

Boundary-Aware Instance Segmentation in Microscopy Imaging

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Accurate delineation of individual cells in microscopy videos is essential for studying cellular dynamics, yet separating touching or overlapping instances remains a persistent challenge. Although foundation-model for segmentation such as SAM have broadened the accessibility of image segmentation, they still struggle to separate nearby cell instances in dense microscopy scenes without extensive prompting. We propose a prompt-free, boundary-aware instance segmentation framework that predicts signed distance functions (SDFs) instead of binary masks, enabling smooth and geometry-consistent modeling of cell contours. A learned sigmoid mapping converts SDFs into probability maps, yielding sharp boundary localization and robust separation of adjacent instances. Training is guided by a unified Modified Hausdorff Distance (MHD) loss that integrates region- and boundary-based terms. Evaluations on both public and private high-throughput microscopy datasets demonstrate improved boundary accuracy and instance-level performance compared to recent SAM-based and foundation-model approaches. Source code is available at <https://github.com/ThomasMendelson/BAISeg.git>.