Dual FDG-DOTATATE PET/CT neuroendocrine neoplasms diagnosis with deep learning

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1. Motivation

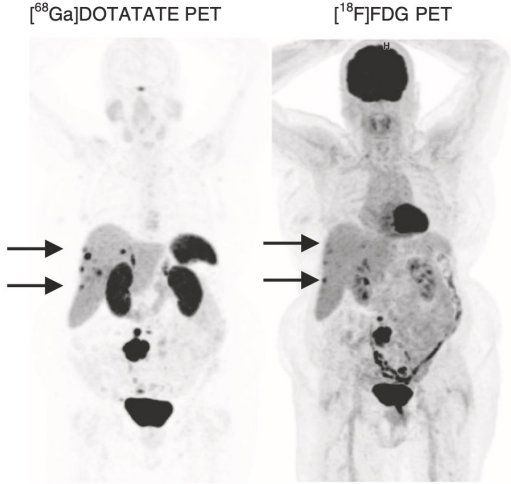
- Project motivation

Neuroendocrine neoplasms are heterogeneous diseases. Accurate estimation of prognosis would help patient communication and treatment selection.

The NETPET Score system leverages dual FDG-DOTATATE PET imaging techniques to measure the aggressiveness of tumours which is significantly associate with the histological grade.

The reading of PET is time-consuming and prone to subjectivity.

No existing automated methods segment dual FDG-DOTATATE PET/CT and grade the NETPET Score. An accurate NETPET Score grading application could be a game-changer.



1. Motivation

- Project Aim

The overall project aim is to develop a multi-task and multi-modal deep learning application to automatically and accurately segment lesions and grade NETPET Scores based on imaging characteristics of lesions on dual FDG and DOTATATE PET/CT.

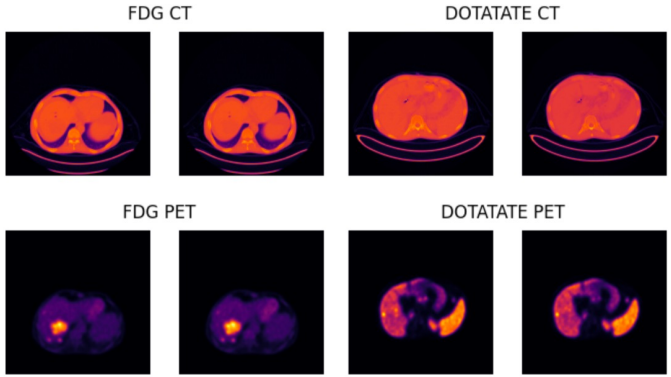
2. Research Questions

- Research questions

For the NETPET score based metastatic neoplasms diagnosis,

We aim to develop deep learning techniques to automate DOTATATE and FDG PET/CT lesion segmentation accurately.

We aim to develop multi-task learning techniques to solve the segmentation and classification tasks simultaneously and enhance the performance.



2. Research Questions

- Research scopes

This project will focus on,

1) Implementing, experimenting and evaluating CNN and Transformer based Multi-Modal and Multi-Task methods for tumour semantic segmentation and NETPET Score classification;

2) Leveraging the complementary of dual DOTATATE and FDG imaging techniques.

3. Literature Review

- Summary of related literature

Deep learning models are playing an increasingly active role in medical imaging research.

Convolutional Neural Networks(CNNs) have remarkable performance on image recognition and segmentation. The u-shape encoder-decoder architecture of U-NET is one of the most representative CNN-based segmentation approach.

Recently, self-attention-based transformers originally designed for natural language processing(NLP) have considerably surpassed previous convolutional or recurrent approaches in various image processing tasks.

Hard parameter sharing which shares the same hidden layers but have different task layers of the model is the most popular Multi-task Learning strategy.

4. Research Method

- Methodology

Start by implementing CNN-based and Transformer-based approaches for tumour segmentation based on single modality imaging.

Evaluate and enhance the performance of these models by applying data augmentation.

Extend some of the implementations to support multi-modality imaging.

Extend one implementation to multi-task architecture for NETPET Score classification.

Enhance the performance by leveraging the complementary of dual DOTATATE-FDG PET.

Evaluate the accuracy and the robustness of the final model, compare with other methods.

4. Research Method

- Data Collection/Analysis

Dataset 1: DOTATATE and FDG PET/CT Dicom files of 310 subjects from the NETPET Score research project.

Dataset 2: Contrast-enhanced abdominal CT Nii files of 130 subjects from The Liver Tumour Segmentation Benchmark (LiTS) 2017.

For both tumour segmentation and NETPET Score classification, there is class imbalance in the datasets.

There might be spatial and temporal alignment issue of the scan slices.

4. Research Method

- Evaluation

Semantic segmentation is pixel-wise binary classification. We will use precision, recall and dice to comprehensively measure the sensitivity, specificity and overall accuracy .

NETPET Score grading is multiple classification. We will use accuracy, precision and recall and F1 for each class to measure how accurately each grade is estimated.

We will use k-fold stratification cross validation and calculate the standard deviations to measure the robustness of the models on different data, to achieve more rigorous performance evaluation.

5. Project Plan

Date	Tasks	Deliverables
2023.10 – 2023.11	Implement and enhance CNN-based and Transformer-based segmentation approaches by data augmentation	Implementations and evaluations of UNet, 3D-Unet, MultiResUNet, SegFormer and Mask2Former
2023.12 – 2023.12	Extend implementations to Multi-modal methods	Two multi-modal segmentation implementations
2023.12 – 2024.01	Extend one implementation to Multi-task architecture	One multi-modal and multi-task implementation
2024.02 – 2024.05	Enhance the implementation to achieve desired performance	Evaluation and comparison results
2023.05 – 2023.06	Prepare reports and presentation	Reports and presentation