The Cancer Genome Atlas glioma MRI collections with expert segmentation labels and radiomic features. Scientific Data 4, 1–13 (2017).
[3] Menze, B. H. et al. The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS). IEEE Transactions on Medical Imaging 34, 1993– 2024 (2015).
[4] Simpson, Amber L., et al. "A large annotated medical image dataset for the development and evaluation of segmentation algorithms." arXiv preprint arXiv:1902.09063 (2019).