

# Supplementary Materials for Self-supervised 3D Skeleton Completion for Vascular Structures

Jiaxiang Ren, Zhenghong Li, Wensheng Cheng, Zhilin Zou, Kicheon Park, Yingtian Pan, and Haibin Ling\*

Stony Brook University

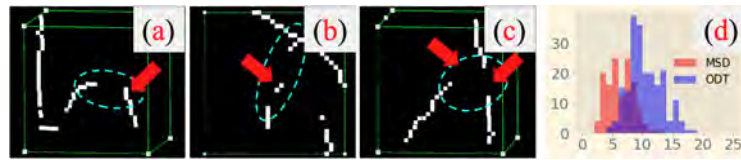


Fig. 1: Weak performance of baselines and the statistic of break length. Curve-fitting methods fail in the following cases: (a) The poorly shaped right branch has different curvature compared with the left branch; (b) The extremely short branch has too few voxels for accurate curve fitting. (c) No universal rule can handle all kinds of bifurcation breaks, causing problems for rule-based methods. (d) The size of input patches in each dataset is chosen according to the break sizes in practice, not due to memory constraints.

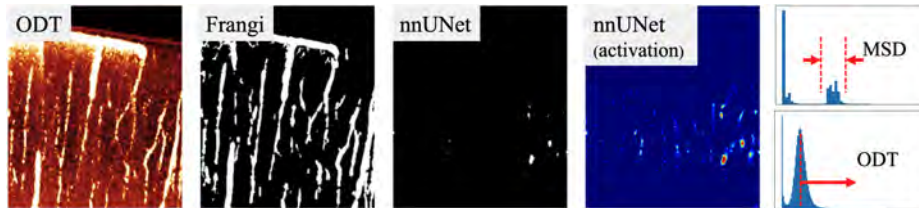


Fig. 2: The nnUNet pretrained on MSD does not work well on ODT due to significant distribution difference. Fine-tuning nnUNet is infeasible without annotations. Consequently, we did not report nnUNet's result on ODT.

Table 1: Ablation study of loss functions on the MSD dataset. *TverskyLoss* alleviates the imbalance issue by adjusting the weights of false positives and false negatives. Thus inspired, we normalize weights of FG/BG in MSE and  $\ell_1$ , leading to improved scores.

Loss	Skel Aug.	Recall	Precision	Accuracy	F1
Tversky $_{\alpha=0.001}$	-	88.16	50.95	50.00	64.58
	✓	96.71	68.69	75.51	80.33
Normalized MSE	-	90.79	53.70	54.76	67.48
	✓	94.74	72.73	78.91	82.29
Normalized $\ell_1$	-	90.13	53.94	55.10	67.49
	✓	96.71	72.06	78.91	82.58
Ours	-	<b>98.03</b>	57.98	62.24	72.86
	✓	92.11	<b>80.00</b>	<b>84.01</b>	<b>85.63</b>

Table 2: Ablation study of model sizes on the MSD dataset. The default model is 256-MaxChannel based on the trade-off between accuracy and size.

Max Channel#	Param.	Recall	Precision	Accuracy	F1
128	1.9M	<b>94.08</b>	73.71	79.59	82.66
256	7.2M	92.11	<b>80.00</b>	<b>84.01</b>	85.63
512	28.7M	93.42	79.33	<b>84.01</b>	<b>85.80</b>

Table 3: Dataset information.

	Training#	Test#	Break anno.	Volume size	Spacing	Skel. density
MSD	242	61	295	(24-181)*512*512	0.8*0.6*0.6 or 0.8*1.0*1.0mm	0.25%
ODT	13	4	600	500*1024*1000	3.0*1.0*3.0 $\mu$ m	0.125%

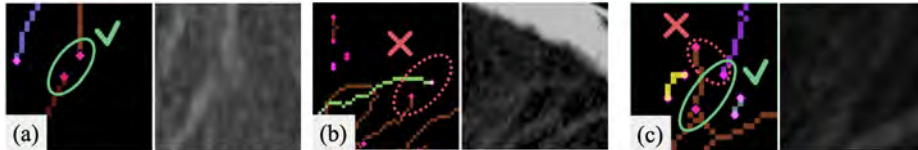


Fig. 3: Examples of break annotation. (a) Skeleton break. (b) Non-break. (c) Manual corrected break. The right panel is the corresponding image for reference. The blue and red ellipses are **break** and **non-break** respectively. The endpoints in each skeleton are marked with the magenta points.