Cloud-hosted Neural Networks for Cell Segmentation and Classification of Multiplexed Ion Beam Imaging Data

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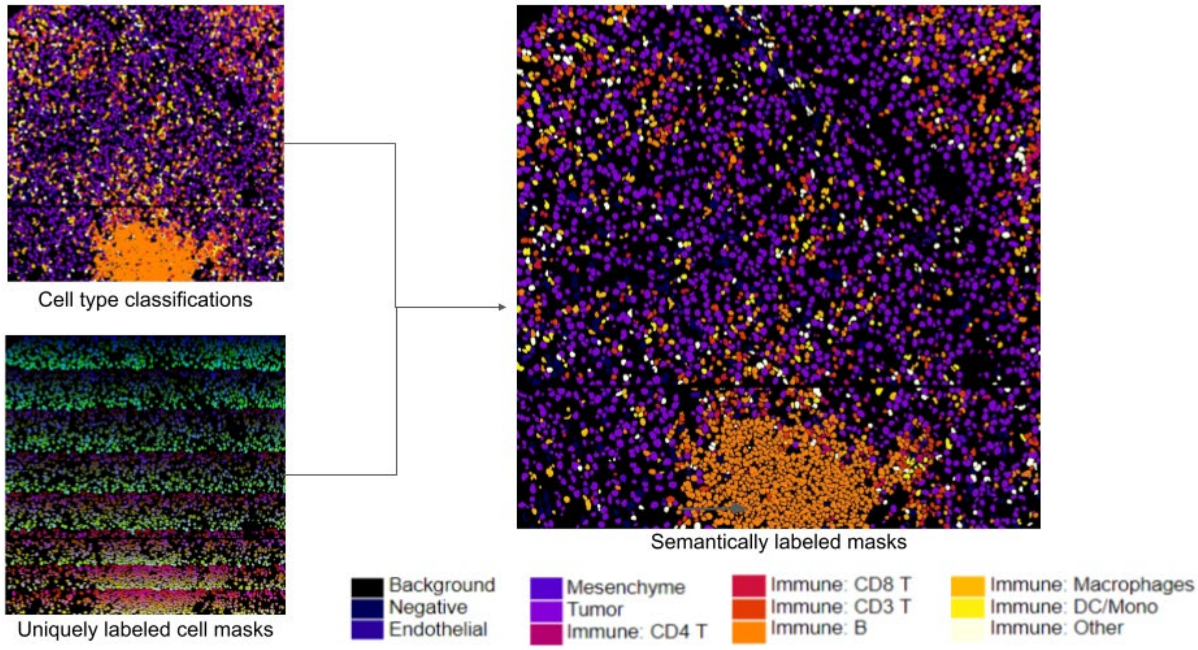
Background:
Multiplexed ion beam imaging (MIBI) is a novel variant of immunohistochemistry utilizing mass-tagged antibodies to enable the simultaneous visualization of up to one hundred independent targets. This is a crucial development in the fields of oncopathology and immuno-oncology, allowing for more accurate mapping of cell types and visualization of complex cellular interactions. However, this data is esoteric, with the high numbers of channels overwhelming for even seasoned pathologists. With potentially thousands of cells per image, hand-annotation is prohibitively time-consuming. Furthermore, current cell classification methods require significant post-processing and are not easily accessible for those less familiar with computation. While MIBI is groundbreaking, its application is bottlenecked by the lack of effective annotation methods. Work by the Van Valen lab has found that a combination of convolutional neural networks (CNNs) and cloud computing offers a promising solution.

Methods:
An 8-channel CNN was trained to generate predictions for cell edge, interior, and background, subsequently converted into cell masks via watershed transform. Semantic labels were generated by combining masks with class predictions from a 26-channel CNN. A custom Redis consumer was developed to enable predictions via web interface for cloud-hosted segmentation models.

Results:
The pipeline for semantic segmentation is shown in Figure 1. Overall pixel accuracy was 93.3%. With an intersection-over-union threshold of 0.5, predicted masks achieved an instance accuracy of 91.6% with a dice score of 0.94, and a corresponding cell type classification accuracy of 87.6%. An improved segmentation model is currently cloud-hosted and available for predictions on the deepcell.org website.

Conclusions:
In concert, these CNNs perform cell classification and segmentation of MIBI data with accuracy comparable with or superior to current computational methods. Segmentation predictions are accessible within minutes, with no start-up time required, through the deepcell.org website. The full deployment of this pipeline to the cloud will provide researchers and medical centers with easy access to rapid, accurate MIBI annotations without requiring training in computational methods. Ultimately, the combination of CNNs and cloud computing will enable the widespread use of multiplexed ion beam imaging in ways that are currently impossible.



Cell type classifications
Uniquely labeled cell masks
Semantically labeled masks
Background
Negative
Endothelial
Mesenchyme
Tumor
Immune: CD4 T
Immune: CD8 T
Immune: CD3 T
Immune: B
Immune: Macrophages
Immune: DC/Mono
Immune: Other

Figure 1.