Graduate Students, Health and Biomedical Sciences

Segmenting Liver Volume for Surgical Analysis

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Introduction

Background

- Two million people around the world die from hepatic-related diseases annually.
- In many cases, a liver hepatectomy is the solution to save a person life.
- To increase the chances of a successful hepatectomy, surgical pre-planning is necessary.
- 3D visualization can aid surgeons in understanding disease progression and for surgical planning.

Aims and Objectives

- Create a 3D rendered liver volume, using machine learning, can help surgeons in visualizing the liver pre-operation.
- Delineate tumors within the 3D rendered volume.
- Delineate significant vessels in the 3D rendered volume.
- Create a script to segment liver tissues with a click of a button.

Methodology

- The methodology contain multiple steps as seen in Figure 1.

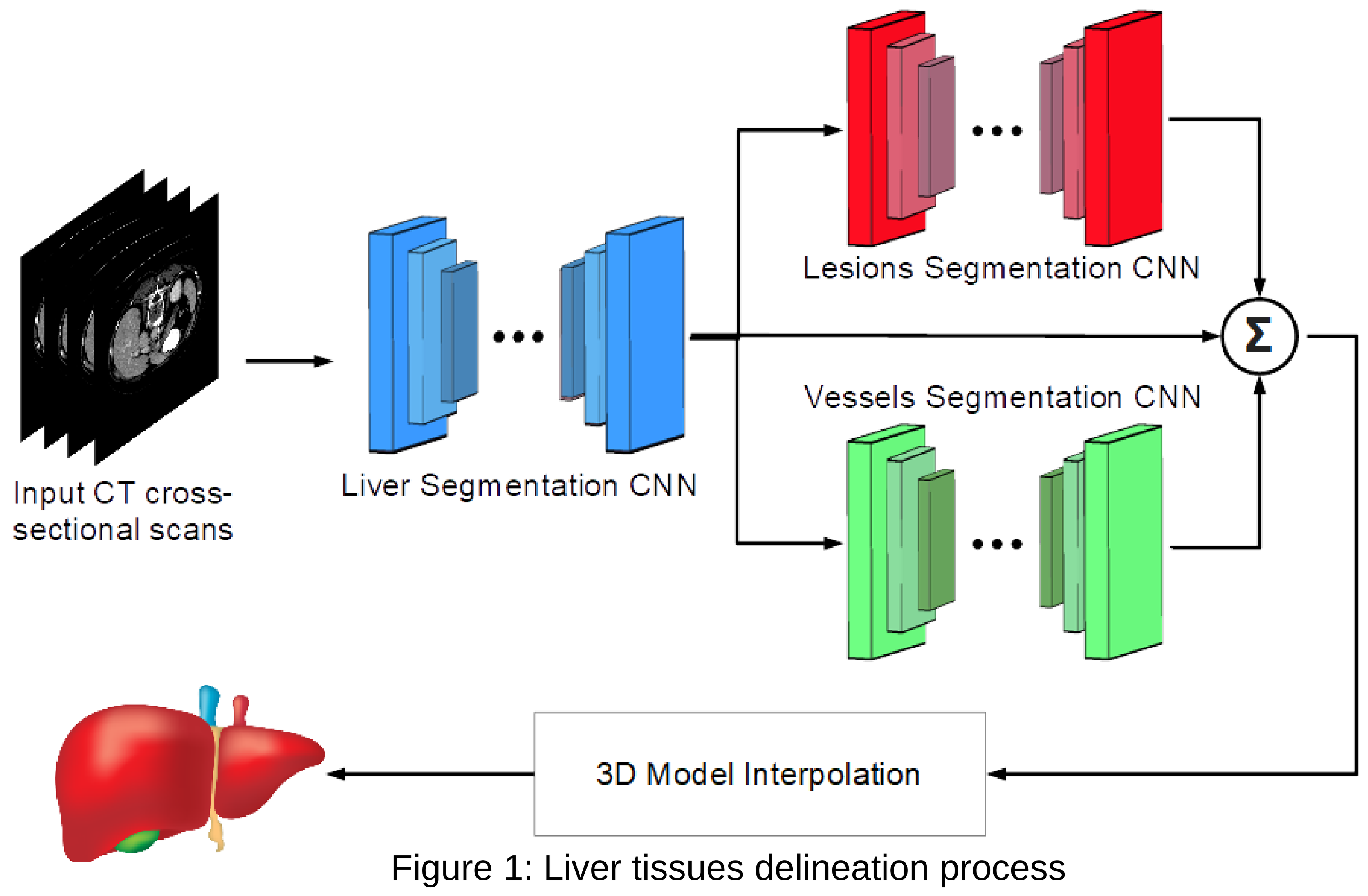


Figure 1: Liver tissues delineation process

- An existing dataset is utilized to test the algorithm. It is from the Medical Segmentation Decathlon Challenge (Task 8: Hepatic Vessel), abbreviated as MSDC-T8.
- The CT records are preprocessed, as shown by Figure 2, before the first ConvNet used for liver segmentation.

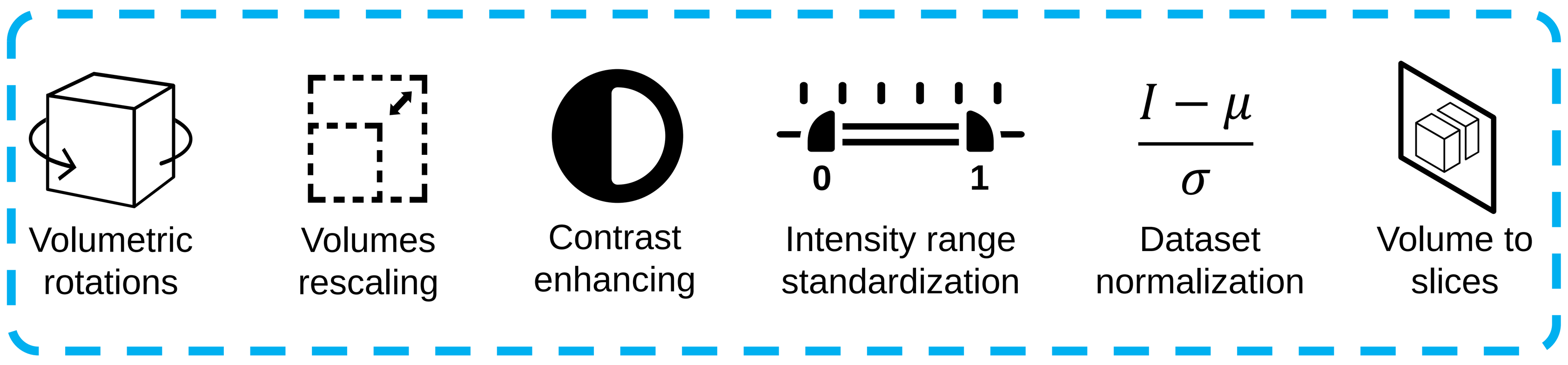


Figure 2: CT records pre-processing

- The slices are gathered into a 2.5D fashion by grouping odd adjacent slices, then outputting the delineation for the middle one (Refer to Figure 3).

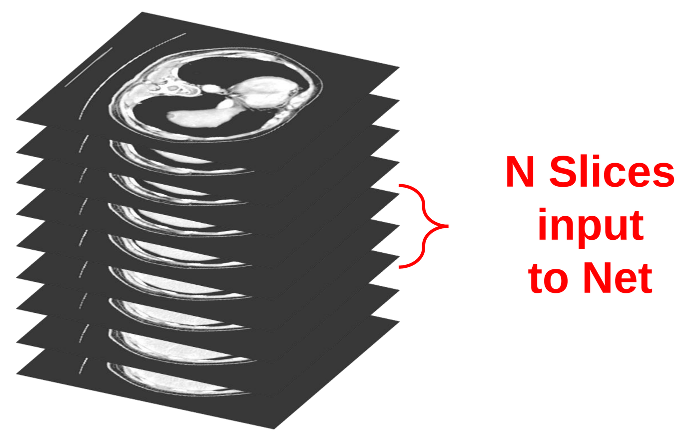
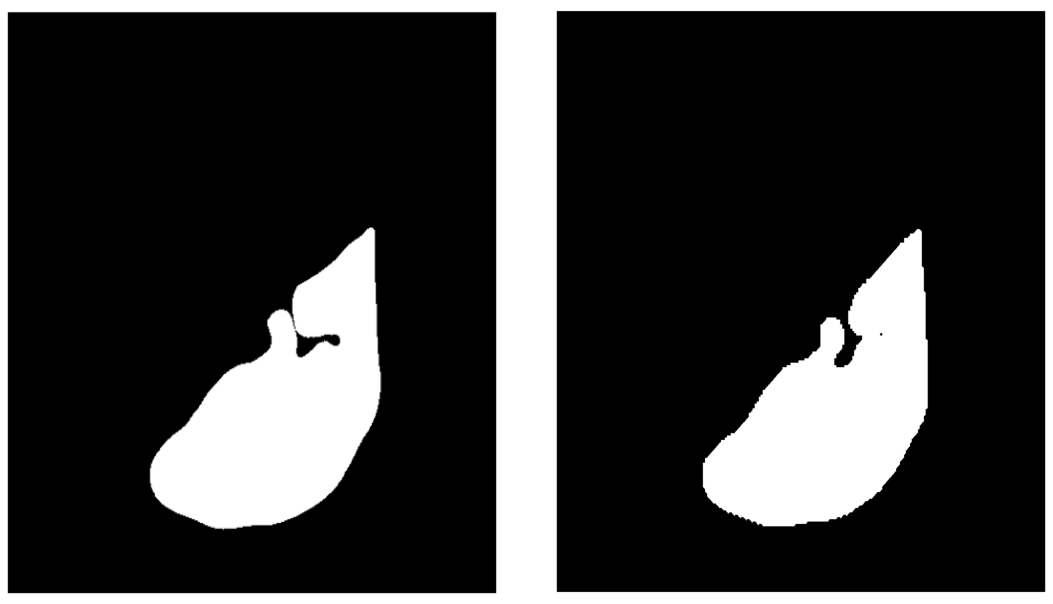


Figure 3: 2.5D Creation

- Finally, after delineating the liver in a CT record, a 3D object is rendered from the segmented slices to create a liver for surgeons to examine.

Results

- U-Net ConvNet is used for segmenting the liver, where a 2.5D input (5 slices) of pre-processed images are inserted into the ConvNet. Training environment is implemented on PyTorch using 5-fold cross validation with 80:20 train / val ratio Maximum epochs is equal to 75, a batch size of 32, and a learning rate = 16×10^{-5} are used. Early stopping intervenes if the model's performance worsens on the validation set.



(a) (b)

Figure 4: Slice 97 in record 294 MSDC-T8
(a) ground-truth (b) segmentation

- A 3D model is created by interpolating the segmented slices via the marching cubes algorithm (Refer to Figure 5). The script can build multiple objects with different colors.

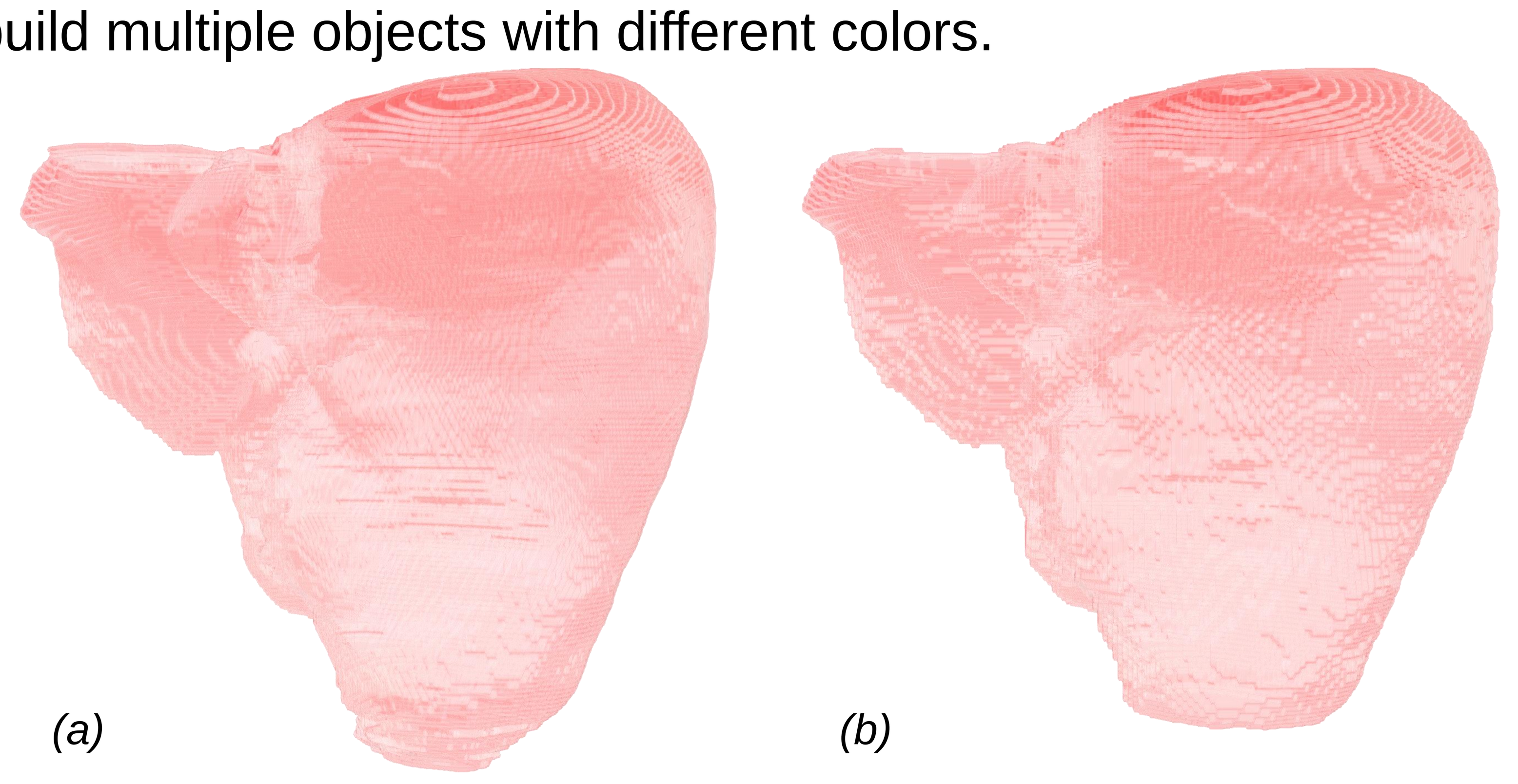


Figure 5: 3D rendered Liver volume in record 294
(a) ground-truth (b) segmentation

- Table 1 shows the average results of the best run from a 5-folds cross-validation process over 23 selected unseen records.

Table 1: Classifications Results

Dice	IoU	Pr	Re	Sp	ASD	RMSD	HD	95% HD
98.12%	96.33%	98.54%	97.73%	99.93%	0.624mm	2.15mm	27.16mm	4.10mm

Conclusion & Future Work

Conclusions:

- Created a U-Net ConvNet model that delineates liver from a contrast-enhanced CT scan.
- Achieved state-of-the-art results with respect to the original paper that published the liver masks for the MSDC-T8 dataset.
- Added 3D modeling aspect to the delineated liver.

Future Work:

- Add the tumor and vessels delineation models to segment these highly relevant tissues.
- Create a program that will take the record and segment all the tissues and render a 3D object for medical use via the click of a button.

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