Regression of Instance Boundary by Aggregated CNN and GCN

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A Appendix

A.1 Data Representation

The left graph of Fig. 1 illustrates how fetal head (FH) boundaries are represented to make it compatible for GCN. The boundary is represented by equally sampled vertices along it and its geometric center is defined as the center vertex. Each triangle consists of three vertices and three edges where two vertices are from the boundary and the other is the center vertex. Then, the vertices locations and their geometric relationships defined by an adjacency matrix from the triangulations can be used by GCN. For the optic disc (OD) and optic cup (OC) segmentation, the centre of the OC is shared as the centre vertex. However, triangulations are made for both the OD and OC, as demonstrated by the right graph of Fig. 1.

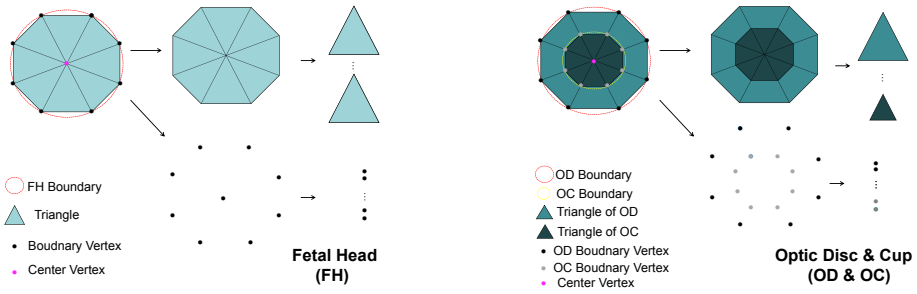

Fig. 1: Illustration of the object contours representation, left: Fetal Head, right: Optic Disc and Optic Cup.

A.2 Ablation Study on Angle Interval

Tasks / Angle Interval	OC		OD		FH	
	Dice Score	AUC	Dice Score	AUC	Dice Score	AUC
40°	0.9025	0.9094	0.9153	0.9231	0.9416	0.9503
18°	0.9104	0.9195	0.9489	0.9555	0.9516	0.9560
10°	0.9196	0.9284	0.9584	0.9648	0.9603	0.9695
5°	0.9239	0.9307	0.9629	0.9716	0.9710	0.9777
2°	0.9245	0.9377	**0.9691**	0.9783	0.9739	**0.9799**
1°	**0.9255**	**0.9385**	**0.9697**	**0.9791**	**0.9746**	**0.9801**

Table 1: Ablation study on different angle interval samplings. With angle interval = 1° or 2°, our model achieves comparable segmentation results on the OD & OC and FH segmentation tasks, and at the end, angle interval = 1° is chosen for our model. Dice score (%) and AUC (%) are reported for the segmentation on OD & OC and FH test dataset.

A.3 Comparison with Ground Truth

For each retina image, when the average Dice score of OD & OC segmentation is lower than 0.85 or our model's segmentation is deviated much from the ground truth, it will be regarded as a 'failed' case. Results of some 'failed' cases in the OD and OC segmentation are shown in Fig. 2. We overlaid segmentations by using our model (green), and the ground truth (red) for better comparison with the center points shown. An expert from an anonymous accredited ophthalmology reading center confirmed that for these cases our segmentations are more accurate than the ground truth. This highlights the robustness of our model as well as the limitations of the ground truth made from manual annotations.

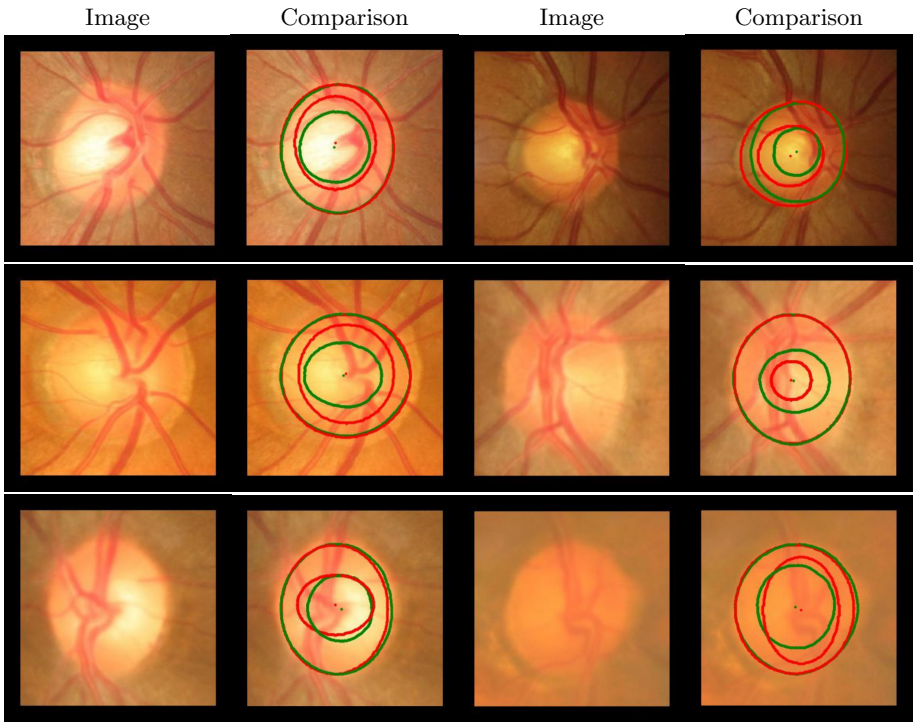

Fig. 2: Illustration of the comparison between our segmentation (green) and the ground truth (red) in some 'failed' cases. The ground truth has inaccurate OC boundaries for most of the cases (The top right corner one is inaccurate in both OC and OD boundaries). Our model can produce more accurate boundaries than the ground truth according to an expert from an anonymous expert at an accredited ophthalmology reading center.

A.4 More Qualitative Results

In Fig. 3 and Fig. 4, we showed the effect of L1 loss, L2 loss, Smooth-L1 loss, and the Fan-loss function on the segmentation of FH and OD and OC, respectively. Intuitively, Fan-loss function produces more faithful and accurate results.

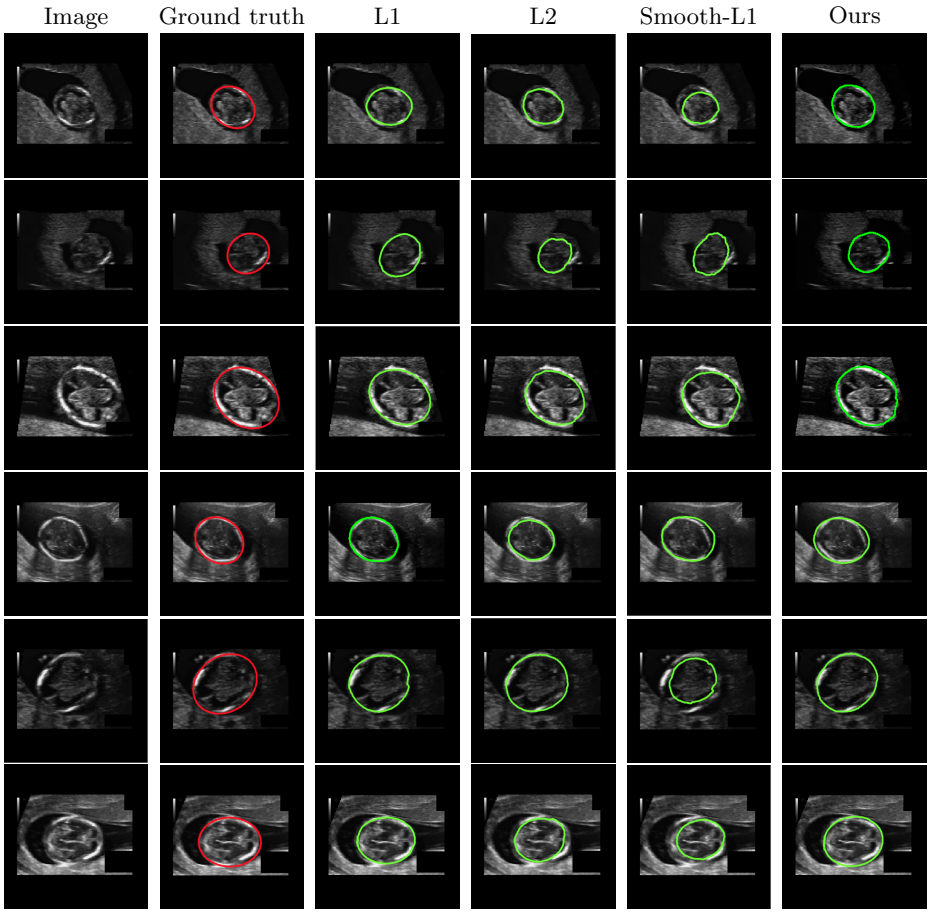

Fig. 3: Comparison in fetal head segmentation when different loss functions are used. The Fan-loss function can produce more accurate and faithful boundaries. In each row, from left to right is the original image, ground truth, segmentations of using L1 loss (L1), L2 loss (L2), smooth-L1 loss (Smooth-L1) and ours.

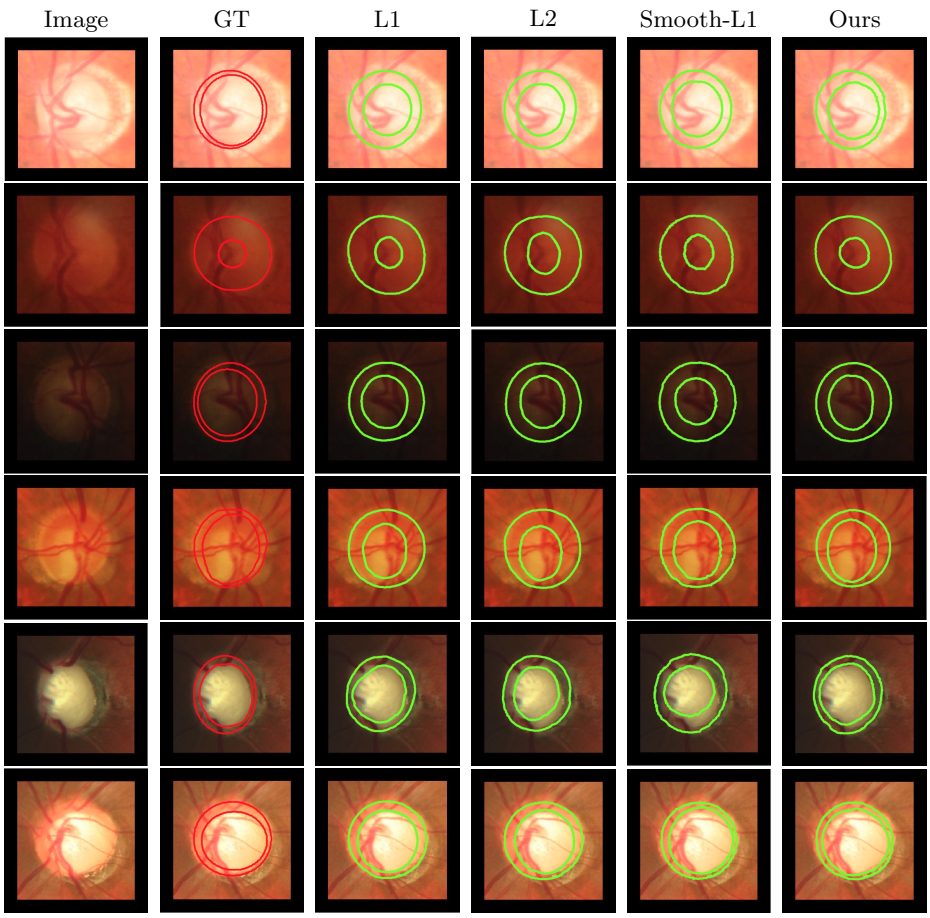

Fig. 4: Comparison of the OD and OC segmentations by using different loss functions. The Fan-loss function can produce more accurate boundaries, especially for the OC. In each row, from left to right is the original image, ground truth (GT), segmentations of using L1 loss (L1), L2 loss (L2), smoothed-L1 loss (Smooth-L1) and ours.