RibSeg Dataset and Strong Point Cloud Baselines for Rib Segmentation from CT Scans

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Introduction

Manual rib inspection in a large number of CT scans is labor-intensive

Automatic Rib Segmentation?

Challenge

- There is **no public labeled dataset** for benchmarking methods and developing downstream applications.

- Previous segmentation methods[3, 4] work on **dense 3D volumes** that are computationally inefficient.
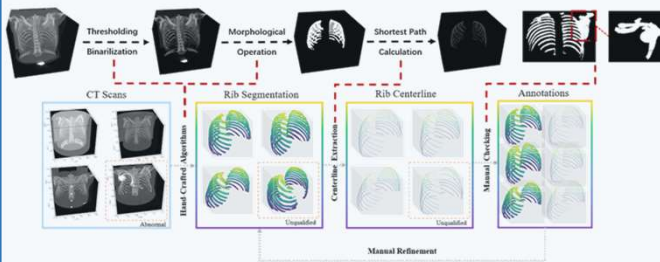
Lack of Dataset & Data Sparsity?

Solution

- Building the first **rib segmentation benchmark, RibSeg Dataset**.

- Propose a novel **point-based perspective** for rib segmentation.

Methodology

RibSeg dataset development

Based on FracNet dataset[1], we built RibSeg dataset by **morphology-based algorithms** and **manual refinements**.

RibSeg dataset overview

RibSeg dataset is the first **public benchmark for rib segmentation**, which enables downstream applications and method comparison.

RibSeg Dataset Distribution

Subset	No. of CT Scans	No. of Individual Ribs
Training	320	7,656
Development	50	1,158
Test	120	2,834

A point cloud-based perspective

We designed a point cloud-based rib segmentation baseline with PointNet++[2]
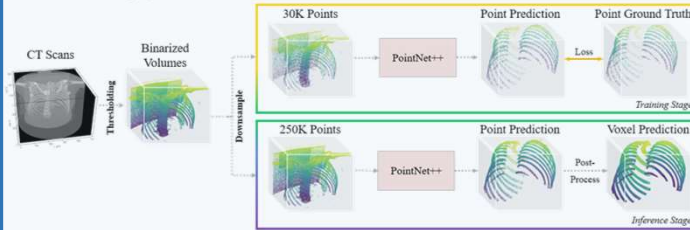

Experiments

Quantitative evaluation

Test on RibSeg test set, including: **Dice** over sparse points and dense voxels, **ratio of missed rib pairs**, and **the model forward time**.
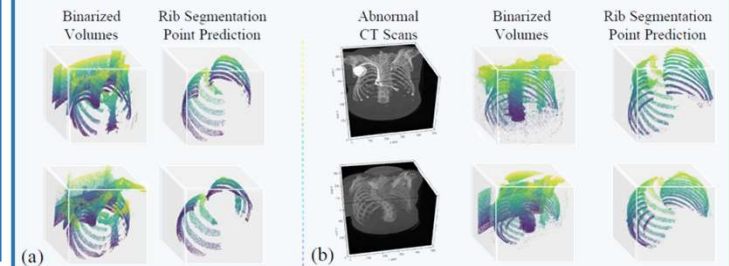
Methods	$Dice^{(P)}$	$Dice^{(V)}$	Missed Ribs (A/F/I/T)	Forward (s)
Voxel-Based 3D UNet [2,7]	-	86.3%	4.6%/7.9%/2.3%/24.6%	30.63
PN++ [13] (30K)	92.3%	91.0%	1.6%/2.9%/0.7%/10.4%	**0.32**
PN++ [13] (250K)	91.5%	92.3%	0.9%/3.3%/0.3%/4.7%	1.12
PN++ [13] (30K) + aug.	**94.9%**	94.3%	1.1%/0.8%/0.4%/9.0%	**0.32**
PN++ [13] (250K) + aug.	94.6%	**95.2%**	0.6%/0.4%/0.2%/5.2%	1.12

Qualitative evaluation

Model performance on unseen CT scans
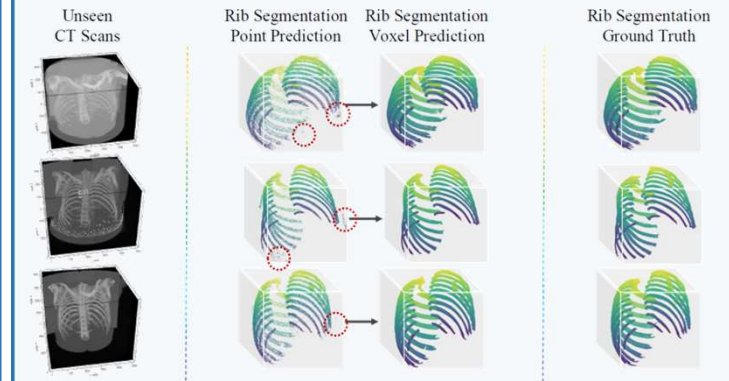
Robust test on extreme cases

Post-processing rib centerlines from predicted rib segmentation

References
[1] Liang Jin, Jiancheng Yang, et al. Deep-learning-assisted detection and segmentation of rib fractures from CT scans: Development and validation of FracNet. EBioMedicine'20
[2] Qi, C.R.,et al. Pointnet++: Deep hierarchical feature learning on point sets in a metric space. NIPS'17
[3] Lenga, M., et al. Deep learning based rib centerline extraction and labeling. MICCAI'18
[4] Wu, D., et al. A learning based deformable template matching method for automatic rib centerline extraction and labeling in ct images. CVPR'12

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