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Topology-Aware AI for Data-Efficient Whole Slide Pathology Analysis

Stanford researchers have developed TopoSlide, a self-supervised AI model that turns gigapixel pathology slides into compact digital fingerprints of both fine tissue detail and overall tissue architecture.

Whole slide images are too large to analyze in one piece, so they are split into thousands to tens of thousands of small tiles that must be combined into a single slide-level representation. Simple averaging loses where each tile sits on the slide. Pathology foundation models train on tens to hundreds of thousands of slides but still miss the global structure of tissue.

TopoSlide groups similar tissue regions and uses topological data analysis to describe how they are arranged, encoding local and global features together. Evaluated on lung cancer benchmarks, TopoSlide trained on relatively small datasets of hundreds of slides demonstrated competitive and often superior performance compared to pathology foundation models.

Stage of Development:
Proof of concept: computational benchmarking on three lung adenocarcinoma cohorts for retrieval, survival, and mutation prediction, plus breast cancer evaluation.

Applications

- Slide-level encoder and training method for digital pathology AI software
- Clinical decision support from H&E slides: similar-case retrieval, subtyping, staging, and prognosis
- Biomarker research tool for predicting tumor gene mutations from histology images

Advantages

- Trained on hundreds of slides, versus tens to hundreds of thousands for foundation models
- Improves histologic pattern retrieval macro F1 by up to 14.8% over the best baseline
- First training strategy to account for both local and global tissue spatial features
- Transfers more reliably across patient cohorts for mutation prediction
- Competitive with, and often better than, models trained with pathology report text

Publications

- Abousamra, S., Sood, A., & Plevritis, S. (2026). TopoSlide: Topologically-Informed Histopathology Whole Slide Image Representation Learning. *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, 13691-13701.

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