

# Cell Tracking in 3D using Deep Learning Segmentations



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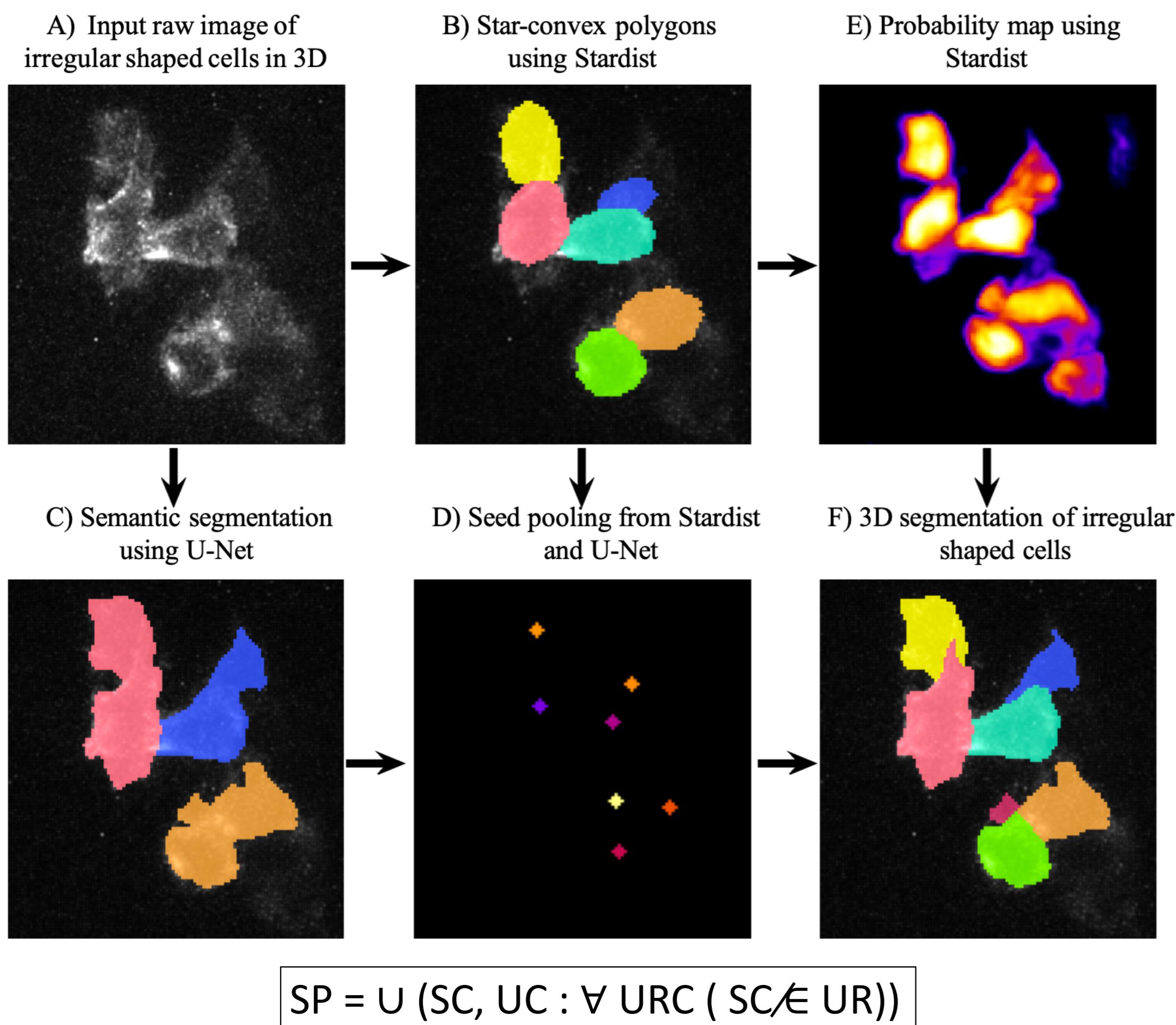
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## Abstract

Live-cell imaging is a highly used technique to study cell migration and dynamics over time. Automated analysis of fluorescently membrane-labelled cells can be highly challenging due to their irregular shape, variability in size and dynamic movement across Z planes making it difficult to detect and track them. We introduce a detailed analysis pipeline to perform segmentation with accurate shape information, combined with BTrackmate, a customized codebase of popular ImageJ/Fiji software Trackmate, to perform cell tracking inside the tissue of interest. We also created an interface in Napari to visualize the tracks along a chosen view making it possible to follow a cell along the plane of motion. We provide a detailed protocol to implement this pipeline in a new dataset, together with the required Jupyter notebooks.

## 1. VollSeg - Our segmentation approach



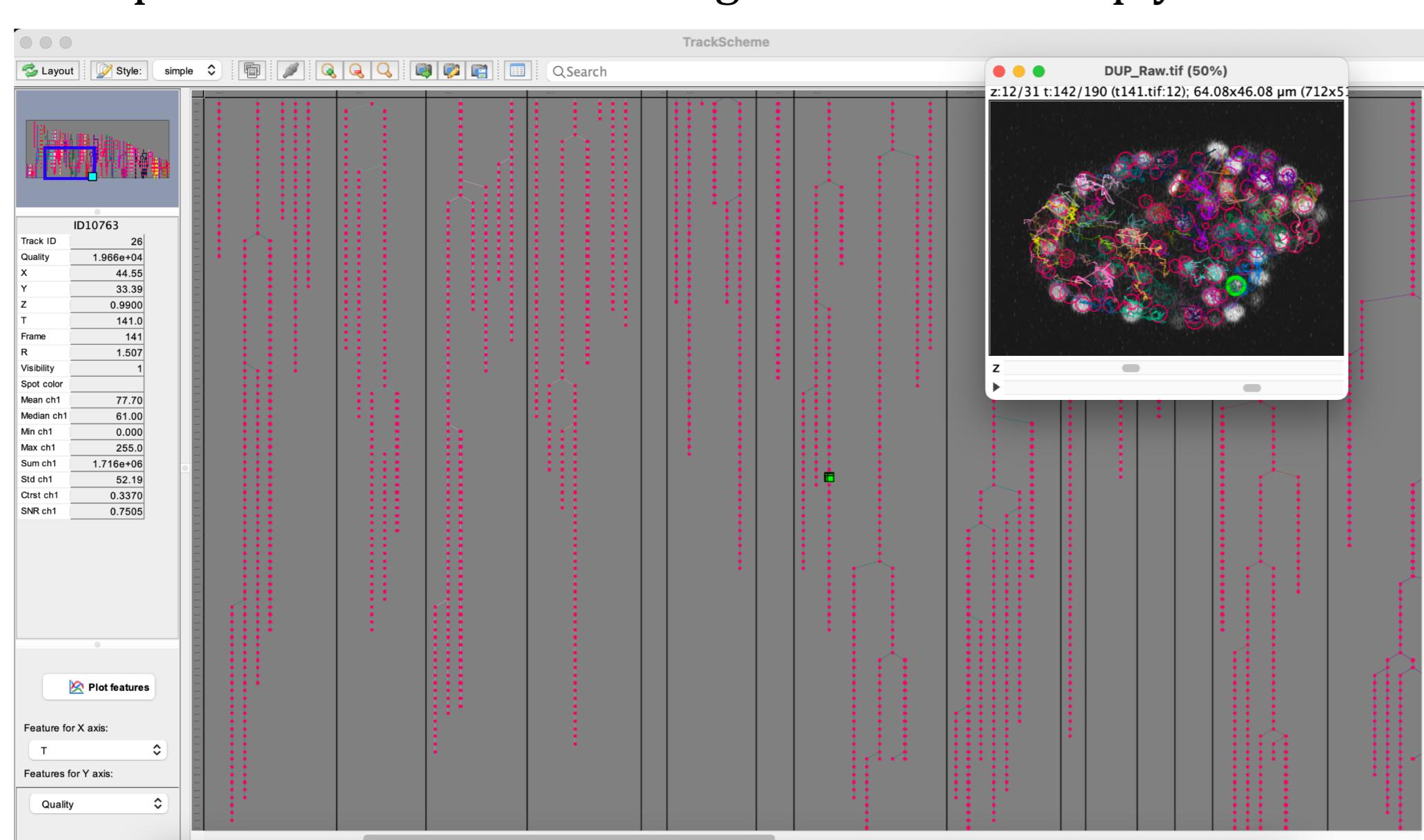
SP = Seed pool; UR(C) = U-Net connected component labelled Region (Centroid);  
SC = Stardist centroids.

- Seeds from Stardist and U-Net for performing a marker controlled watershed pooling.
- Probability map coming from Stardist to do watersheding on.

## 4. BTrackMate



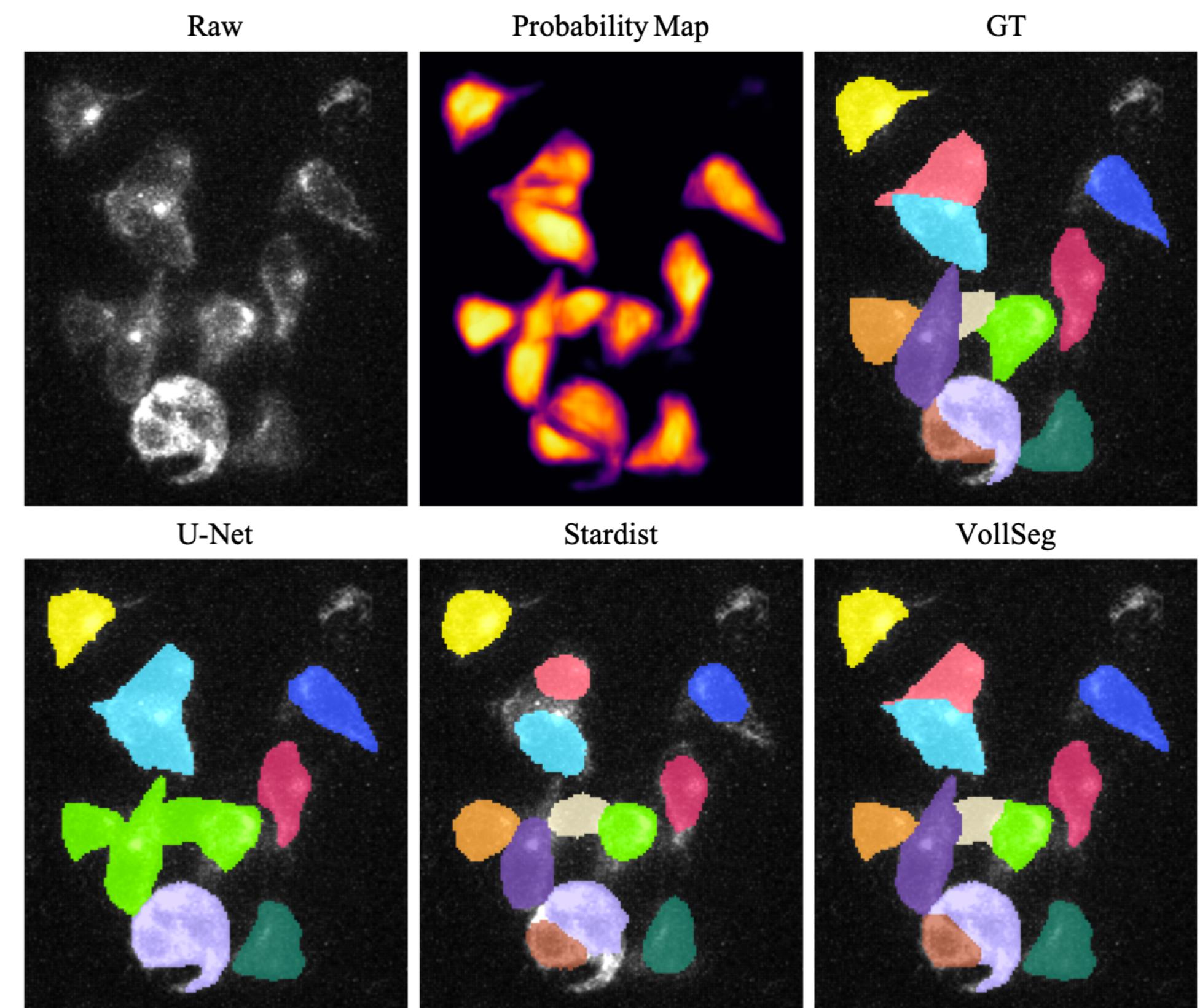
- Create a csv file of the cell attributes for memory optimized tracking.
- Use of Trackmate codebase for track editing interface.
- Interactive graph and image listeners for track editing in 3D.
- Track inspector to remove short segments in a multiply-connected graph.



## References

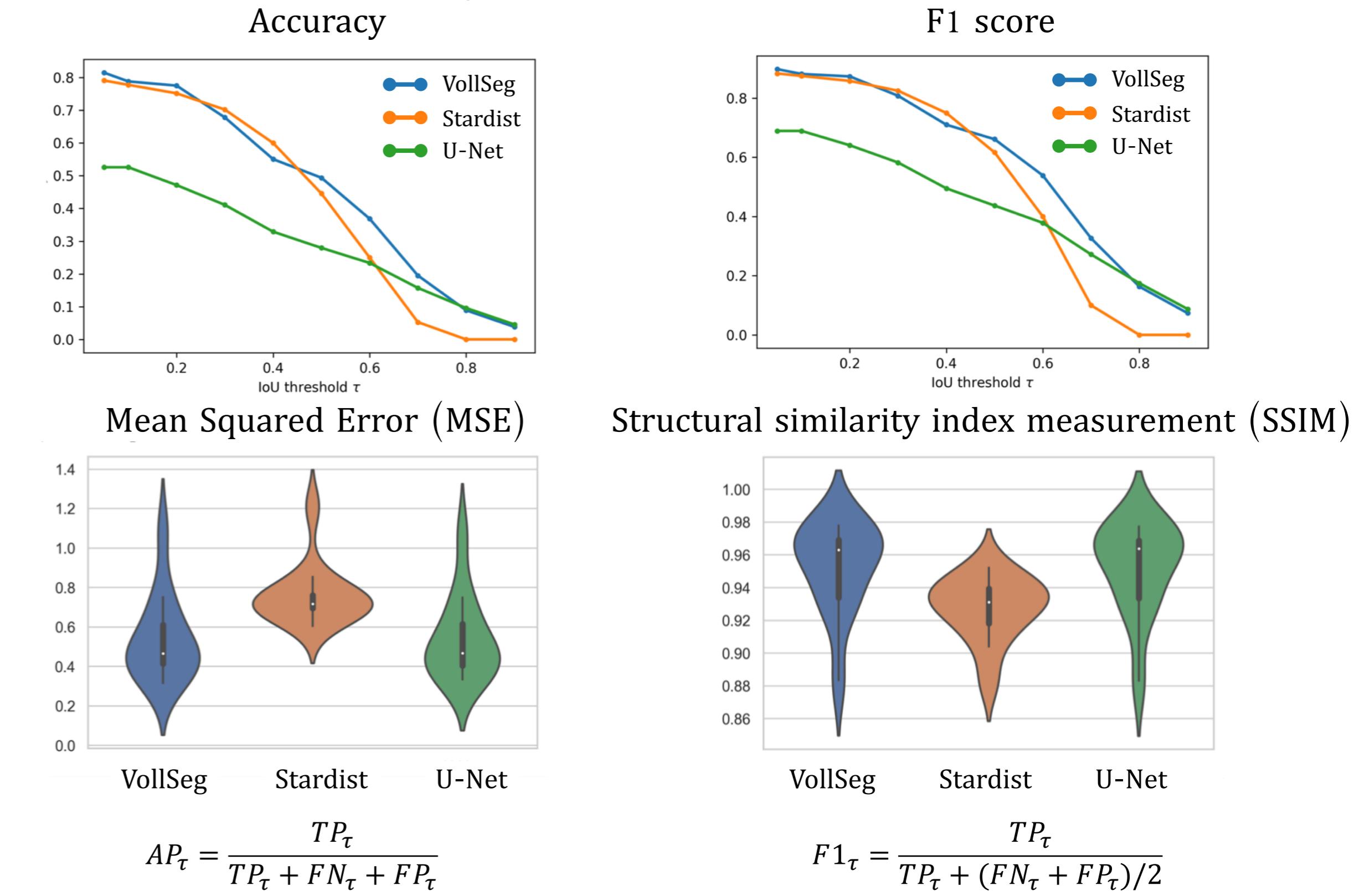
1. Jean-Yves Tinevez et al. Trackmate: An open and extensible platform for single-particle tracking. *Methods*, 115:80–90, 2017.
2. Kristina Ulicna et al. Automated deep lineage tree analysis using a bayesian single cell tracking approach. *BioRxiv*, 2020.
3. Martin Weigert et al. Star-convex polyhedra for 3D object detection and segmentation in microscopy. In *IEEE WACV 2020*.
4. Olaf Ronneberger et al. U-net: Convolutional networks for biomedical image segmentation. In *MICCAI 2015*.

## 2. Comparison with other approaches



- Stardist performs well to segment overlapping cells but is limited to star convex shapes.
- U-Net obtains the shape information but doesn't distinguish overlapping cells.
- VollSeg is able to detect membrane-labelled cells with low signal-to-noise ratio and dense packing.

## 3. Quantitative Metrics

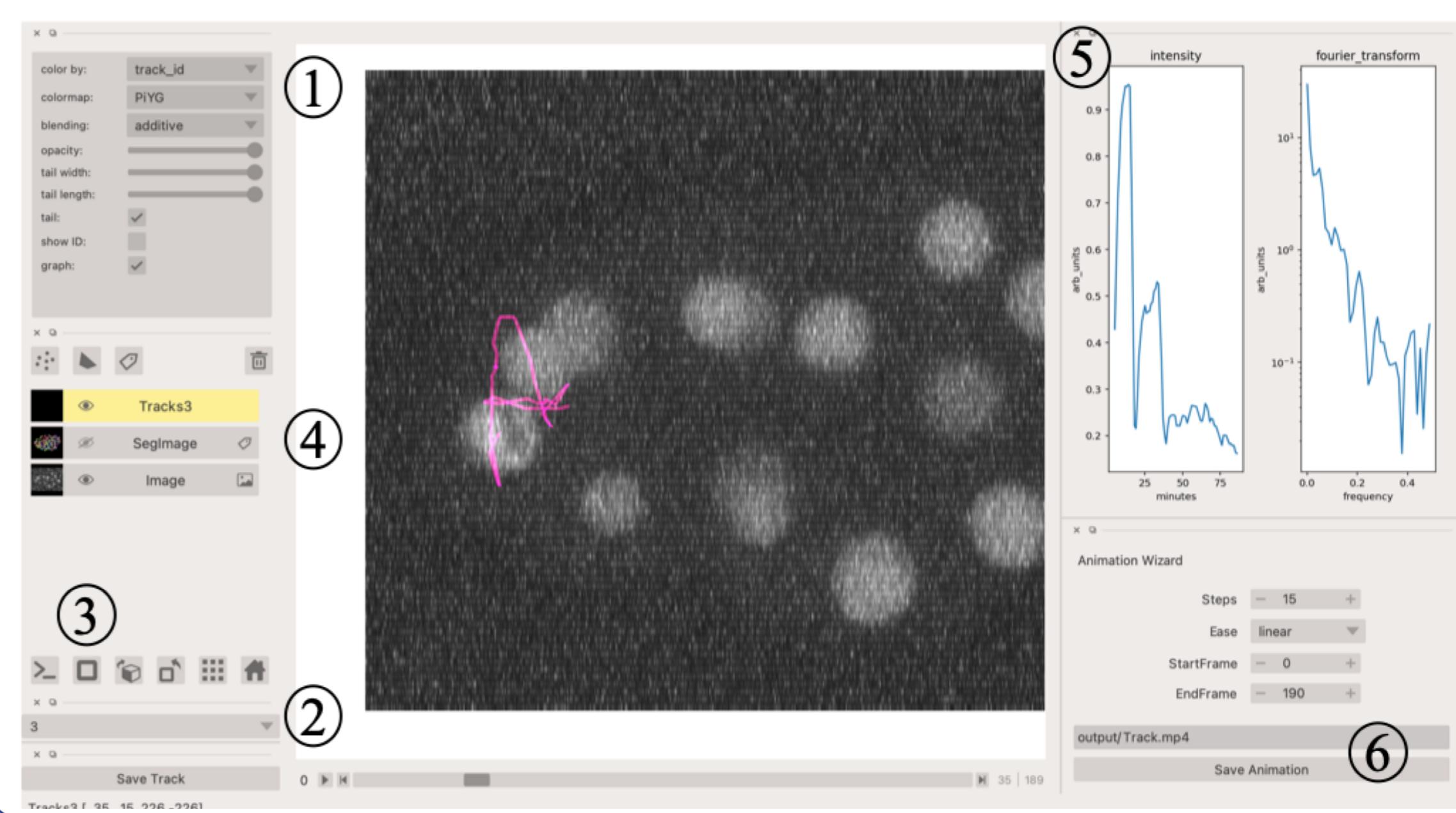


- VollSeg has the highest shape and instance segmentation accuracy.

## 5. Tracking Analysis with Napari



- Cell distance from the tissue boundary change over time.
- Intensity change with FFT for each tracklet.
- Track saving along user chosen plane.



Codes and  
Jupyter  
Notebooks  
Available at:

