Kidney Tumor Segmentation

Hosein Beheshtifard
Computer Science

UNIVERSITY OF CALGARY

Introduction

- Kidney cancer is the 13th most common cancer worldwide, accounting for 2.4% of all cancers, with more than 330,000 new cases diagnosed yearly, and its incidence is still increasing[1].
- Manual segmentation of kidney tumors is time-consuming and subjective, as it relies on the expertise of radiologists and surgeons to interpret the imaging data. Automated segmentation methods have the potential to overcome these limitations.

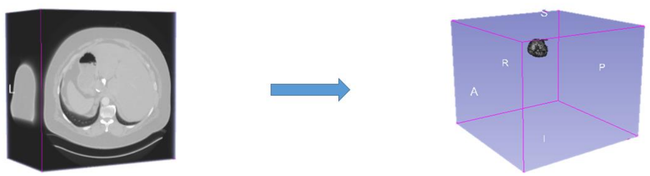


Figure 1: A representation of an abdominal CT image as input and a 3D tumor segment as output of our project

Model Architecture

- U-Net base model with 5 layers of ResNet34 encoder blocks.
- Pre-trained weights on ImageNet.

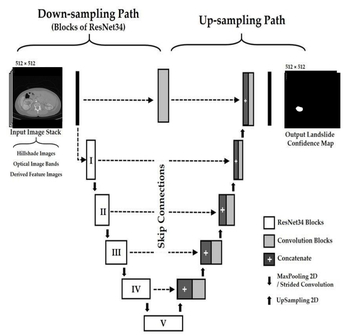


Figure 2: A representation of the U-Net architecture with ResNet34 Encoders.

Dataset

- KITS21: includes 300 data patients who underwent partial or radical nephrectomy for suspected renal malignancy between 2010 and 2020.
- Each instance of Kidney, Tumor, and Cyst was annotated three times.

Preprocessing

- We convert 3D images to 2D slices.
- Volume intensity change to [0, 200]
- Normalization
- Random transformations such as random rotation, random flip, random crop and random gaussian noise.

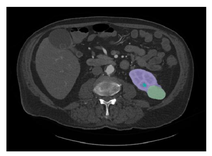


Figure 3: An example of a manually segmented axial slice[2].

Training Procedure

The proposed U-Net model was implemented using segmentation_models_pytorch with:

- Optimizer = Adam (lr = 0.001)
- Criterion = BCEWithLogitsLoss
- Epoch = 100
- Dataloaders with batch size 128
- early stopping and saving the best model regarding validation loss
- Hardware: AMD Ryzen threadripper, Nvidia RTX A6000, and 251GiB memory

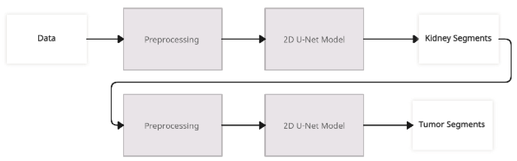
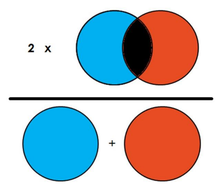


Figure 4: Training pipeline

Evaluation

$$\text{Dice Score} = \frac{2 \times (O \cap E)}{O \cup E}$$

if O is the observed segmentation mask and E is the expected segmentation mask.



Phase	Average Dice Score		
	Simple U-Net with 5 Layers	Our model(first run)	Our model(after optimization)
Kidney Segmentation	0.736	0.932	0.961
Tumor Segmentation	-	0.793	0.811

Table 1: Dice scores for tumor and kidney segmentation in two iterations of model

Discussion

- The top performers in KITS19 and KITS21 challenges approximately obtained dice scores of 90-97 for kidney segmentation and 80-85 for tumor segmentation. They all used 3D U-Net with heavy computations.
- We achieved a good result regarding the simplicity of 2D segmentation.
- Following works: add sagittal and coronal segmentation and combine results, try 3D segmentation, and synthesize more data using available annotations to train data on a larger dataset.

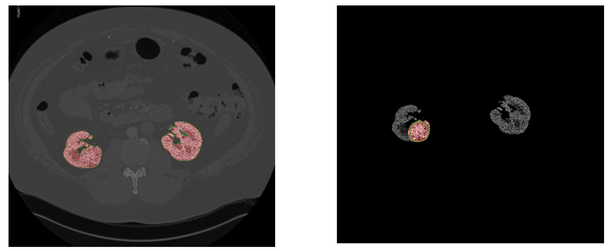


Figure 5: Phase 1 and 2 expected vs. predicted mask

References
1. Ghislaine Scelo and Tricia L Larose. Epidemiology and risk factors for kidney cancer. Journal of Clinical Oncology, 36(36):3574, 2018.
2. https://kits21.kits-challenge.org/

Hosein.beheshtifard@ucalgary.ca