CROWN 2023 Challenge Task2 (AIntropy)

Pengcheng Shi[1], Wei Liu[1], and Ting Ma[1,2](✉)

[1] Electronic & Information Engineering School, Harbin Institute of Technology (Shenzhen), Shenzhen, China
[2] Peng Cheng Laboratory, Shenzhen, China

1 Introduction

This challenge's aim is to contrast automated methods for categorizing the Circle of Willis (CoW) configuration and gauging the major artery diameters and bifurcation angles of the CoW. Current risk prediction models for identifying individuals with a high risk of unruptured intracranial aneurysm (UIA) are insufficient. Employing automated methods to analyze CoW configurations and artery morphology can help find new risk factors for UIA in large patient groups.

This task involves quantifying 15 primary artery diameters and 10 bifurcation angles of the CoW on TOF-MRA images using weakly labeled data. The expected regression output should have 25 values corresponding to the angles and diameters per image (Fig. 1).

Relevant codes can be found at : https://github.com/PengchengShi1220/NexToU and https://github.com/PengchengShi1220/VesselGrapher.

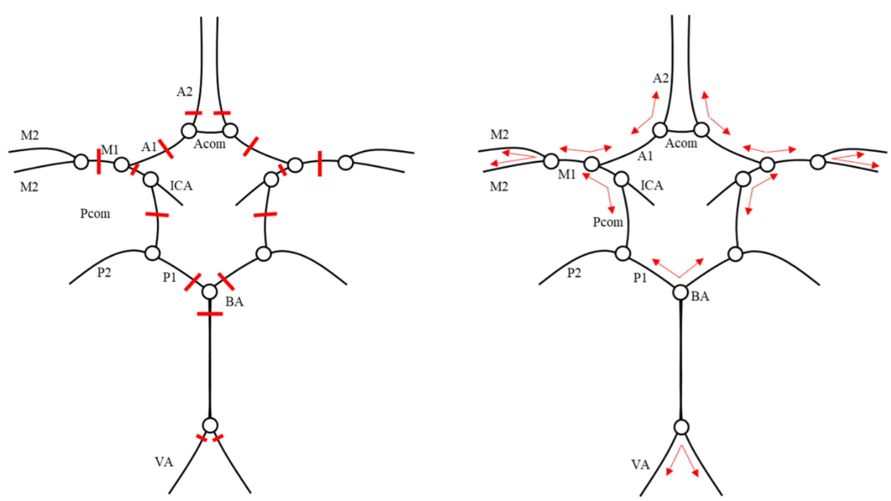

Fig. 1. Schematic representation of circle of Willis with annotations used in the CROWN challenge

2 Method

Circle of Willis Intracranial Artery Classification and Quantification In our study, we employed a combination of nnUNet [1] framework and our NexToU [3] architecture for 3D full-resolution. Next, we procured the binary segmented prediction mask and used the soft skeleton algorithm from ICCV 2023 [2] to extract its skeleton. Following this, we built the vessel graph from the centerline neighborhood's minimum spanning tree. This process was subsequently utilized to ascertain the topological relationships among features via graph convolution, a key operation within the **VesselGrapher** module. Following the integration of this module with the Multilayer Perceptron (MLP), the resultant system was designated as the **Vessel GNN** module.

After acquiring the whole brain vascular anatomy segmentation of 24 classes, we binarized them to obtain the binary segmentation masks, skeletonized them for the vascular centerline, and carried out the distance transform edt on the binary segmentation masks to get the boundary distance map. By combining multi-class anatomical segmentation masks, vascular centerlines, and Boundary distance maps, we are able to determine the coordinates, diameter and angle of the key points to perform Circle of Willis Intracranial Artery Quantification (Fig. 2). After obtaining the diameter of the key positions, we use the logic judgment in the Posterior Classification table to classify Anatomical variations in the posterior part of the CoW (Table 1). However, for Anterior Classification, since class $A2_{3rd}$ is not included among the 24 anatomical classes and the annotation data of CROWN 20 cases in TopCoW 2023 was not used for training, unfortunately, we are unable to classify Anatomical variations in the anterior part of CoW.

fetaltype_L	fetaltype_R	Pcomm_L	Pcomm_R	P1_L	P1_R	Posterior class
No	No	No	No	No	No	a
Yes	Yes	No	No	No	No	c
Yes or No	Yes or No	No	No	No	No	b
No	No	Yes	Yes	No	No	e
No	No	Yes or No	Yes or No	No	No	d
Yes	N/A	No	N/A	Yes	No	f
N/A	Yes	N/A	No	N/A	Yes	f
Yes	N/A	N/A	Yes	No	No	g
N/A	Yes	Yes	N/A	No	No	g
Yes	N/A	Yes	N/A	Yes	No	h
N/A	Yes	N/A	Yes	N/A	Yes	h
Yes	Yes	N/A	N/A	Yes	Yes	i
Yes	Yes	N/A	N/A	Yes or No	Yes or No	j

Table 1. Posterior Classification.

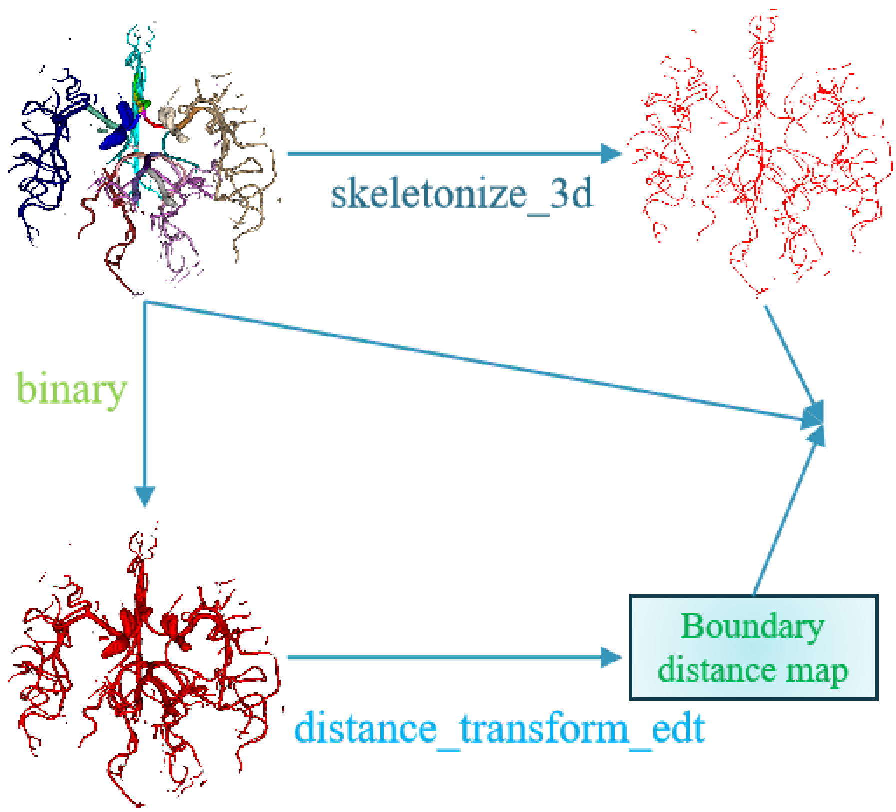

Fig. 2. Quantification of the Circle of Willis Intracranial Artery

References

1. Isensee, F., Jaeger, P.F., Kohl, S.A., Petersen, J., Maier-Hein, K.H.: nnu-net: a self-configuring method for deep learning-based biomedical image segmentation. Nature methods **18**(2), 203–211 (2021)
2. Menten, M.J., Paetzold, J.C., Zimmer, V.A., Shit, S., Ezhov, I., Holland, R., Probst, M., Schnabel, J.A., Rueckert, D.: A skeletonization algorithm for gradient-based optimization. In: Proceedings of the IEEE/CVF International Conference on Computer Vision. pp. 21394–21403 (2023)
3. Shi, P., Guo, X., Yang, Y., Ye, C., Ma, T.: Nextou: Efficient topology-aware u-net for medical image segmentation. arXiv preprint arXiv:2305.15911 (2023)