Tumor Cell Nuclei Segmentation with Topology-Preserving

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Abstract

Traditional segmentation algorithms are prone to make **topological errors** on fine-scale structures, we propose a novel method to segment with **correct topology**

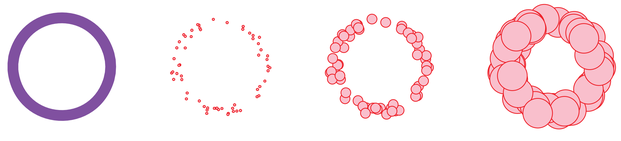
- Proposed a new topological loss by **persistent homology**
- Incorporated the loss function into end-to-end training of deep neural network
- The results demonstrated that our method segments images with **correct topology**

Motivation

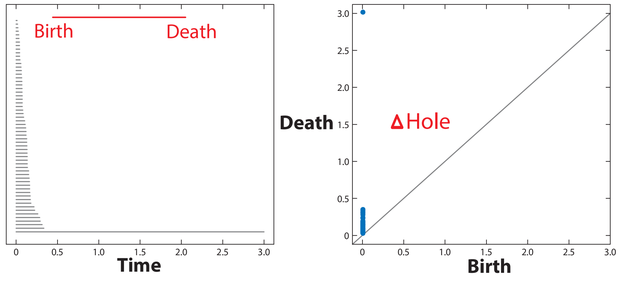
Topological errors on fine-scale structures are **nonnegligible** in cell nuclei segmentation tasks

Topological Data Analysis

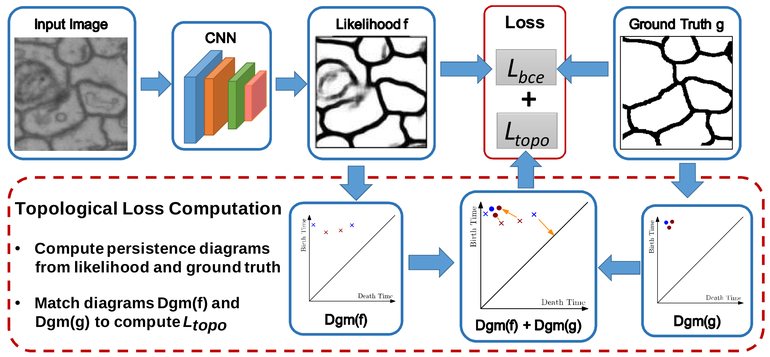
- Filtration and Betti Number (β_0, β_1, ...)



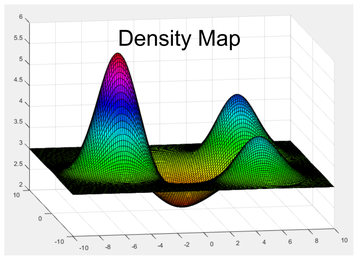
- Barcode and Persistence Diagram

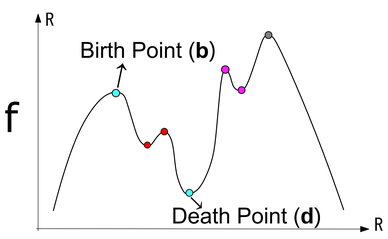


TopoNet

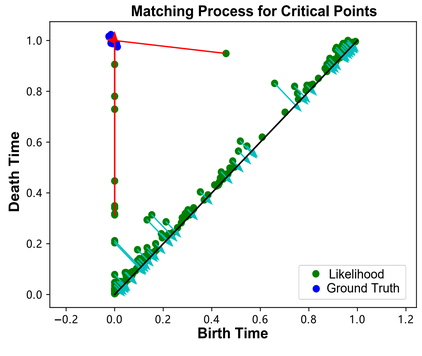


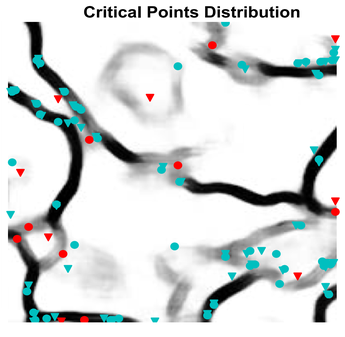
- Density Maps and Critical Points





- Matching Processes between Persistence Diagrams





- Loss Function

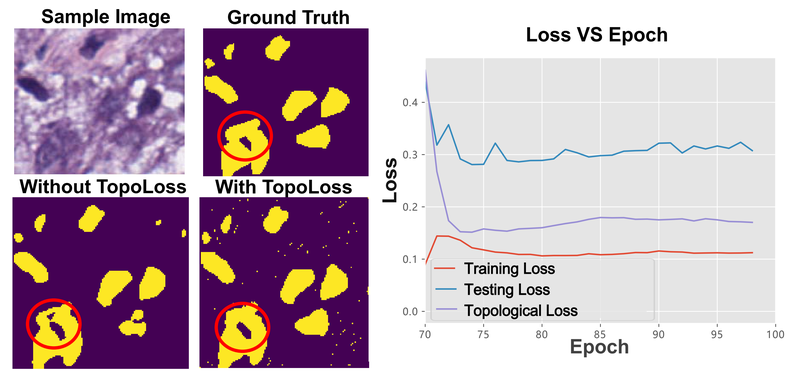
$$L(f, g) = L_{bce}(f, g) + \lambda L_{topo}(f, g)$$

$$L_{topo}(f, g) = \sum_{p \in \mathrm{Dgm}(f)} [\mathrm{b}(p) - \mathrm{b}(\gamma^*(p))]^2 + [\mathrm{d}(p) - \mathrm{d}(\gamma^*(p))]^2$$

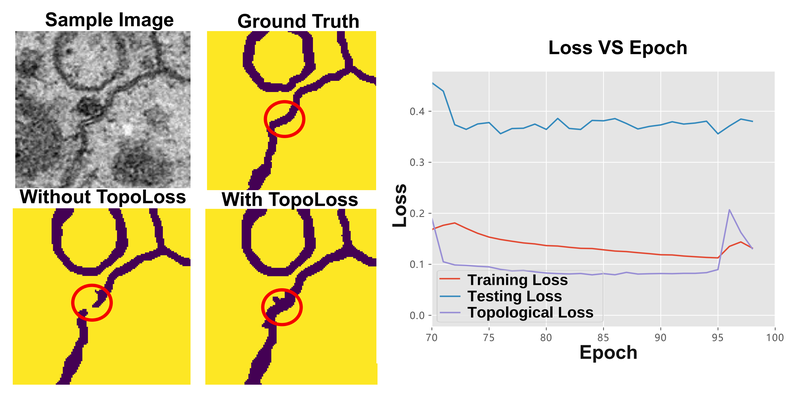
where γ^* is the optimal matching

Experimental Results

- β_0-Based TopoLoss on TCIA Dataset



- β_1-Based TopoLoss on ISBI12 Dataset



Conclusions and Future Work

- Outstanding performance in segmenting fine structure images in both the β_0 and β_1 TopoLoss evaluations, while segmentation results under β_0 baseline lead to some noises, a noise-robust model may be used in subsequent study
- Consideration of topological loss as transferability in transfer learning tasks in future works

Reference

Hu, X., Li, F., Samaras, D. and Chen, C., 2019. Topology-Preserving Deep Image Segmentation. Advances in neural information processing systems.