3D Bone Models from Pelvic MR Imaging

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INTRODUCTION AND MOTIVATION

- Medical segmentation is used to automatically isolate a region of interest in a scan.
- Deep learning (DL) can be used in healthcare settings to more efficiently and accurately analyze magnetic resonance imaging (MRI) through medical segmentation.
- **Objective**: Use a DL algorithm to segment pelvic MRIs and generate 3D models of bones to better visualize the human body and aid radiologists.

METHODS

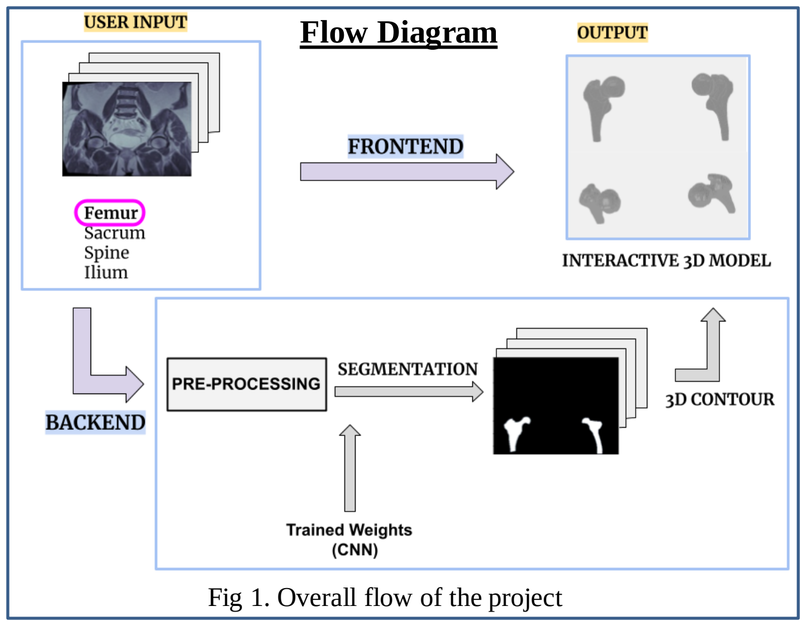
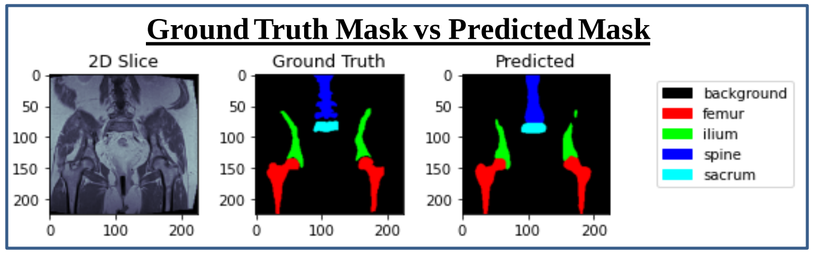


Fig 1. Overall flow of the project

1. Obtained a dataset of Pelvic Region 3D MRI scans from the Cancer Imaging Archives.[1,2,3]
   - Dataset size: 23 3D scans
   - Scan size: 385 x 385 x (31-50)
2. Manually assigned each pixel of each 2D slice to its corresponding class.
3. Applied 2D and 3D deep learning models for semantic segmentation.
   - DeepLabV3, 2D U-Net, 3D U-Net
4. Stacked the 2D slices and to create a 3D model of each bone that represents the volume data. The Marching Cubes algorithm is used.
5. Developed frontend of the website and merged with the backend so user can input a 3D pelvic MRI scan and receive a 3D model of the selected bone.

RESULTS: SEMANTIC SEGMENTATION

- Given an MRI scan of pelvic area, we trained a DL model to automatically assign each pixel of the scan to one of the 5 classes.



Approach 1: 3D volumetric architecture

- Since the MRI scans are 3D, 3D U-Net was first applied. Although 3D models were known to learn the context between the slices better, it was not suitable for our case due to the small dataset size.

Approach 2: 2D architecture

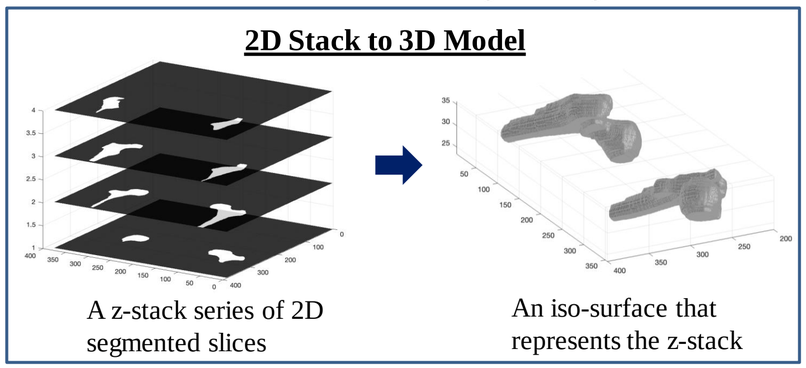
- Trained the model slice by slice. The performance of DeepLabV3 and 2D U-Net (ResNet-34) were compared and is summarized in the table below. The performance on each bone type is shown.

Bone Type	Segmentation Model	Median Dice Score
Femur	DeepLabV3	0.885
	U-Net	0.837
Ilium	DeepLabV3	0.753
	U-Net	0.787
Spine	DeepLabV3	0.774
	U-Net	0.764
Sacrum	DeepLabV3	0.882
	U-Net	0.786

- DeepLabV3 achieves higher dice score for femur, spine, and sacrum segmentations. U-Net trains faster.

RESULTS: 3D MODELING AND VISUALIZATION

- The semantic segmentation outputs multiple slices of 2D segmented masks for each slice of the scan.
- The goal of 3D modeling is to turn this stack of 2D masks into a volumetric 3D bone model. The marching cubes algorithm was used.



A z-stack series of 2D segmented slices

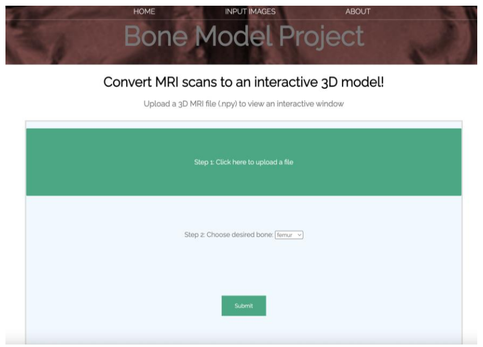
An iso-surface that represents the z-stack

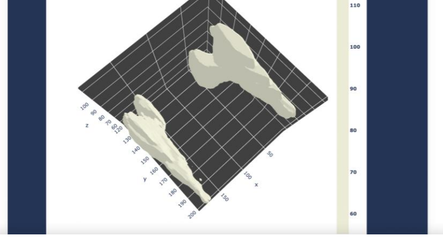
RESULTS: WEB APP

- Developed a website where the user can input 3D MRI scans and choose a bone. The developed machine learning algorithm segments the specified bone and outputs a 3D interactive model.
- The loading time, including the inference and 3D model, is about 20-30 seconds.

Input Page

A user inputs a 3D MRI scan and selects a desired type of bone.





Output Page

The website redirects the user to a page with an interactive model of the selected bone.

CONCLUSION AND FUTURE RESEARCH

- Developed a website that performs segmentation and 3D modeling to output an interactive 3D bone model given a 3D pelvic MRI scan.
- For semantic segmentation, several 2D deep learning models are applied. For 3D modeling, marching cubes algorithm is applied.
- The 3D model is outputted to the website using the Plotly package.

- **Future Plans**: Continue developing both the frontend and the backend of the website with a goal of deploying it to the public

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- Scan the QR code on the right to access the references page.