Visualisierung Medizinischer Daten 2
3. Vorlesung
Segmentation Correction
ViviSection: Skeleton-based Volume Editing

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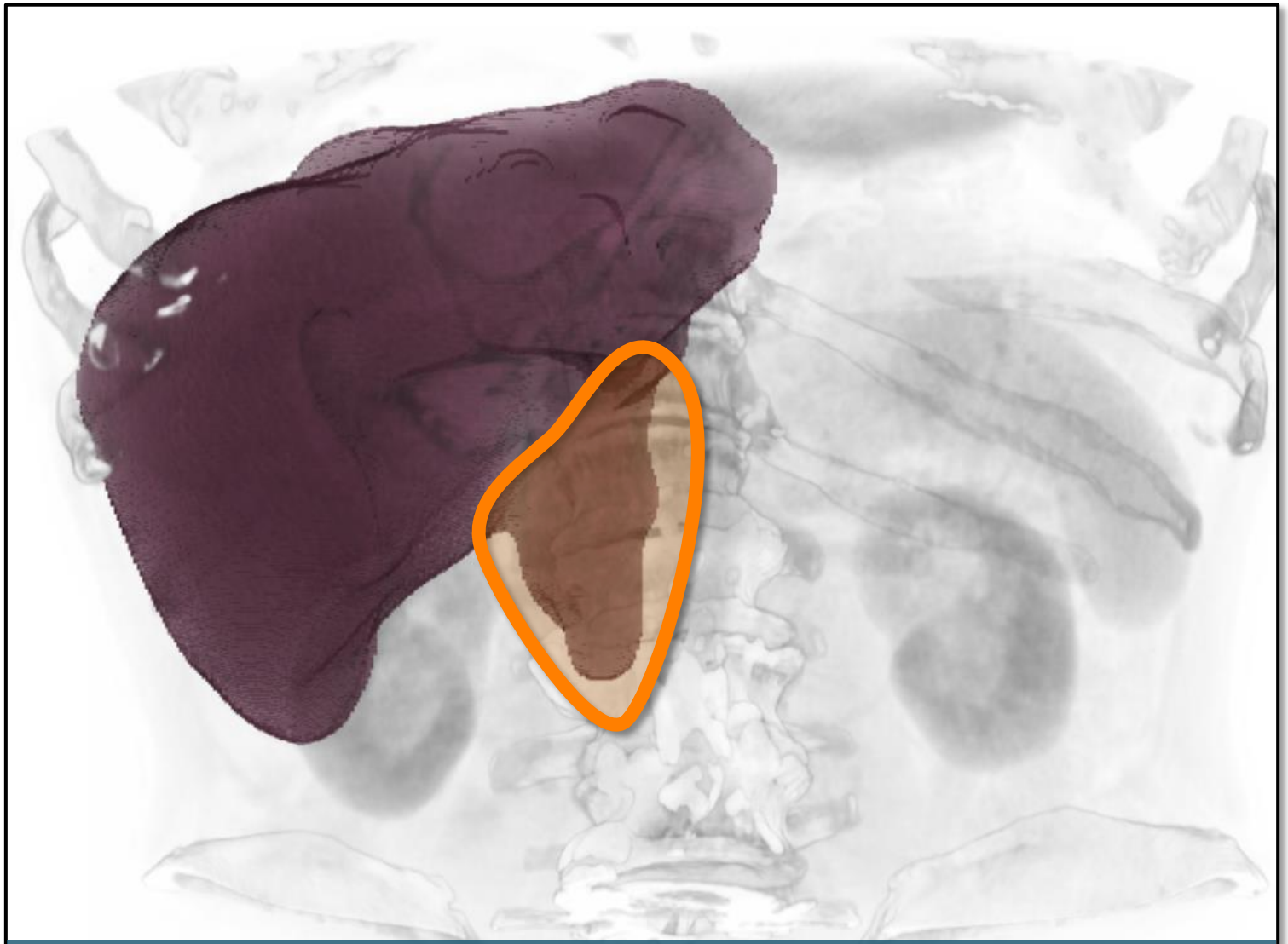
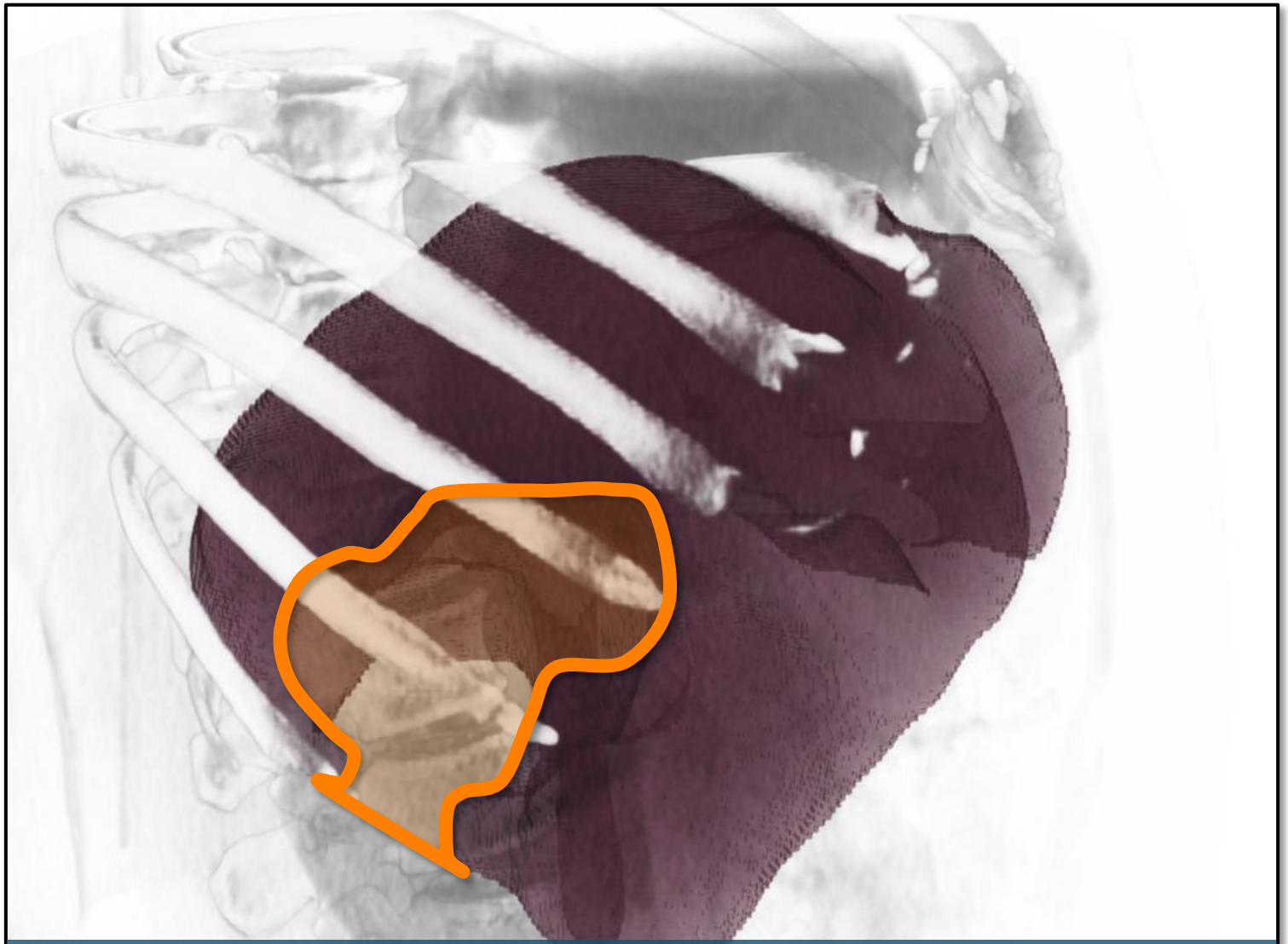
Segmentation Problems



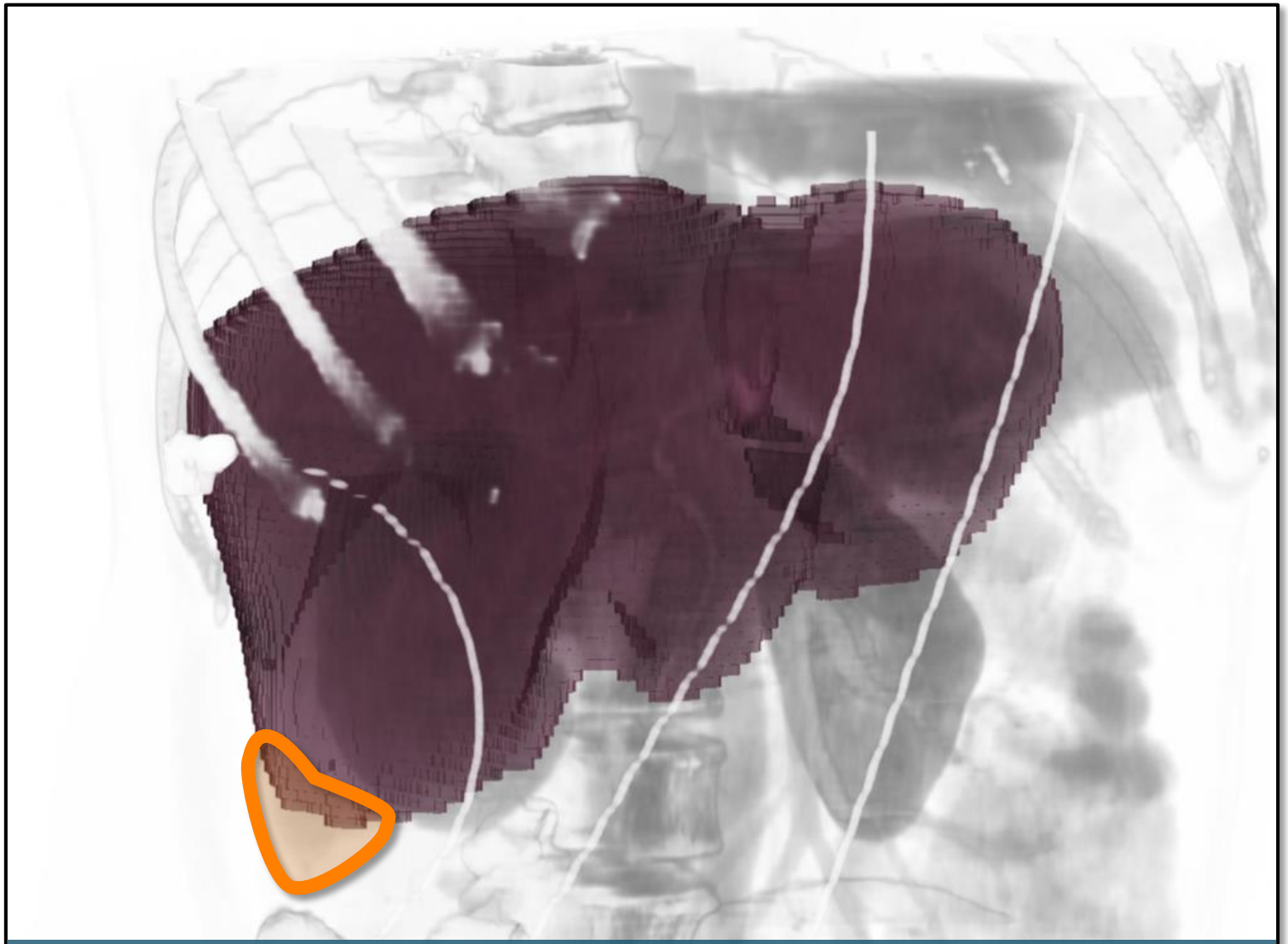
Over-segmentation

Segmentation Problems



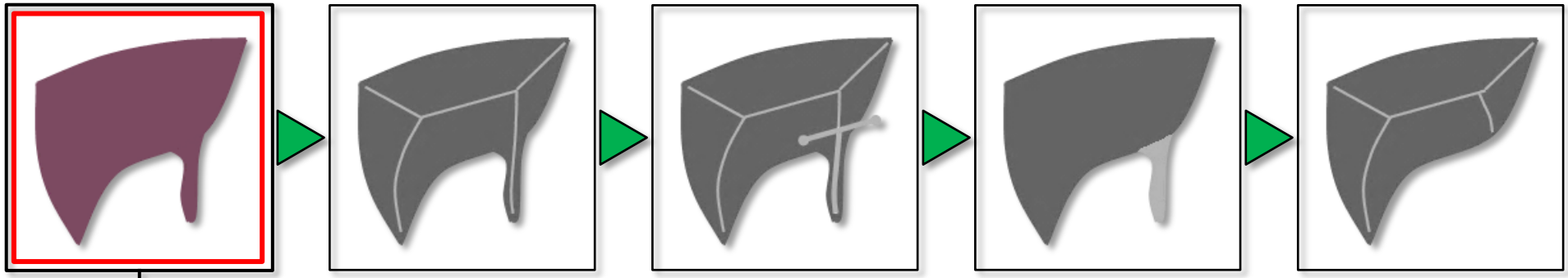
Under-segmentation

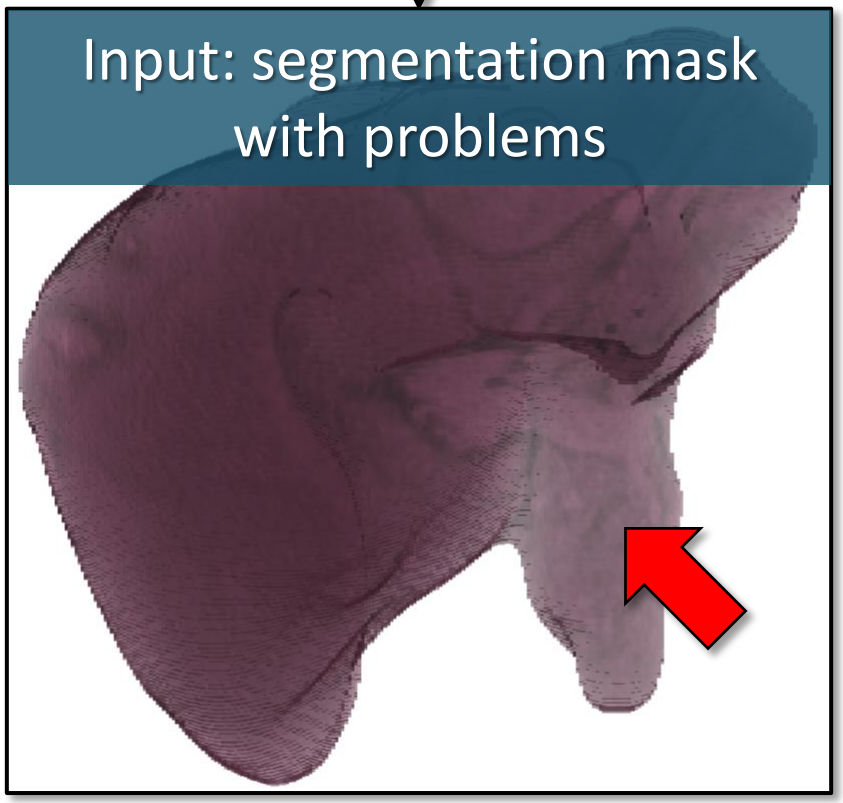
Segmentation Problems



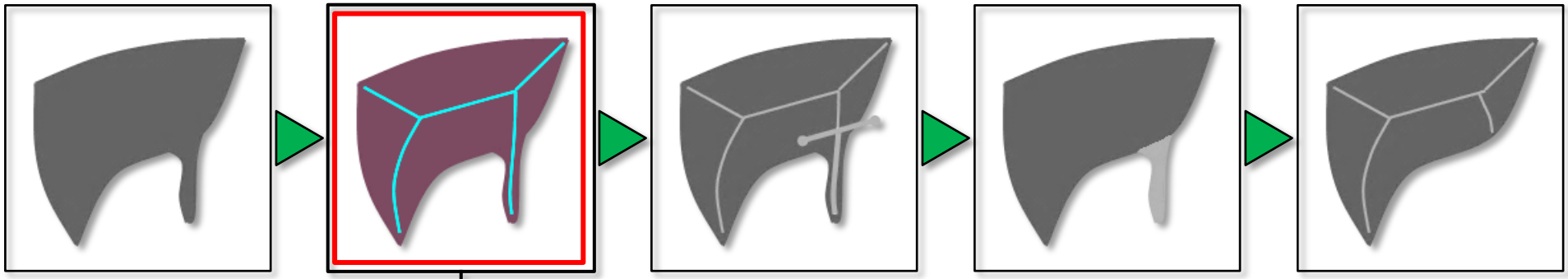
Local boundary artifacts

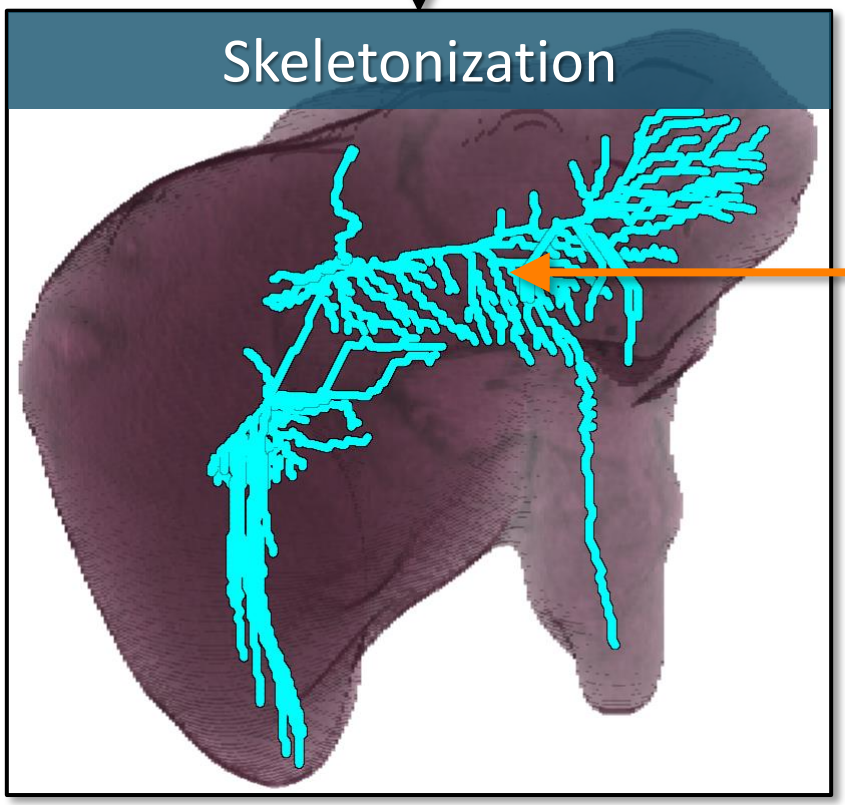
Correction Workflow



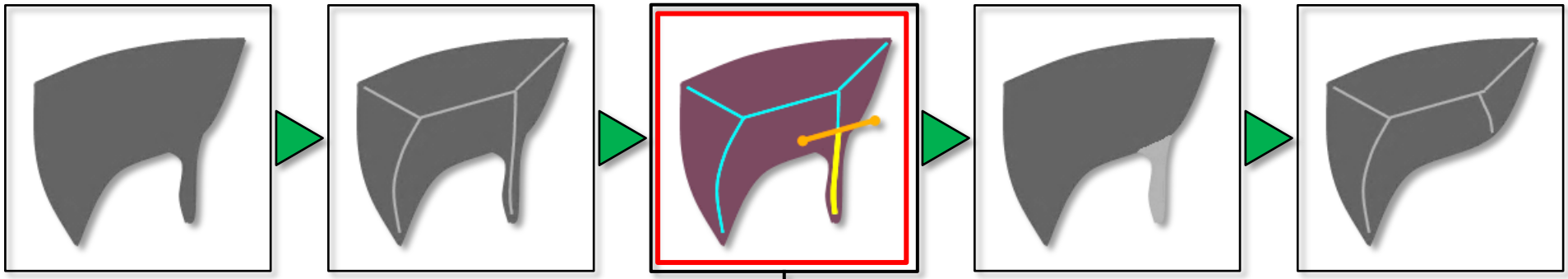


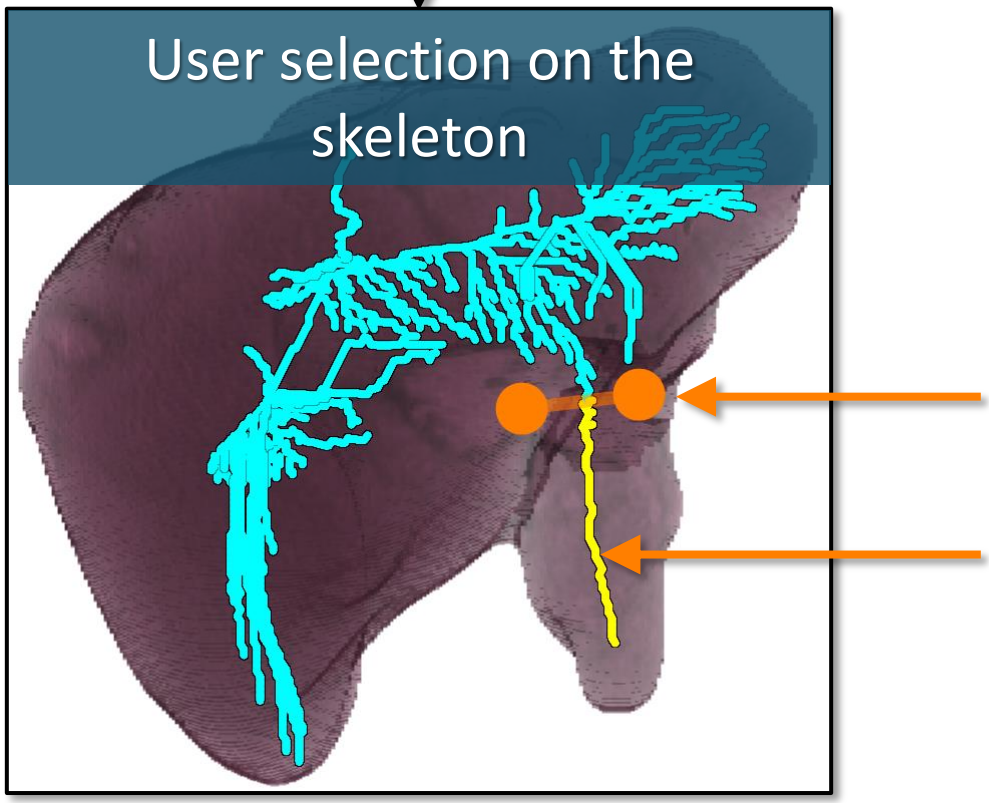
Correction Workflow



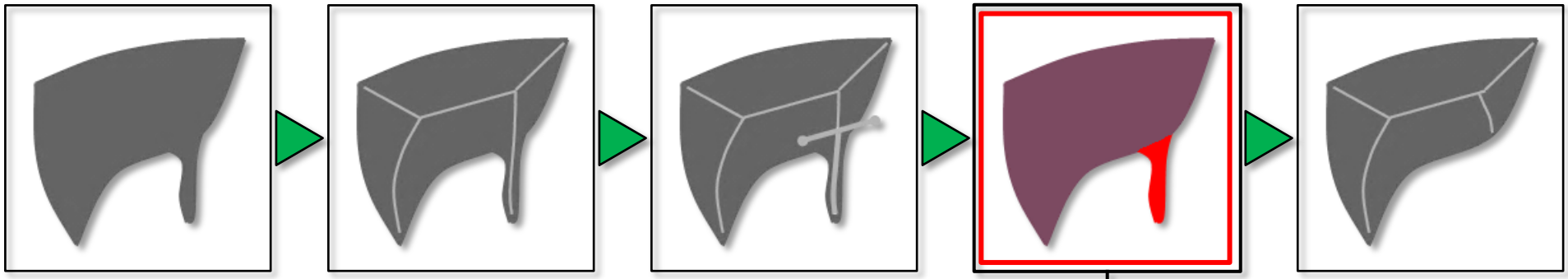


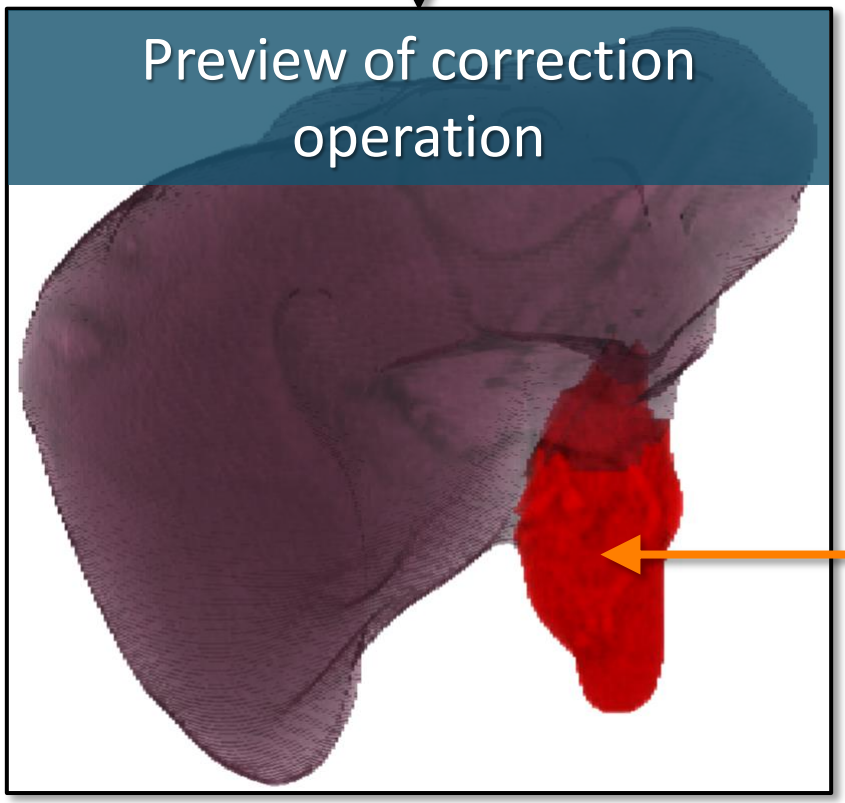
Correction Workflow





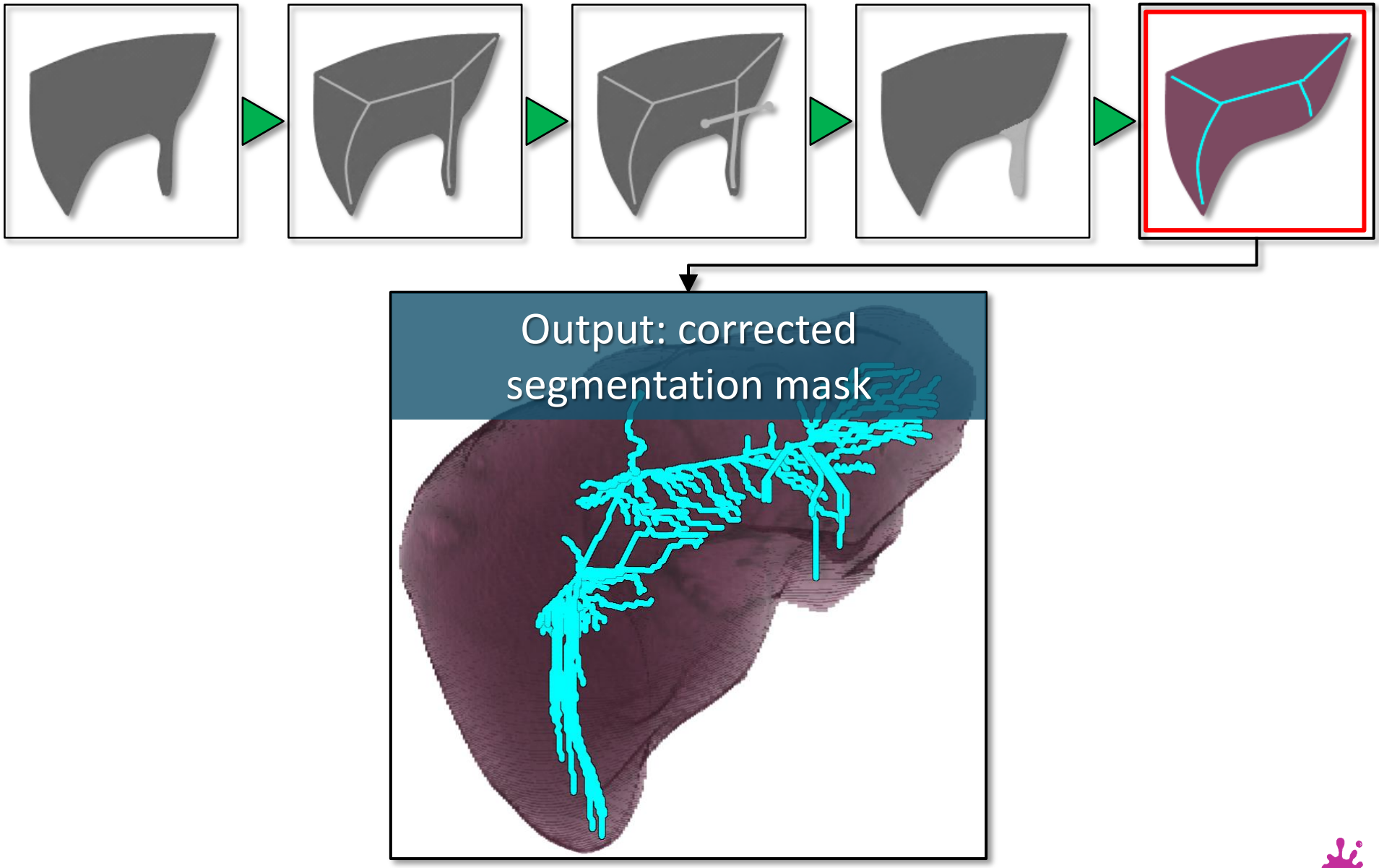
Correction Workflow



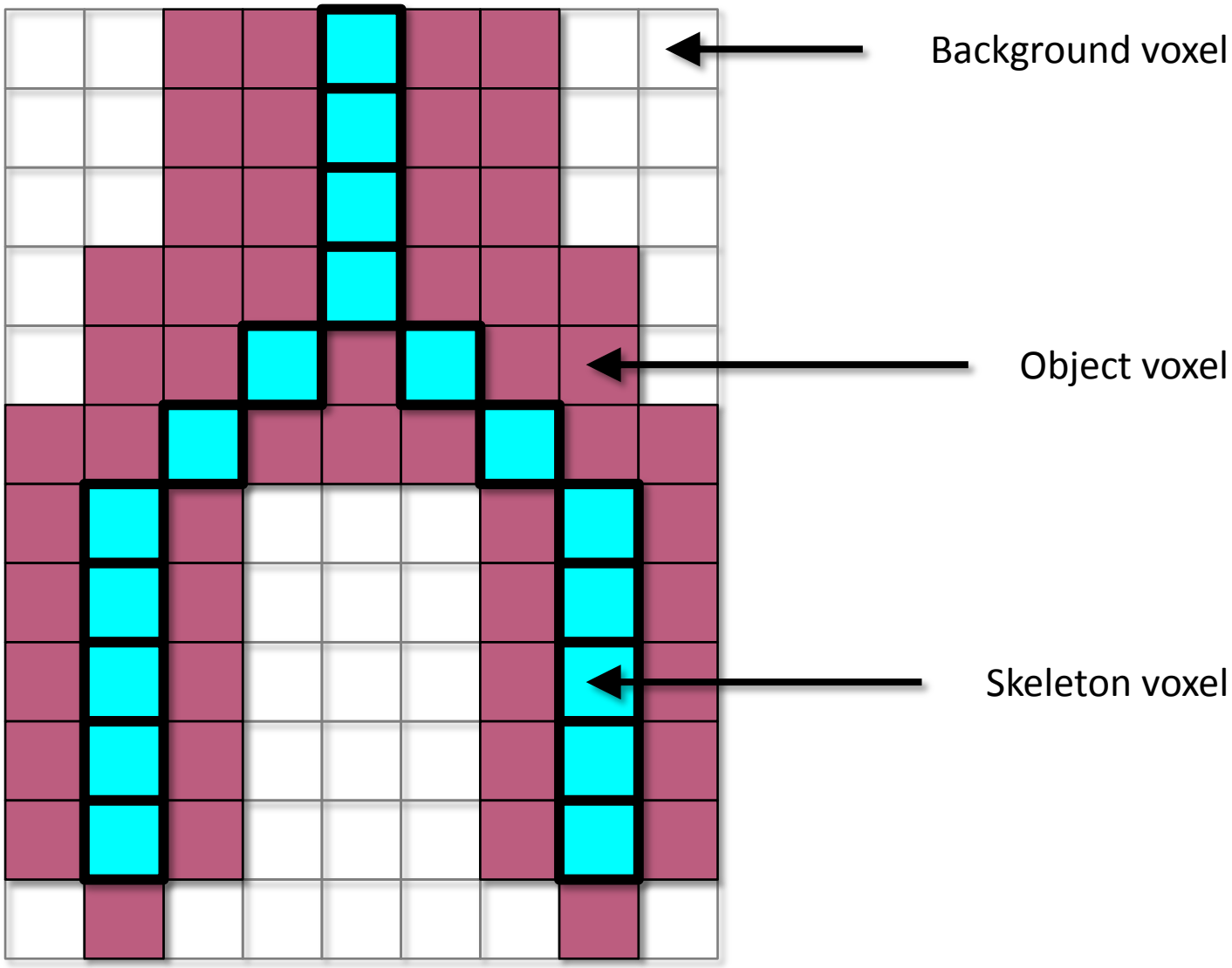


Selected part of the object

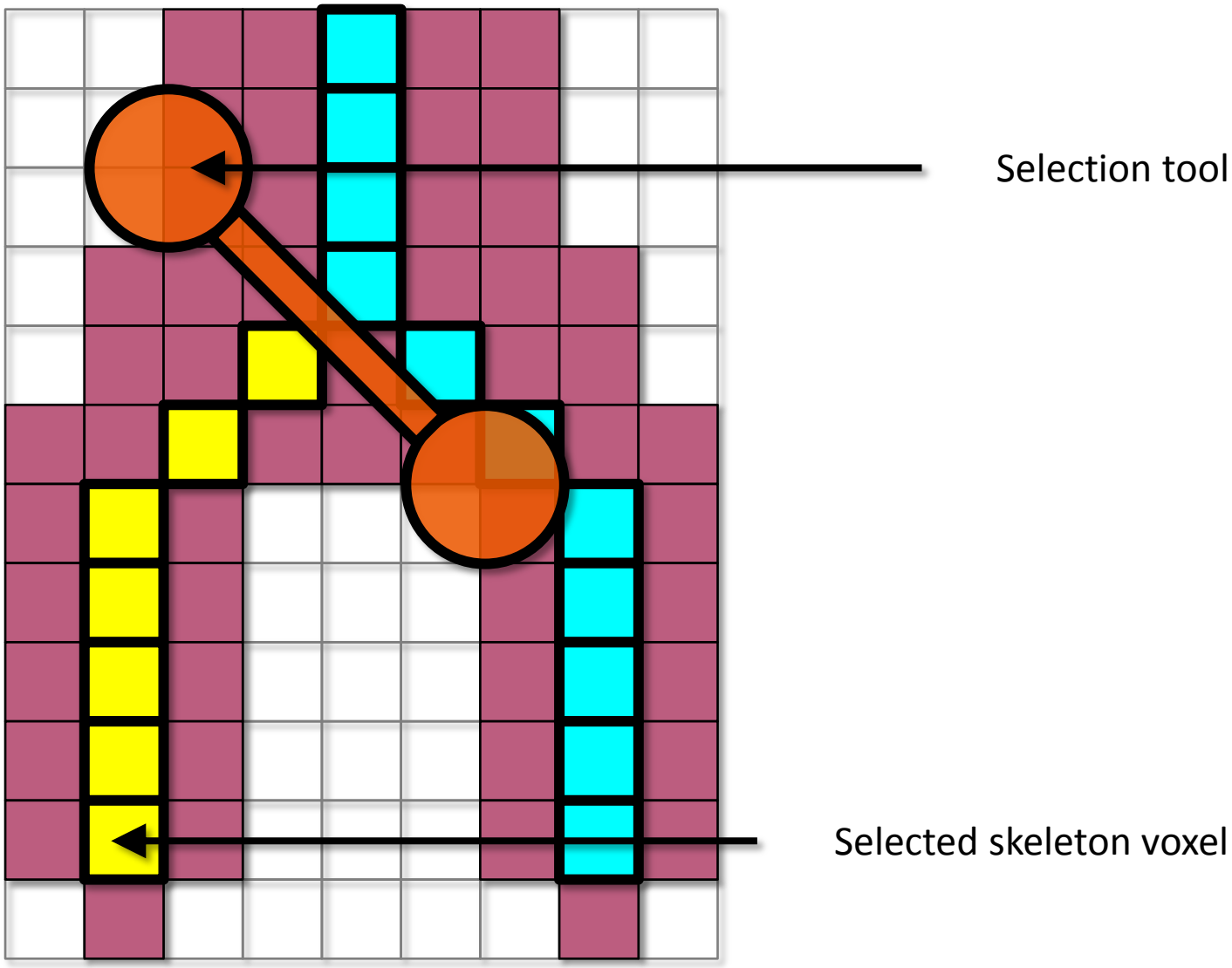
Correction Workflow



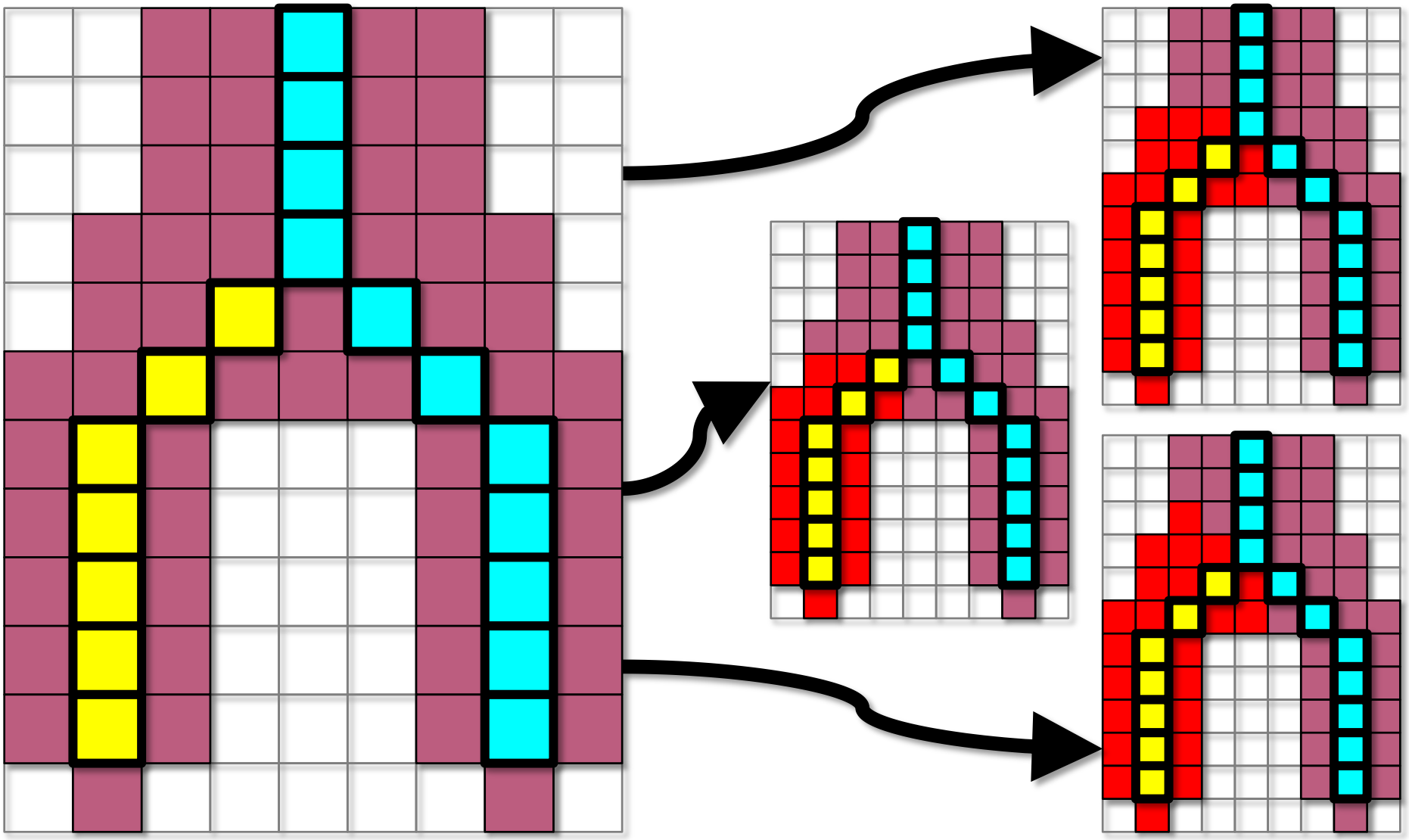
From Skeleton to Object Voxels



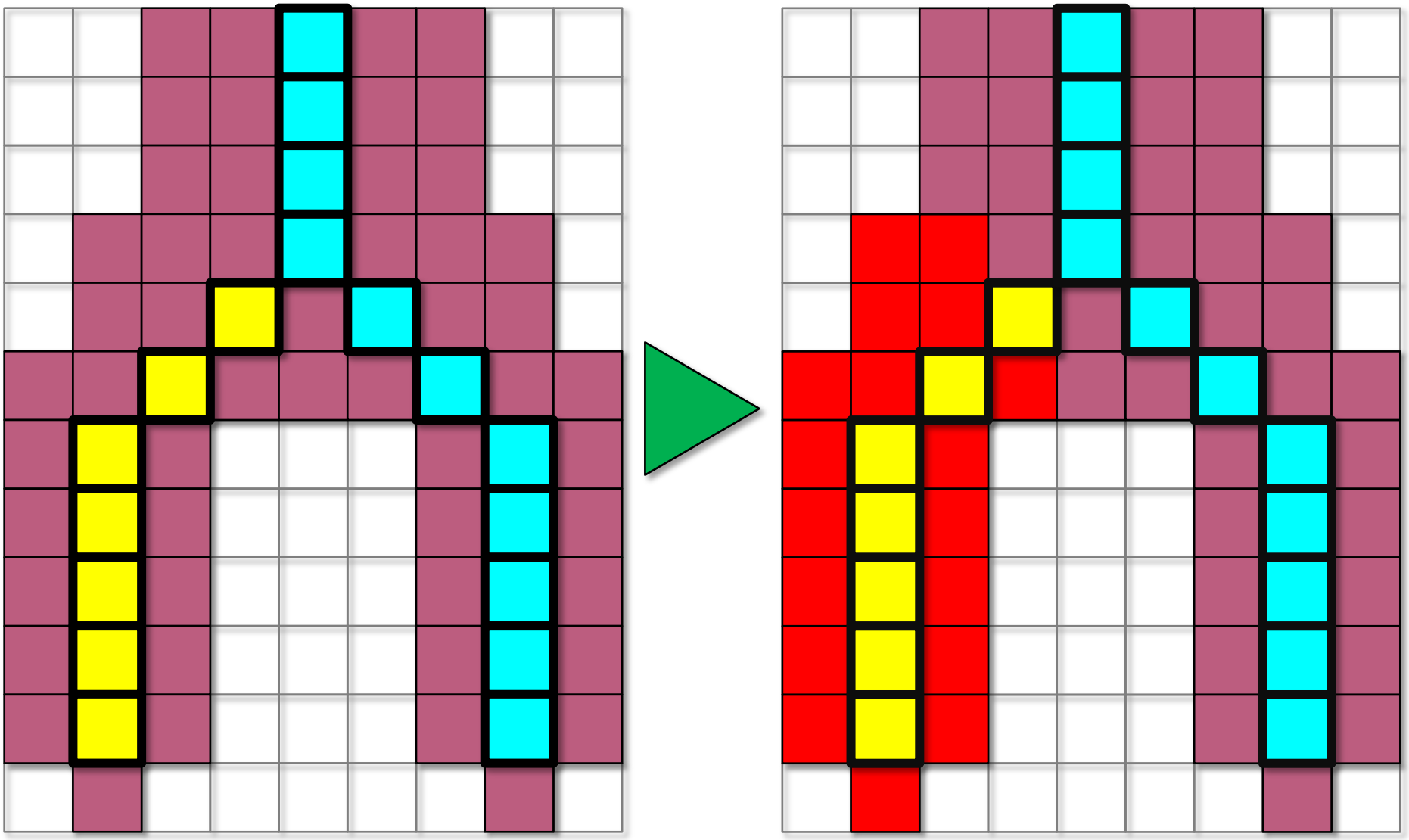
From Skeleton to Object Voxels



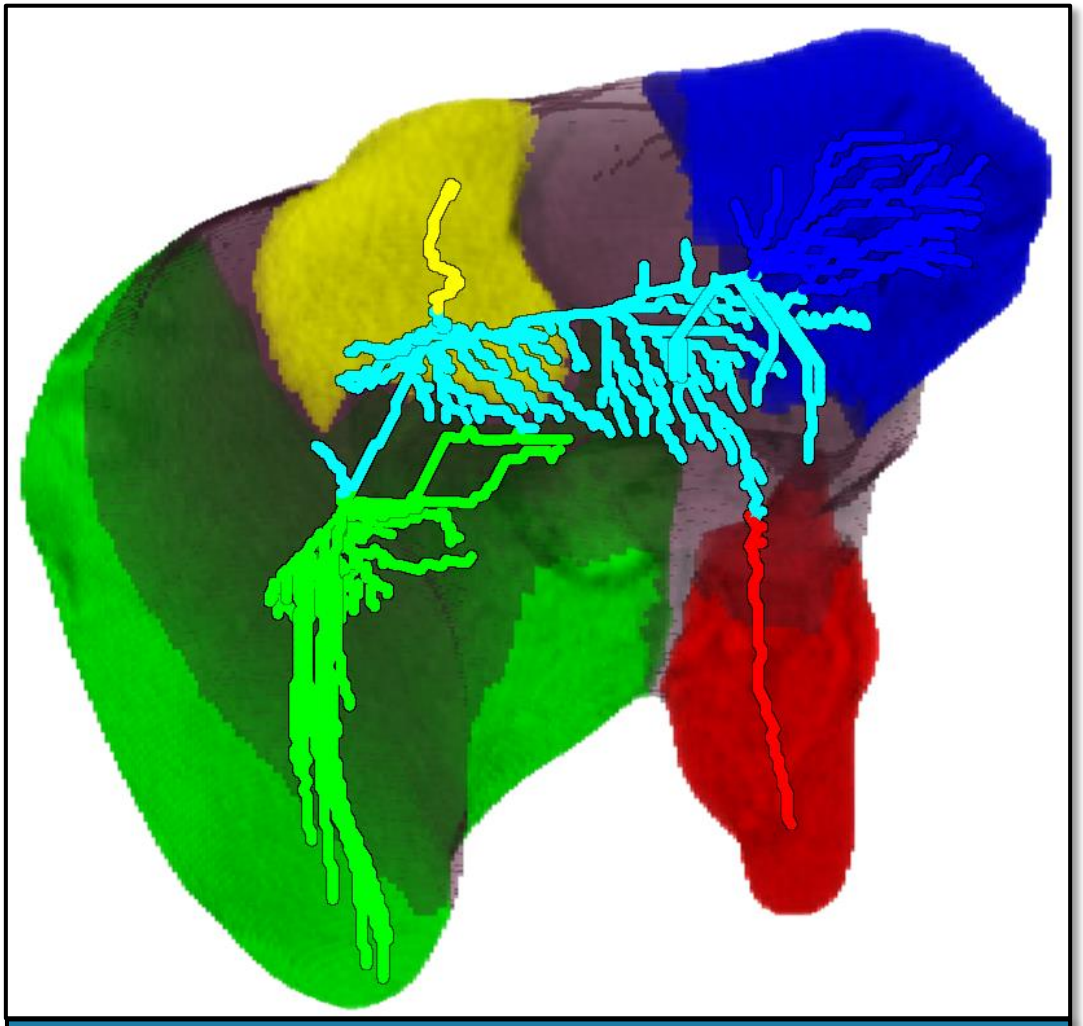
From Skeleton to Object Voxels



From Skeleton to Object Voxels



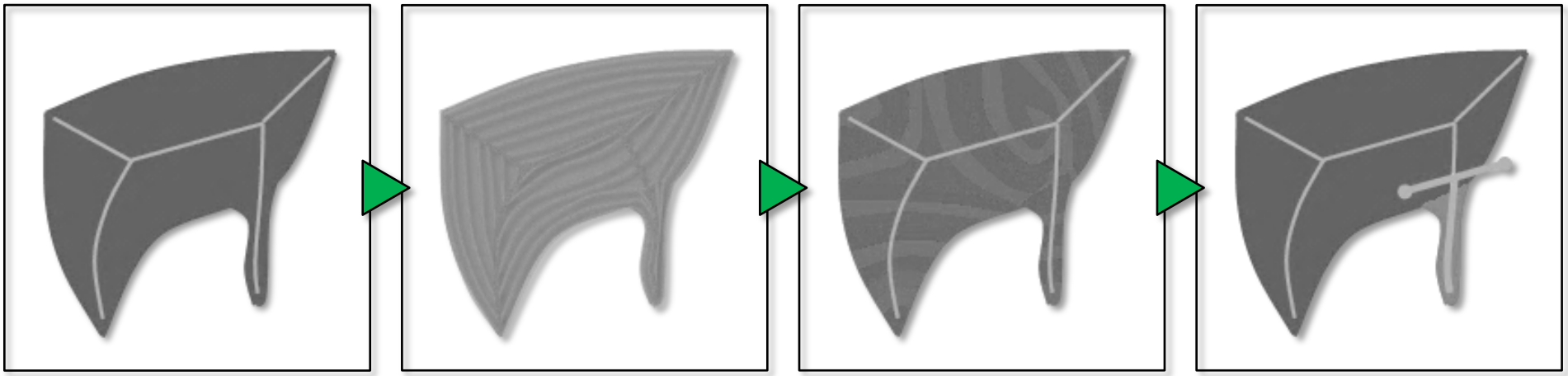
From Skeleton to Object Voxels



Parts of the object, corresponding to parts of the skeleton

Pipeline

Skeletonization → Skeleton Distance Field → Influence Zones → Interaction + Correction



Pipeline

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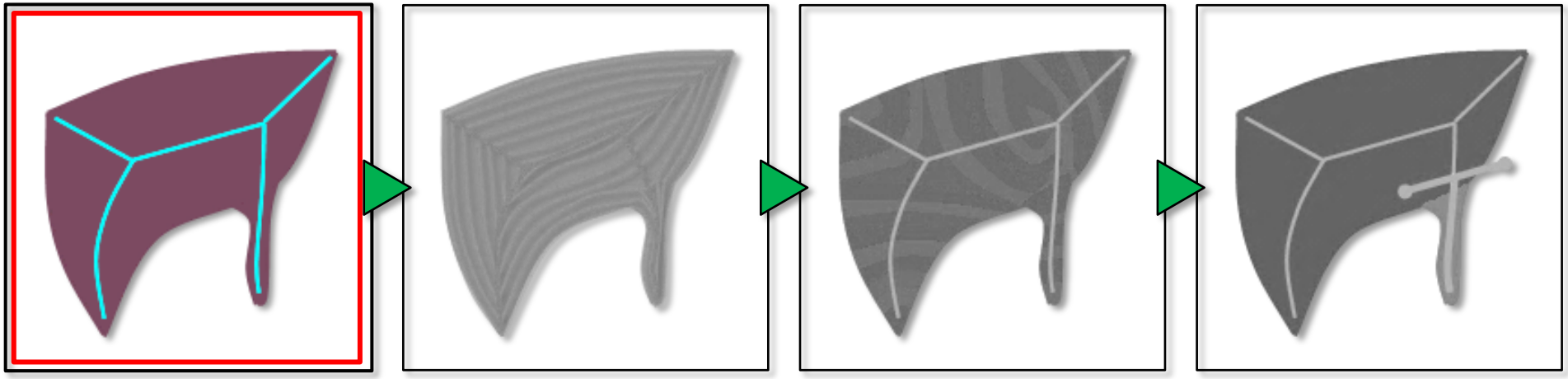
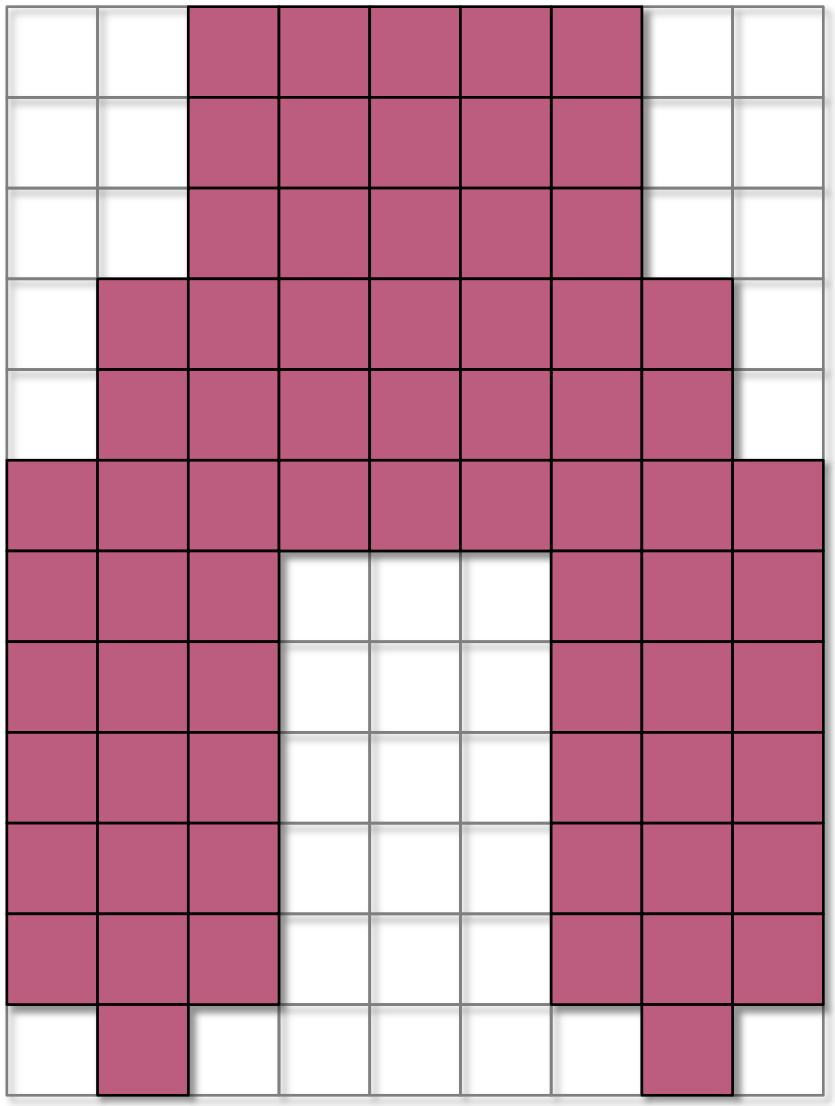


Thinning-based Skeletonization

- Iteration-based
- Removes voxels on the boundary of the object



Thinning-based Skeletonization

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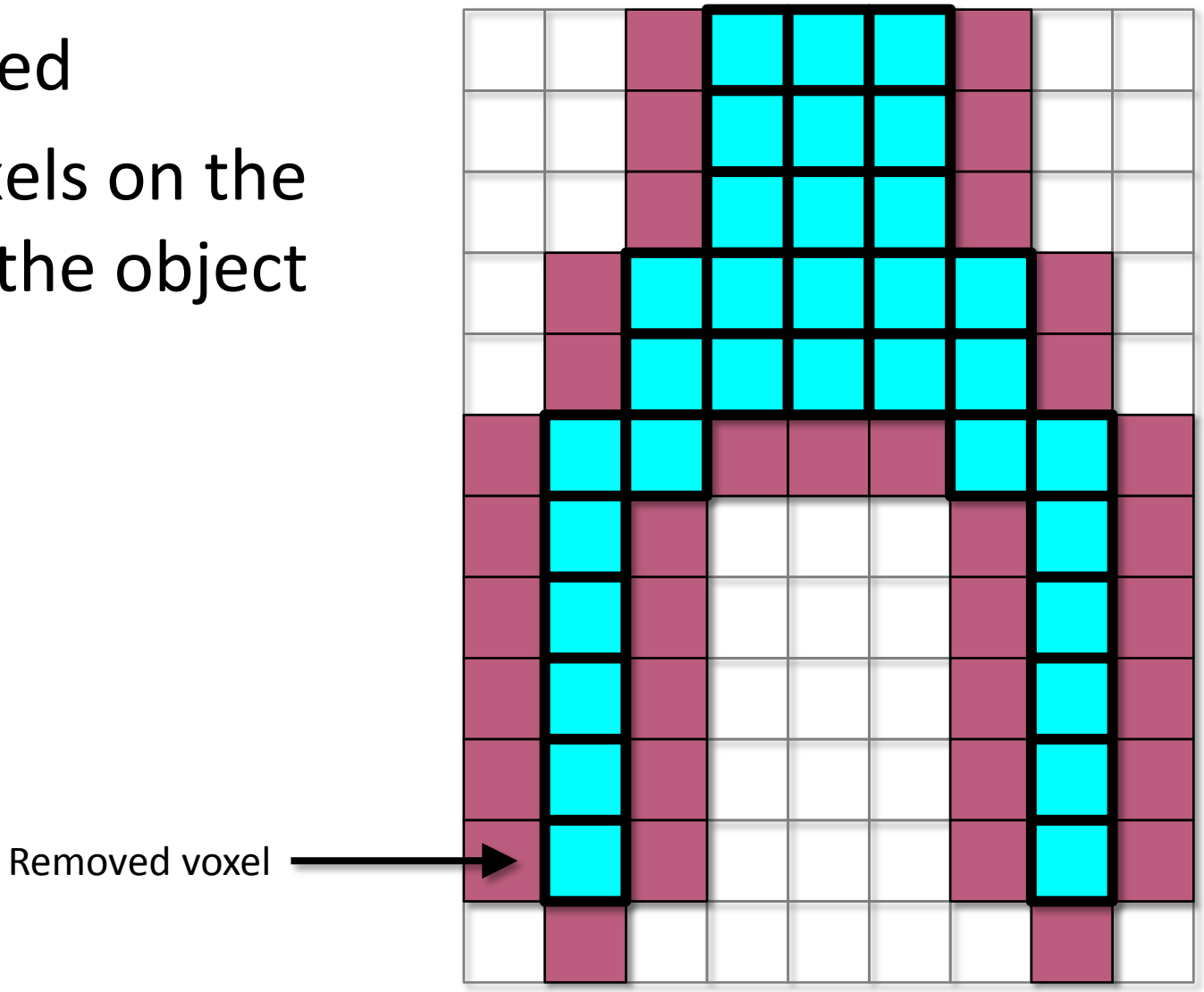
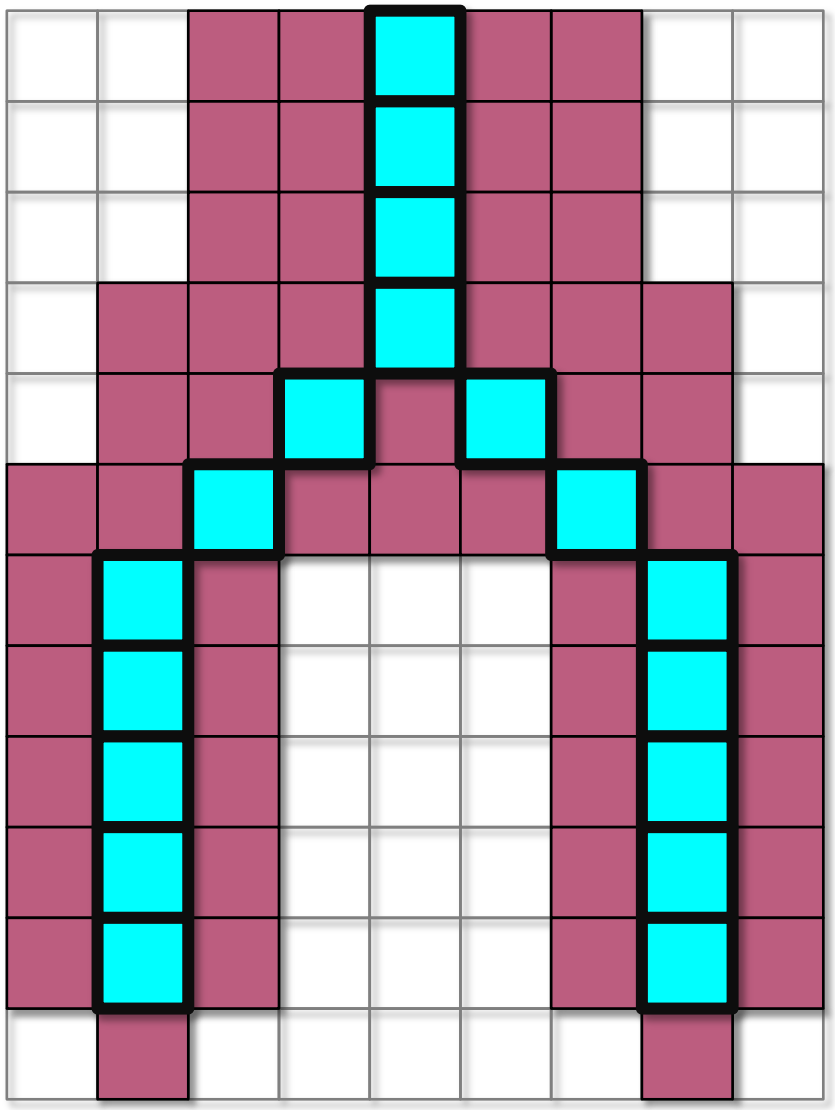
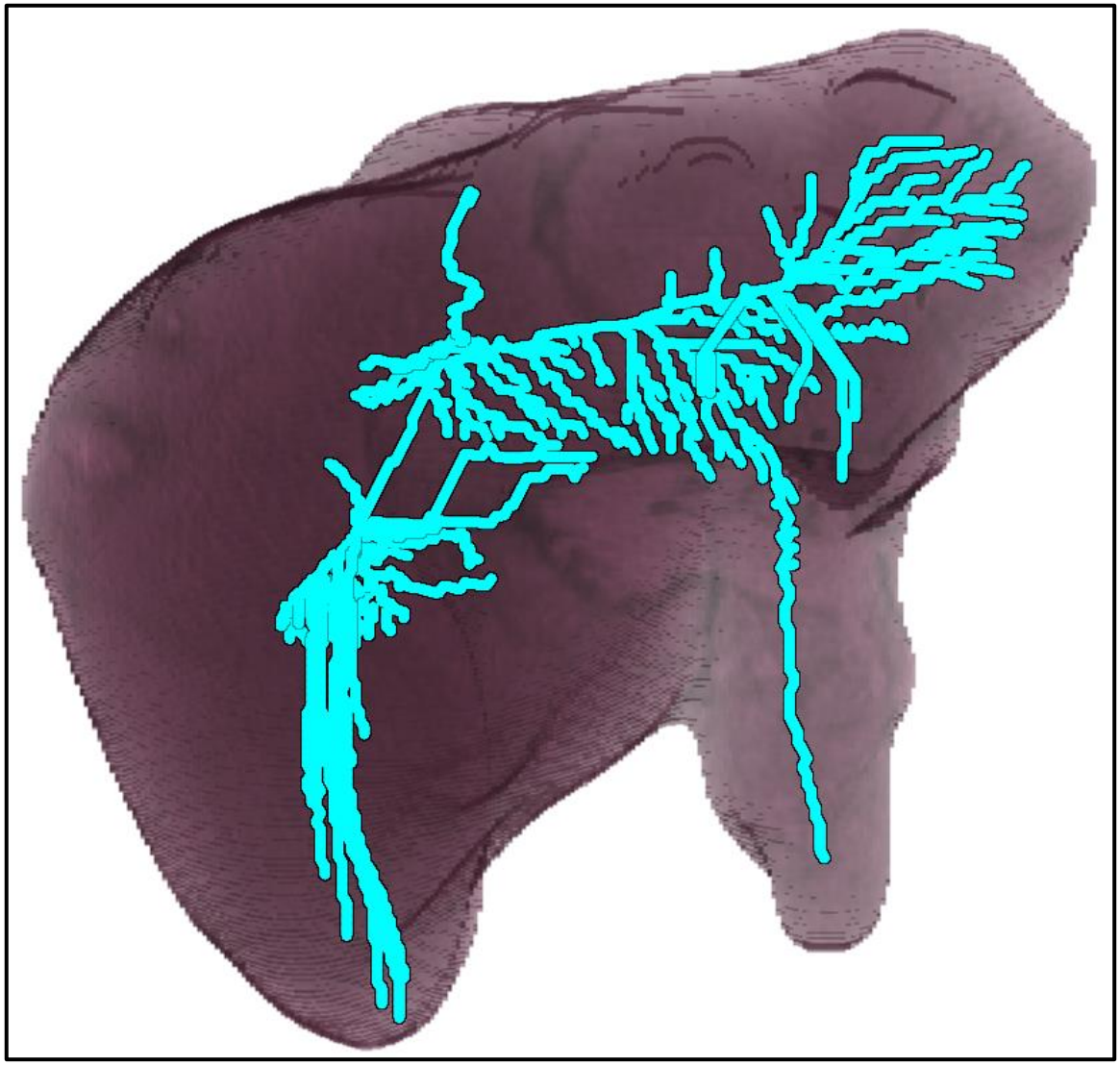


Thinning-based Skeletonization

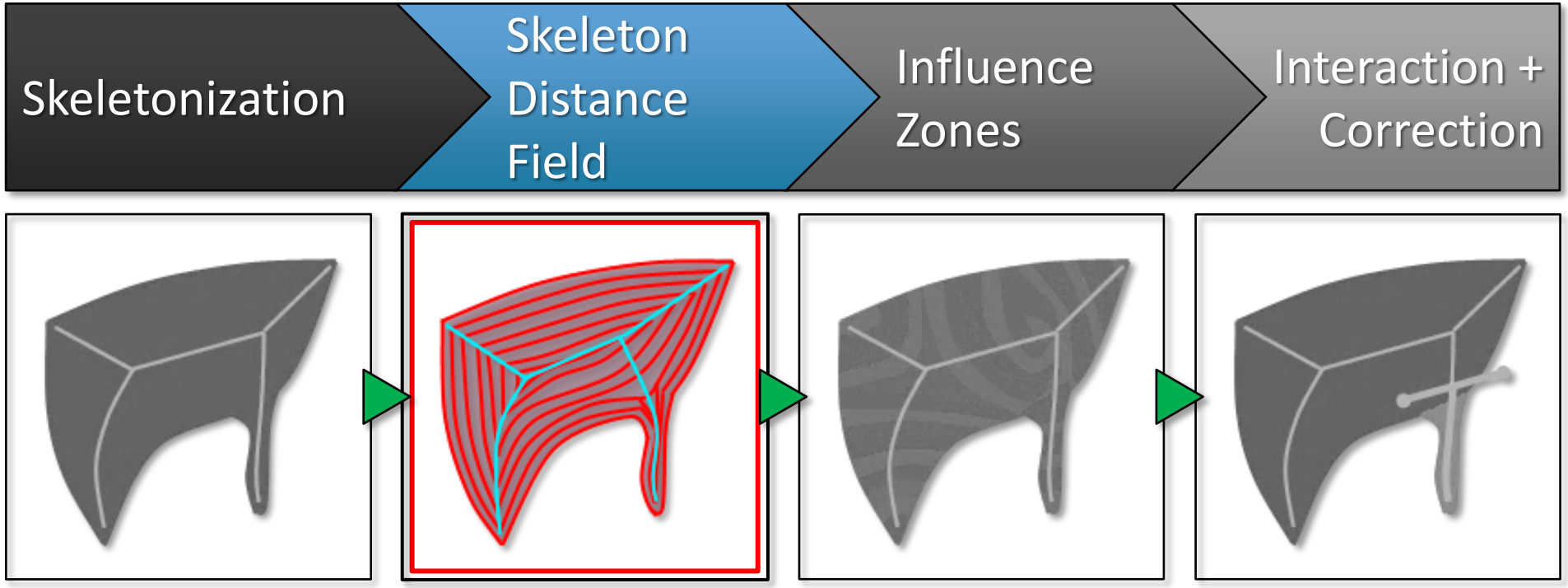
- Iteration-based
- Removes voxels on the boundary of the object
- Leaves only skeleton voxels



Thinning-based Skeletonization

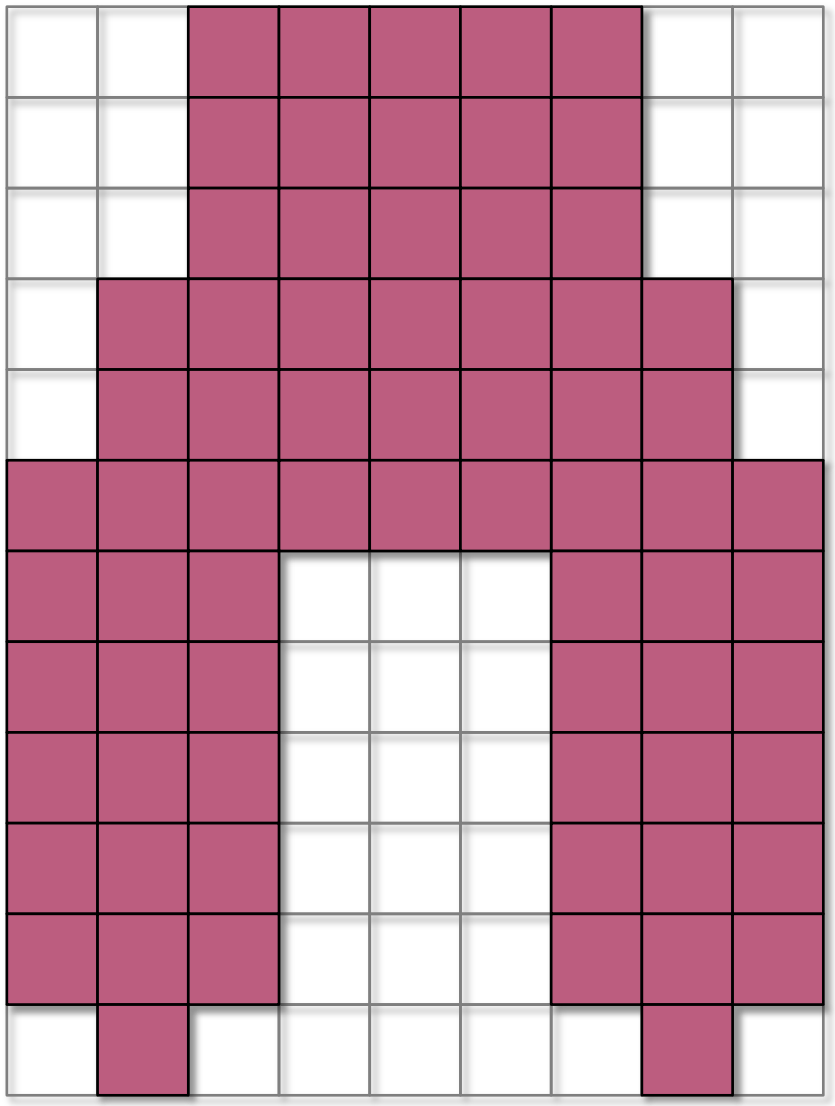


Pipeline


Skeletonization
Skeleton Distance Field
Influence Zones
Interaction + Correction

Skeleton Distance Field

- Constructed during the skeletonization
- Orders object voxels with respect to the skeleton



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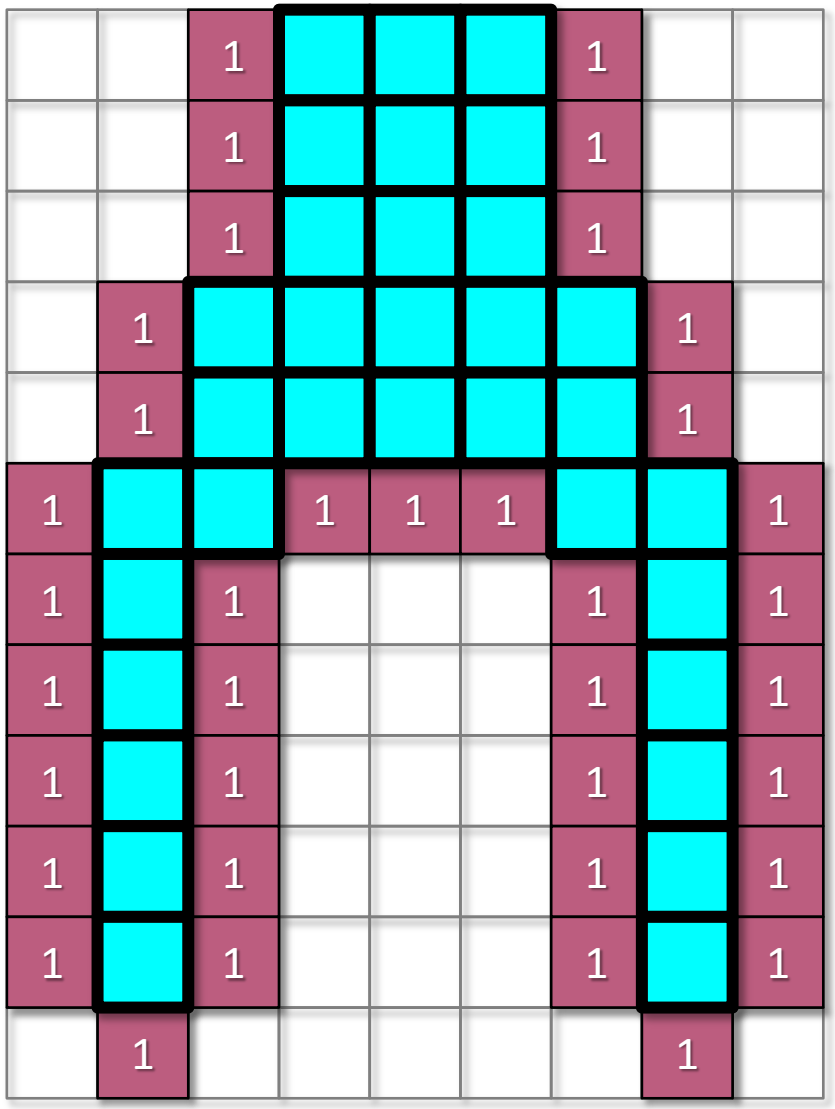
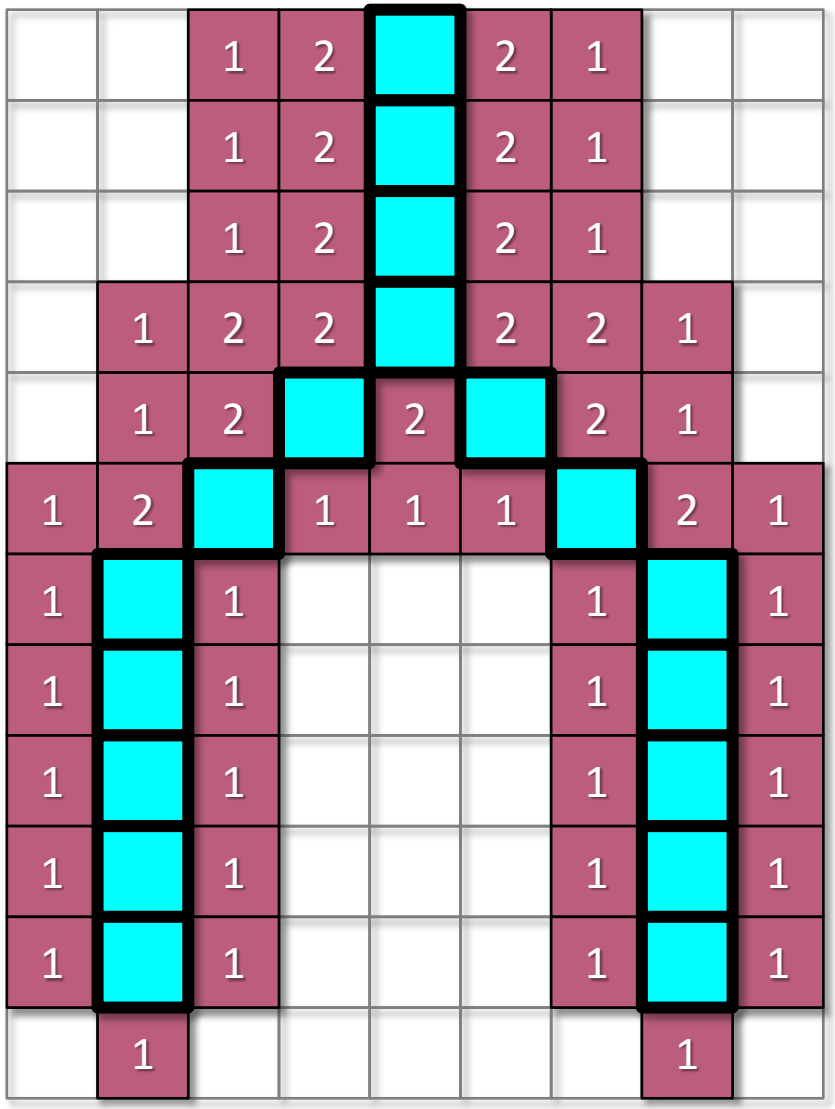


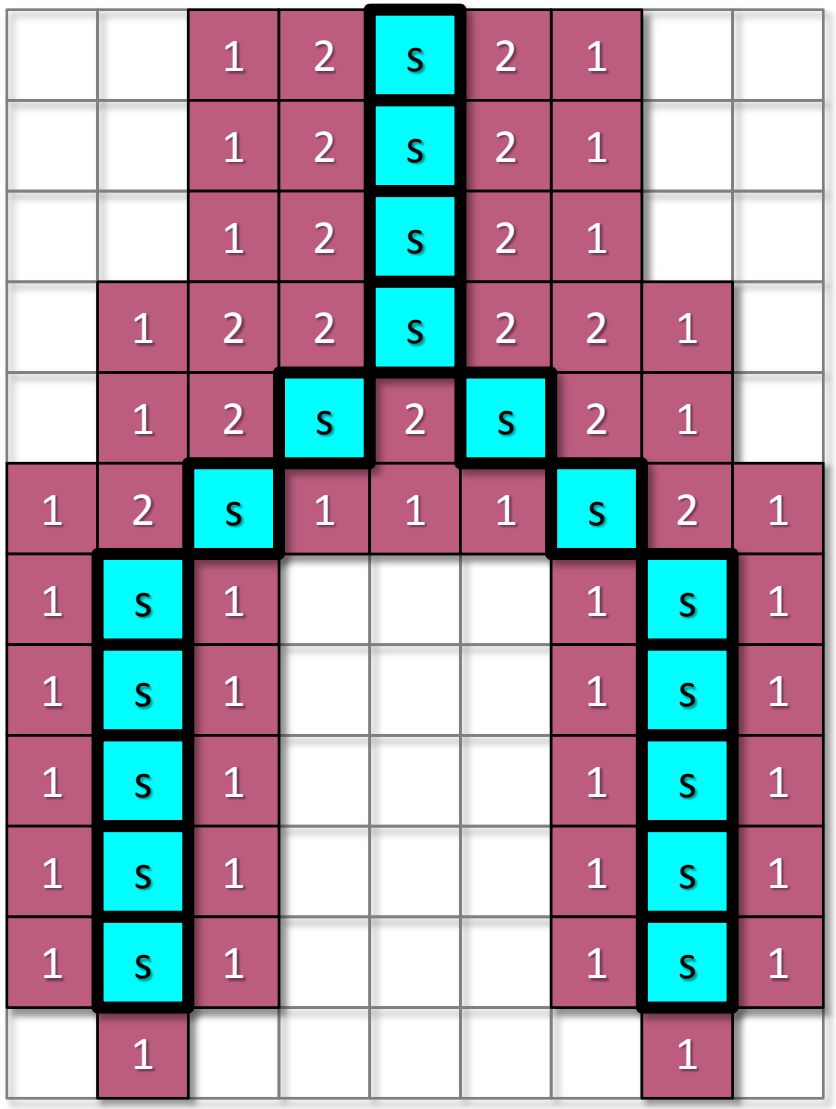
Skeleton Distance Field

- Constructed during the skeletonization
- Orders object voxels with respect to the skeleton

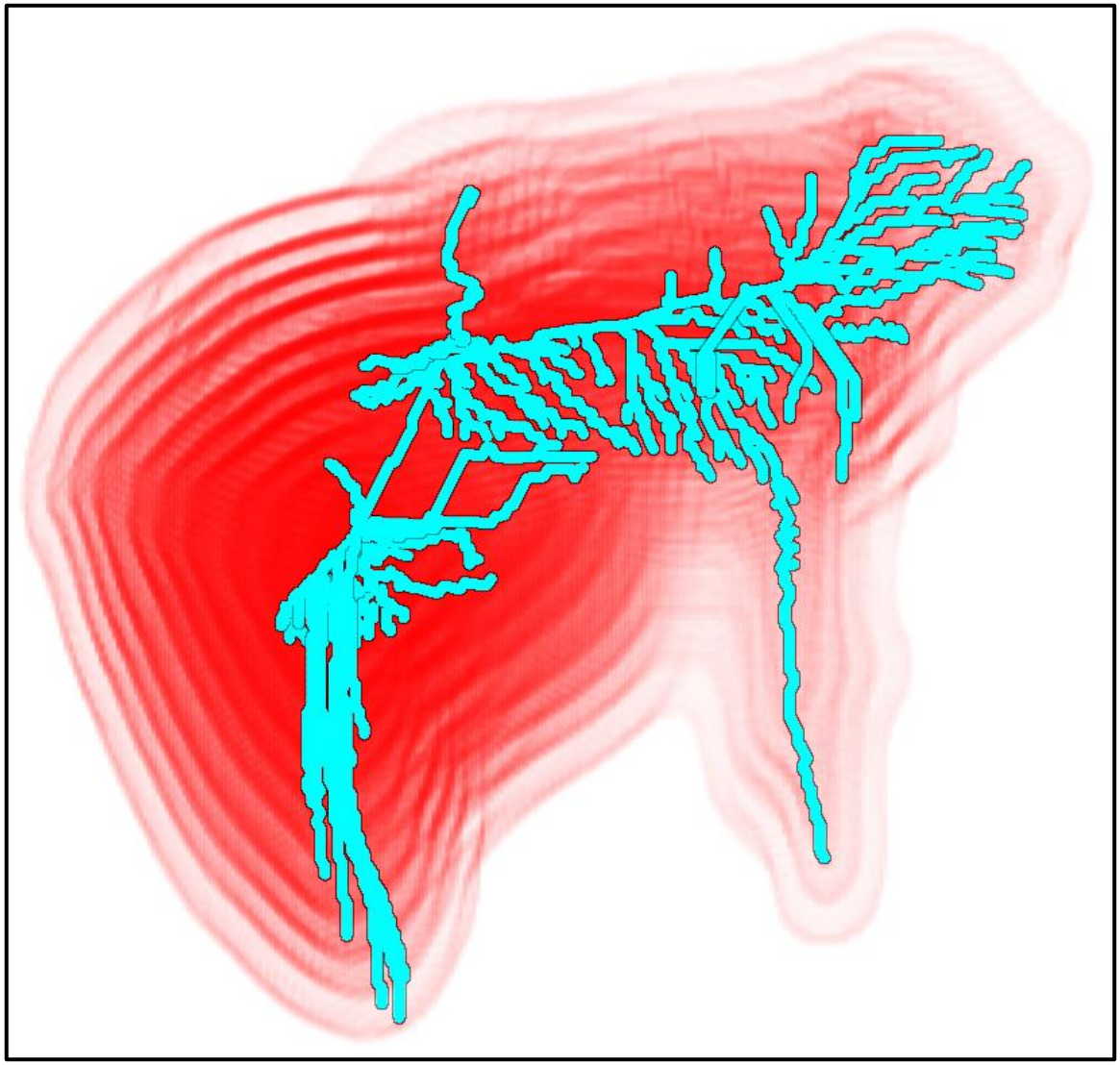


Skeleton Distance Field

- Constructed during the skeletonization
- Orders object voxels with respect to the skeleton
- $s = \#Iterations + 1$

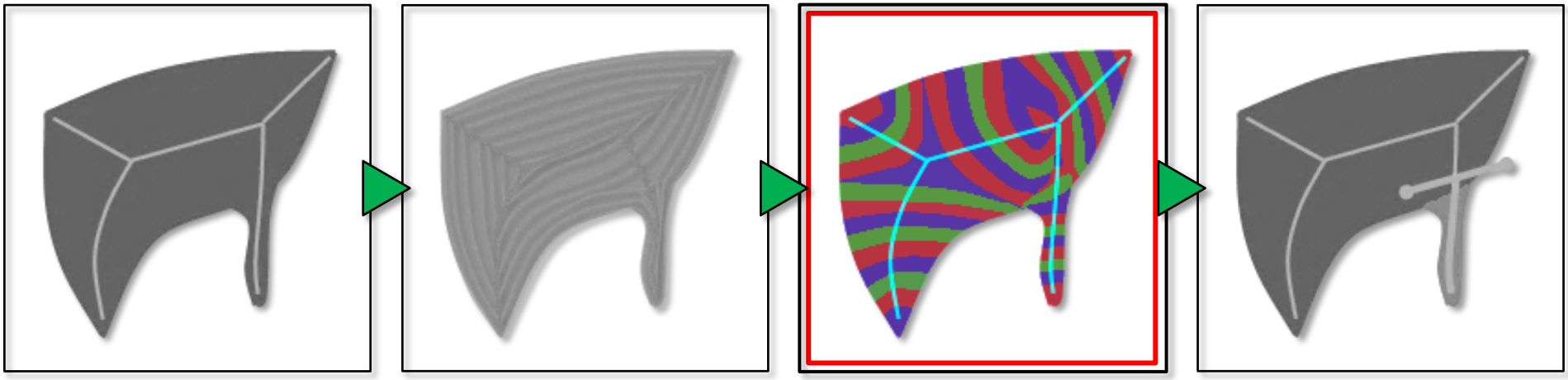


Iso-Surfaces of Skeleton Distance Field



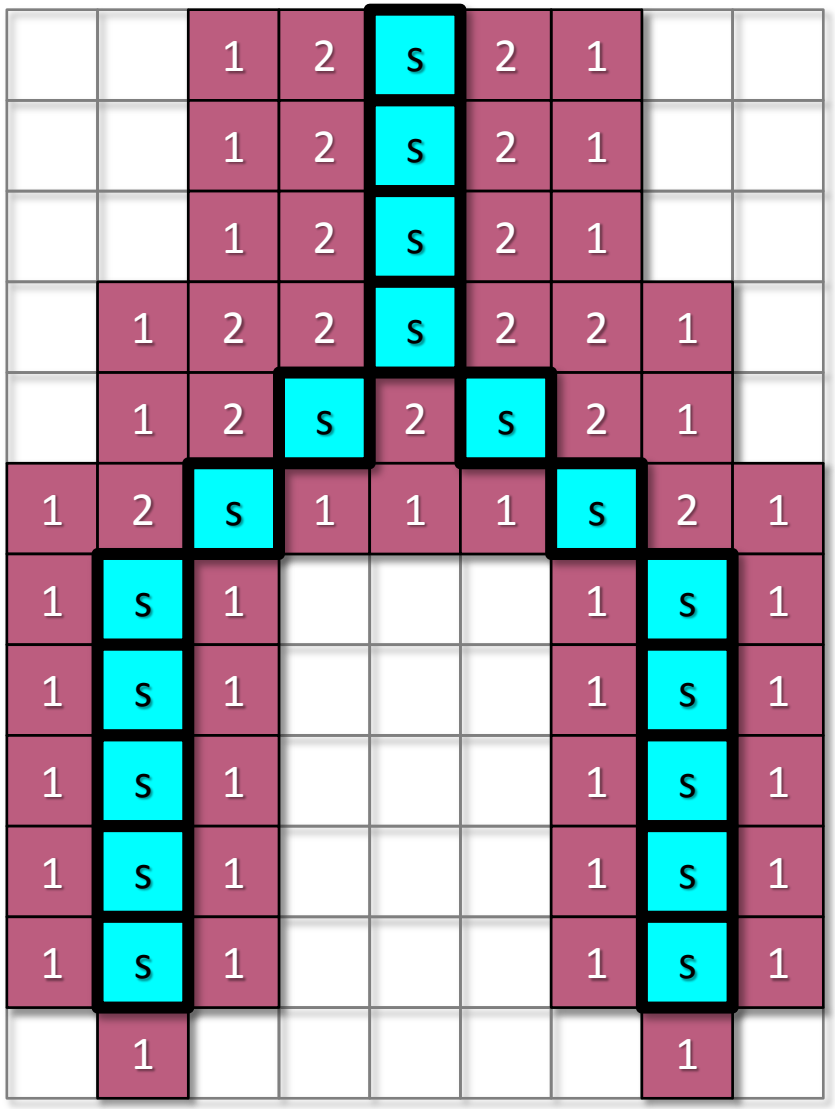
Pipeline

Skeletonization → Skeleton Distance Field → Influence Zones → Interaction + Correction



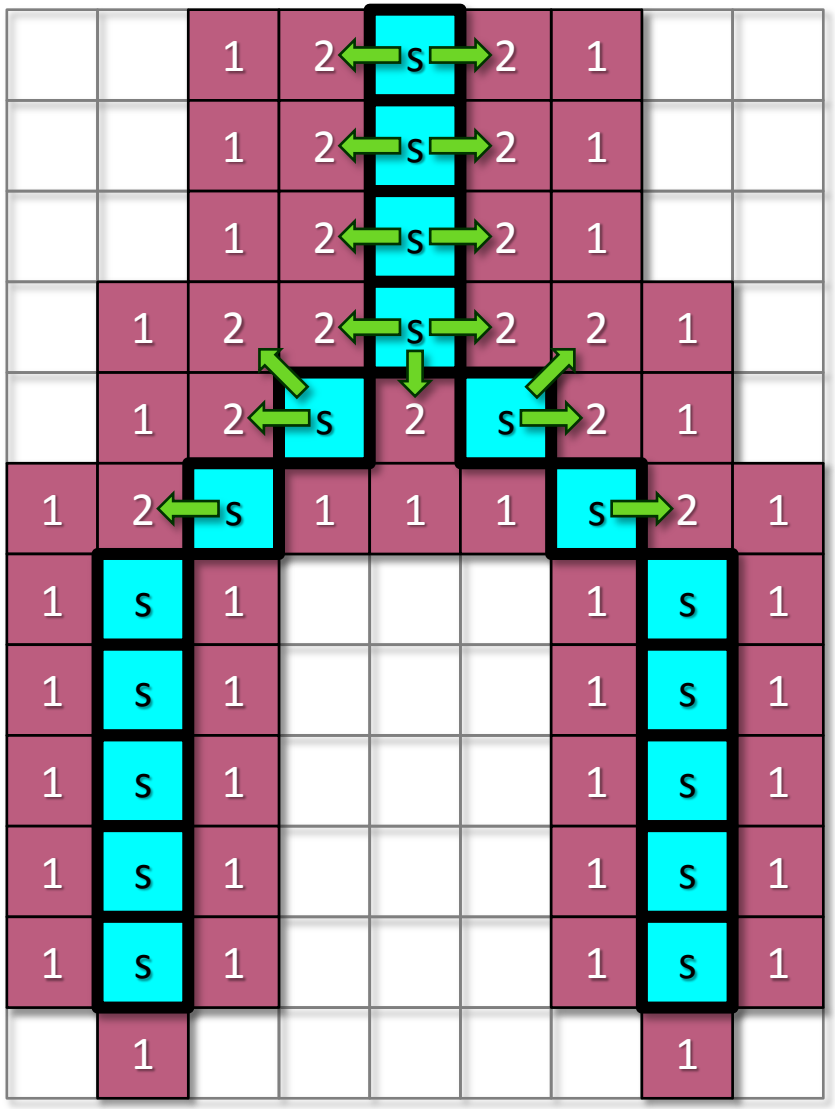
Influence Zones

- Local parts of the object, connected to skeleton voxels
- Based on the skeleton distance field



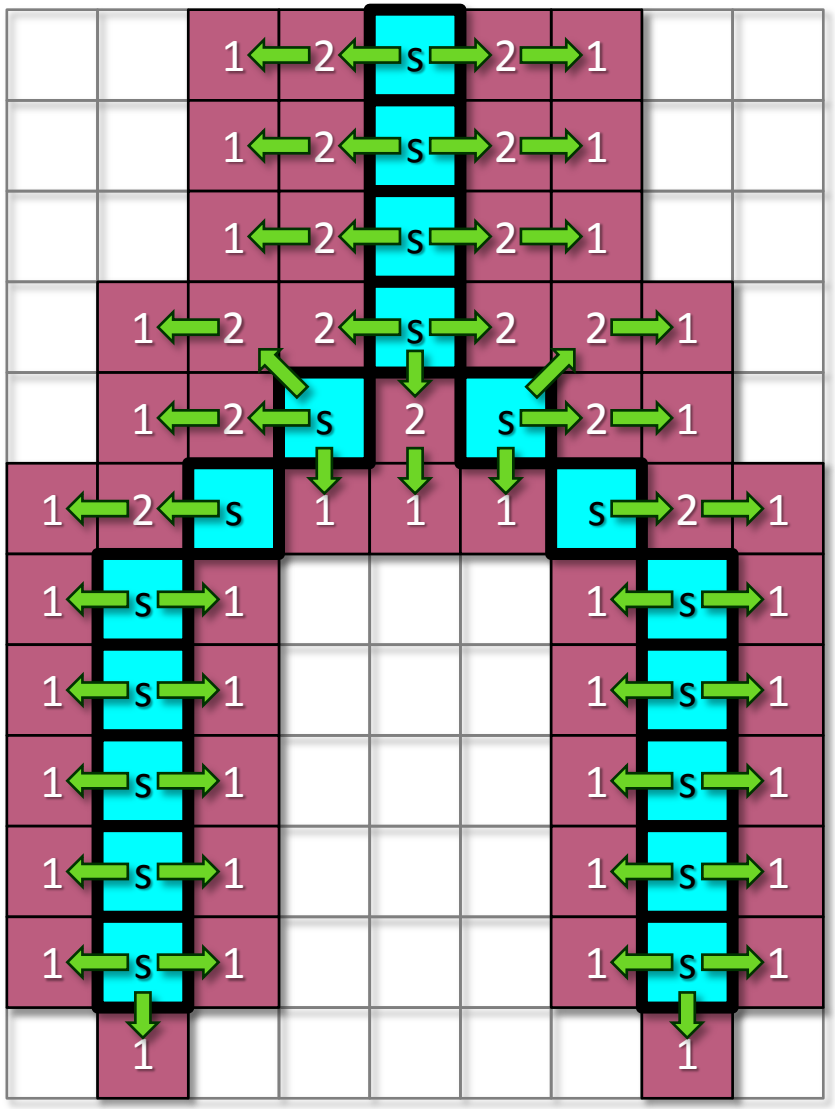
Influence Zones

- Local parts of the object, connected to skeleton voxels
- Based on the skeleton distance field

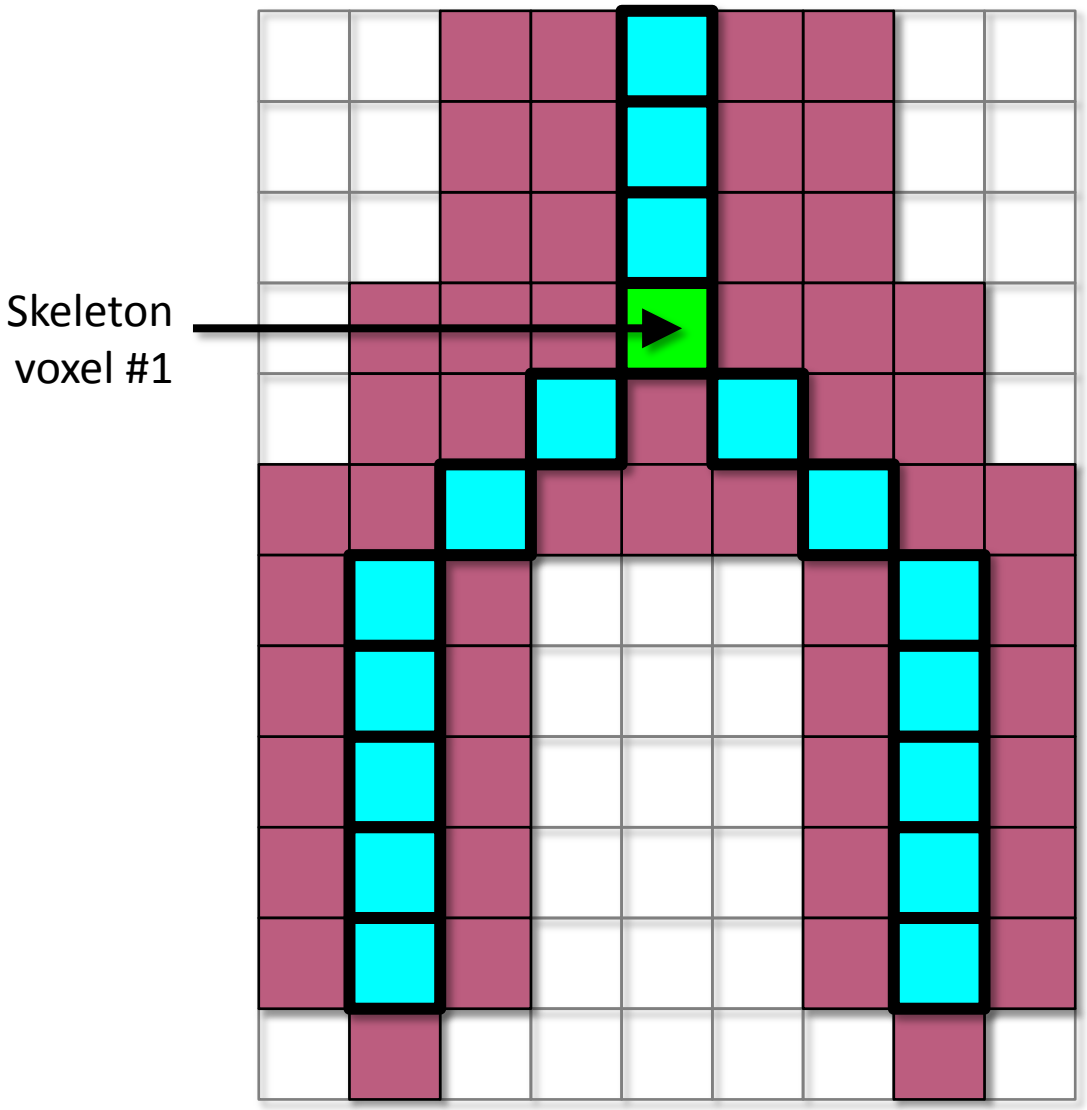


Influence Zones

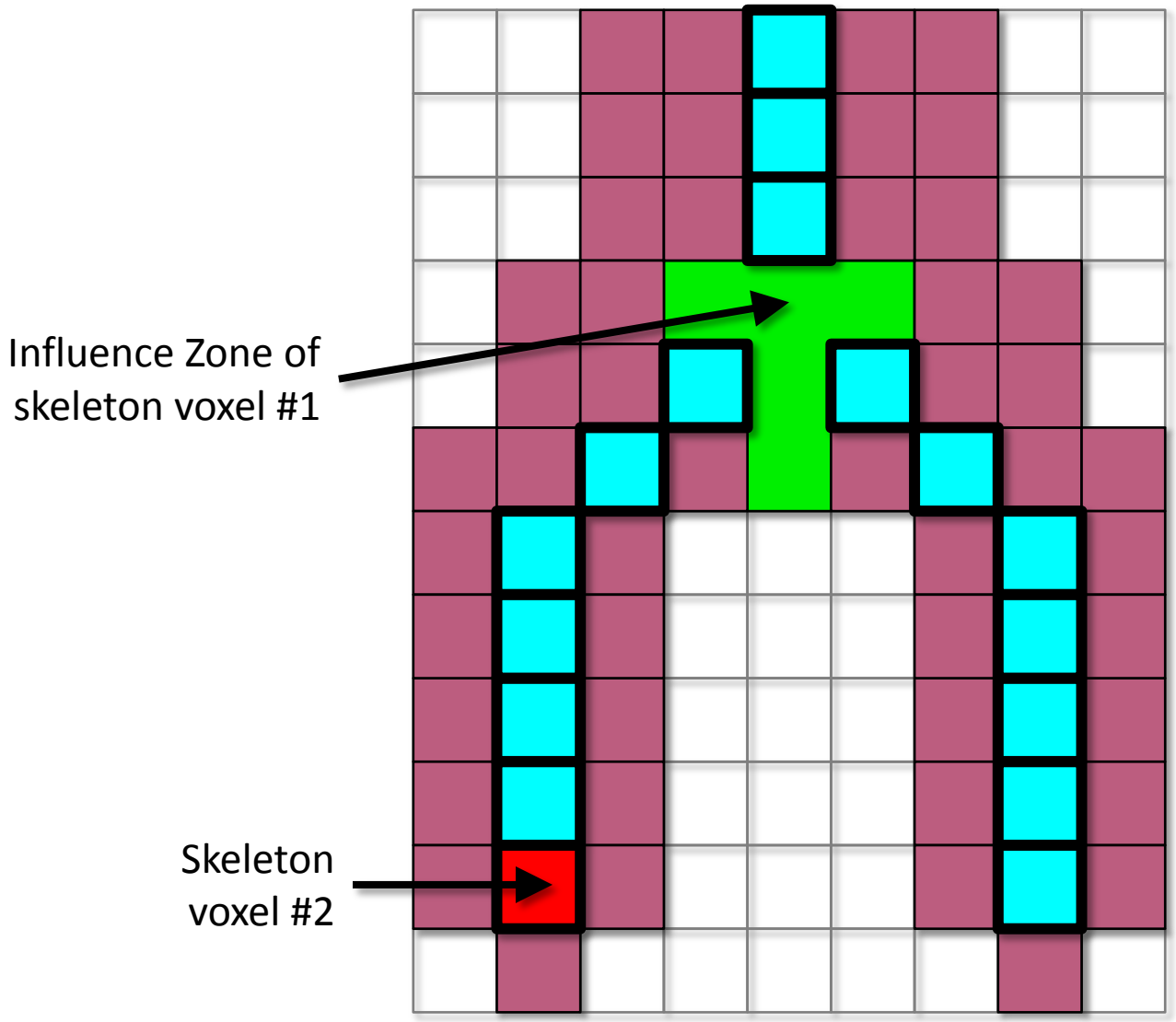
- Local parts of the object, connected to skeleton voxels
- Based on the skeleton distance field



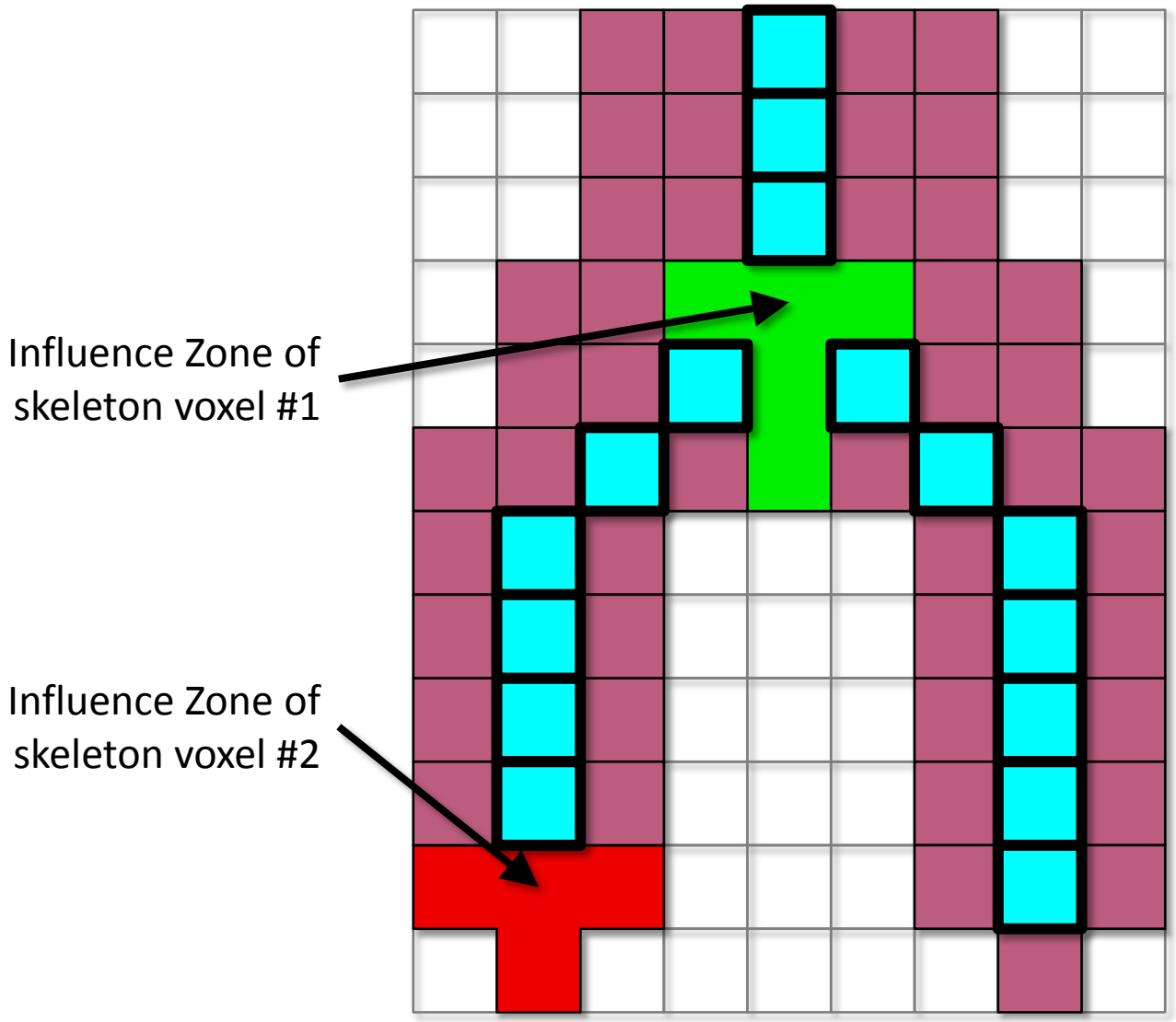
Influence Zones (as Color Bands)



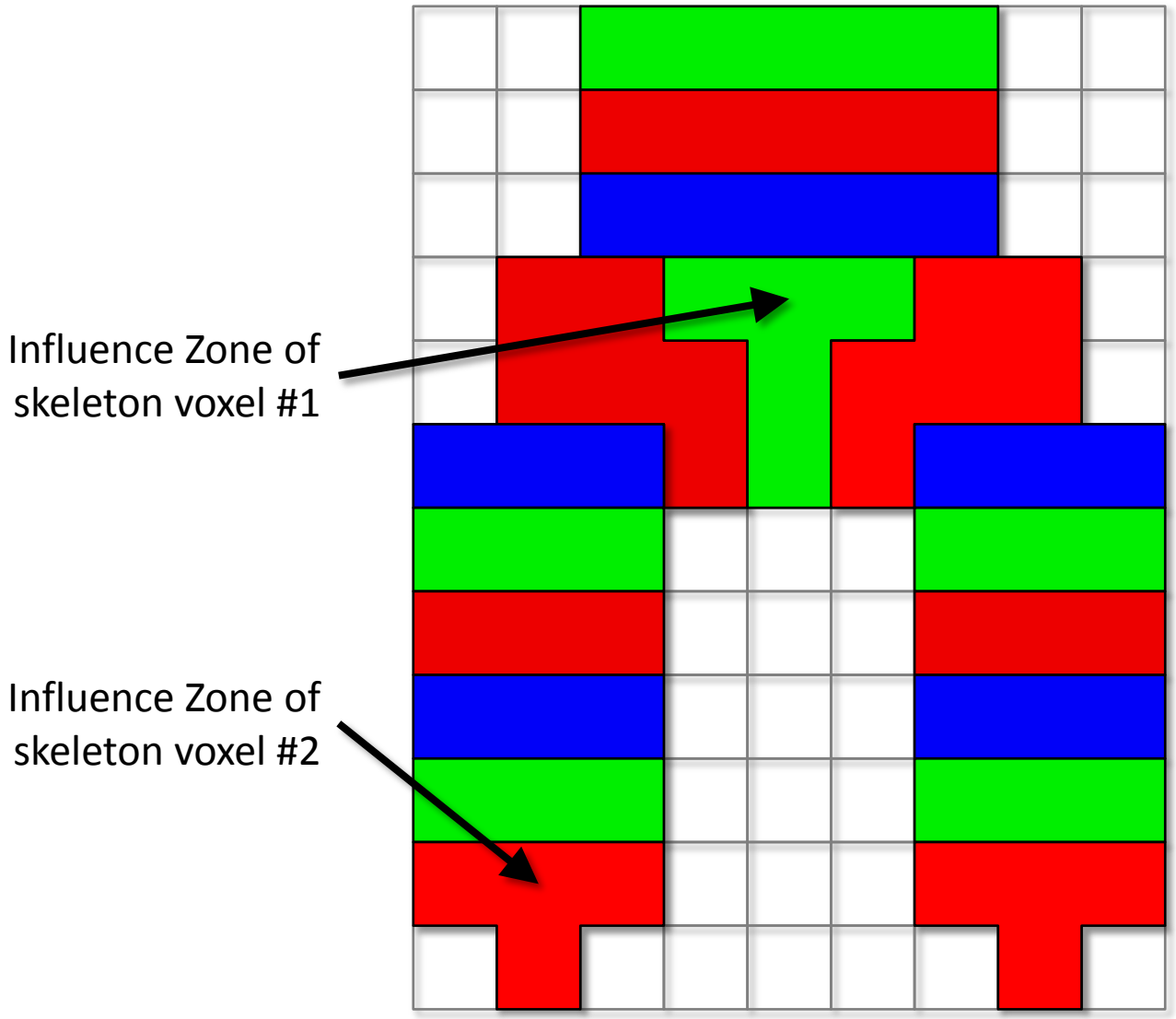
Influence Zones (as Color Bands)



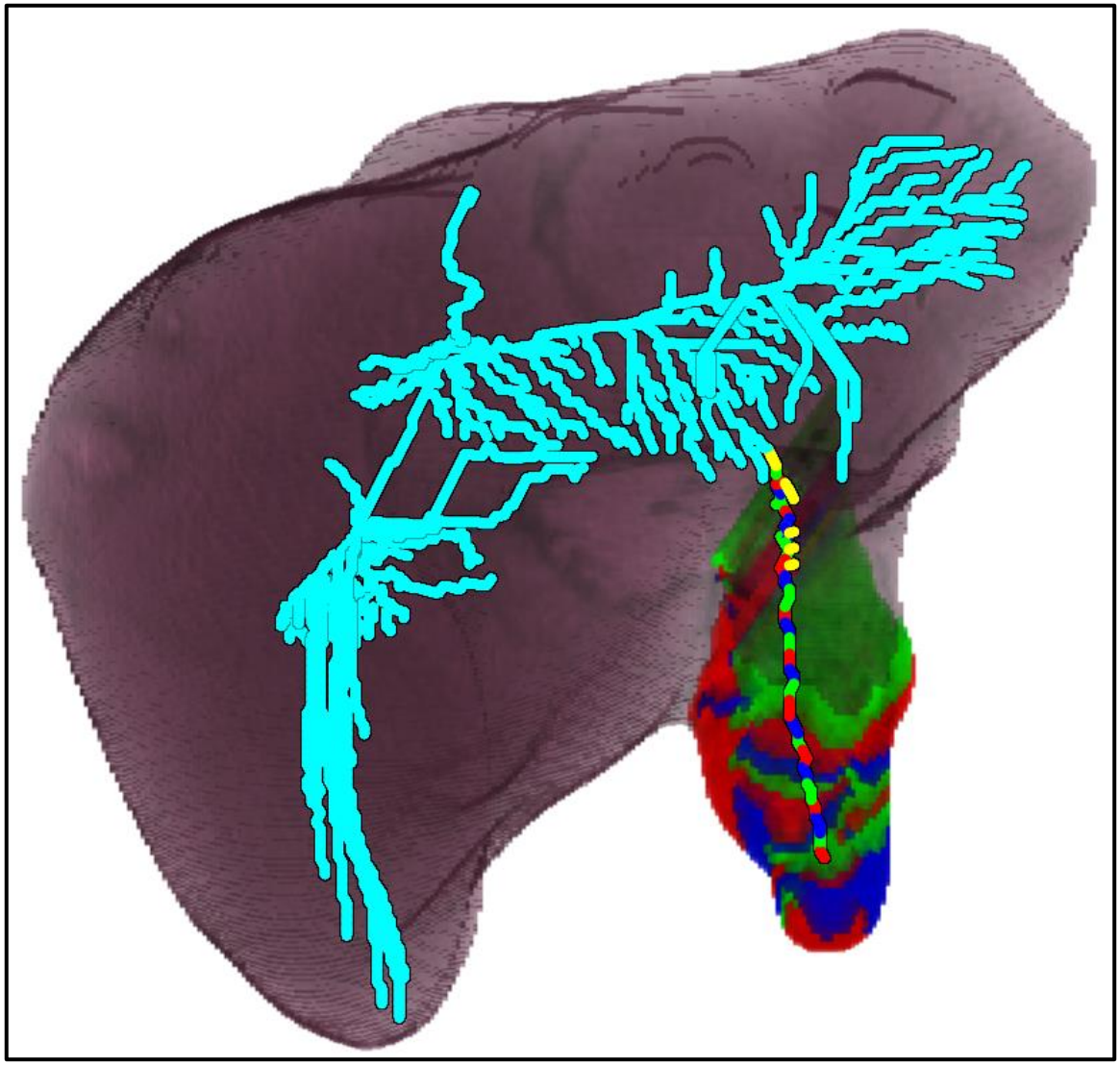
Influence Zones (as Color Bands)



Influence Zones (as Color Bands)

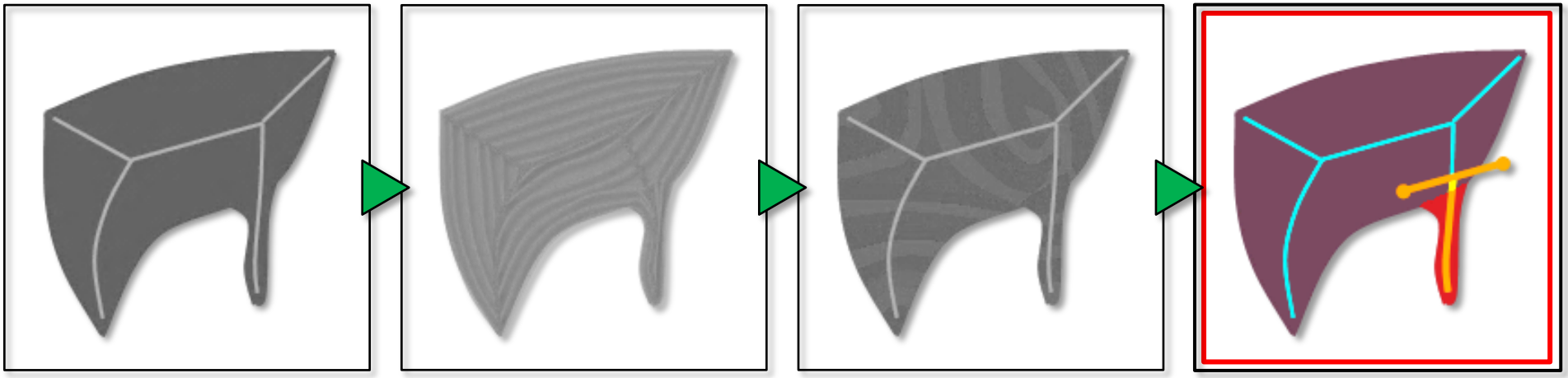


Influence Zones (as Color Bands)

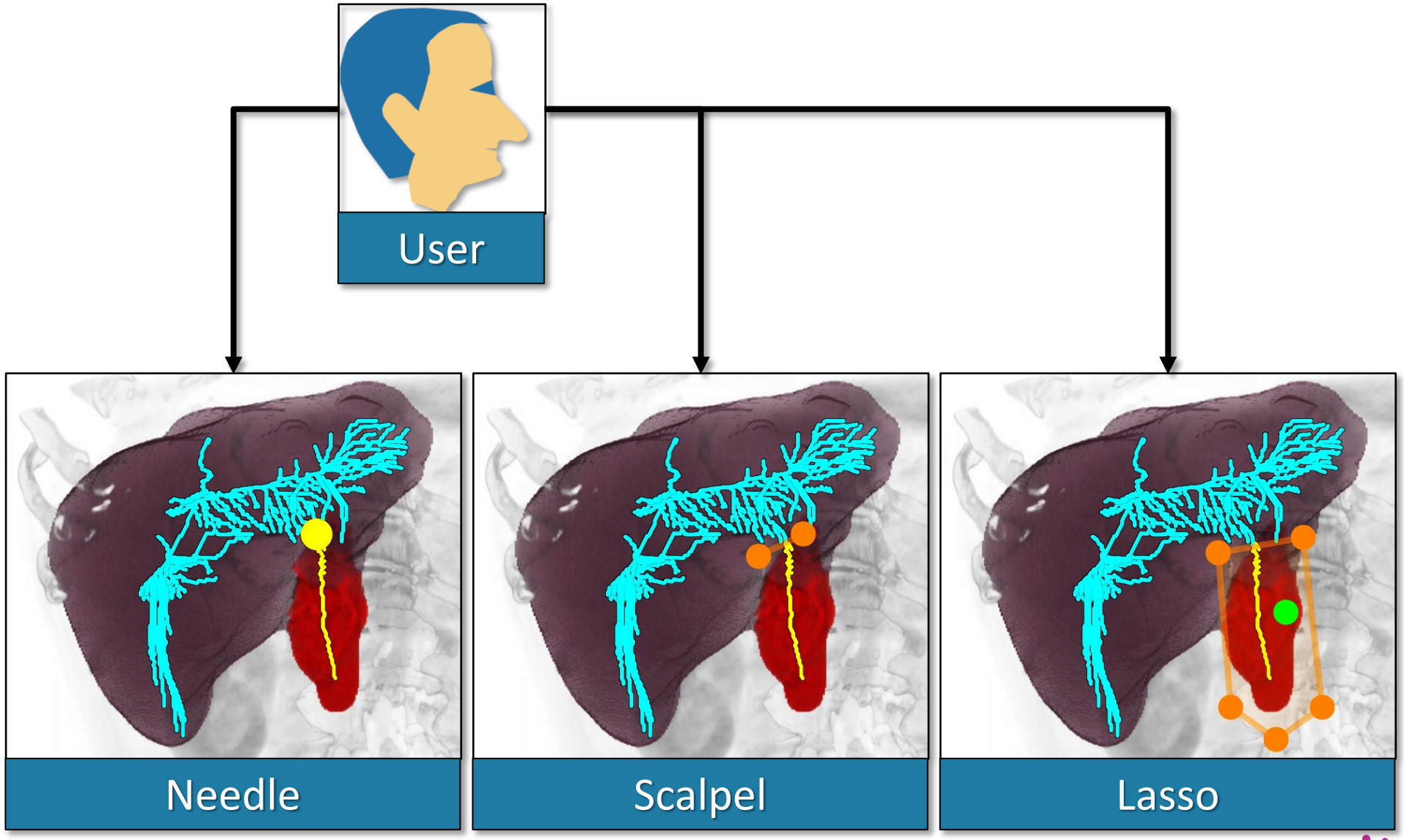


Pipeline

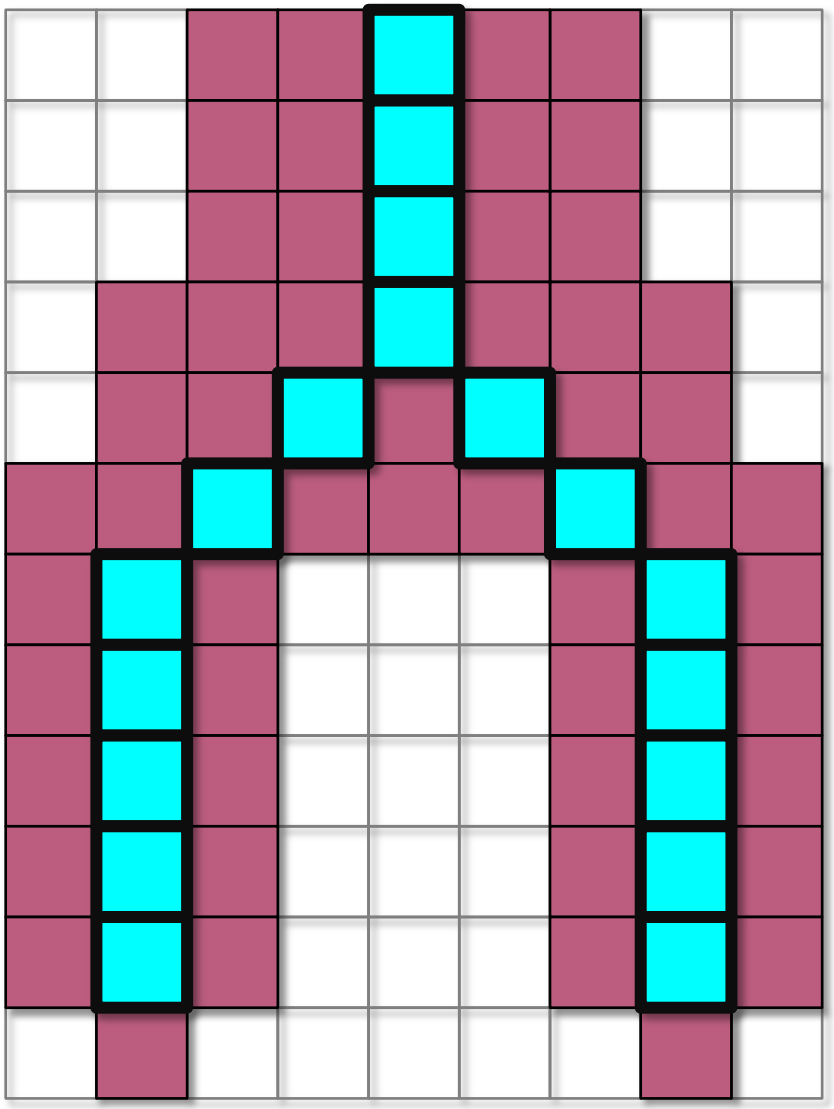
Skeletonization → Skeleton Distance Field → Influence Zones → Interaction + Correction

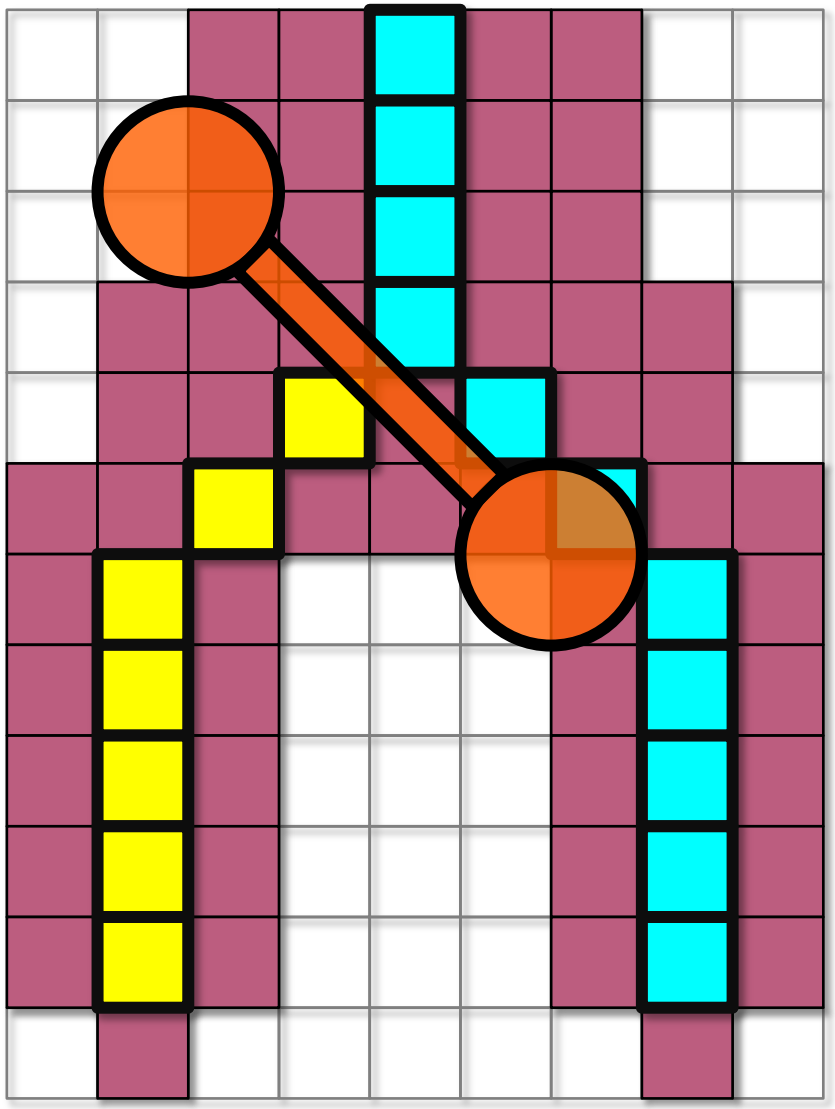


Selection Tools

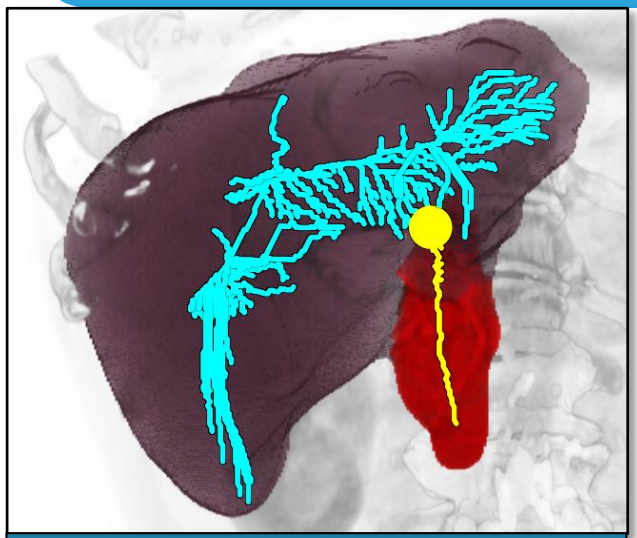


Interaction + Correction

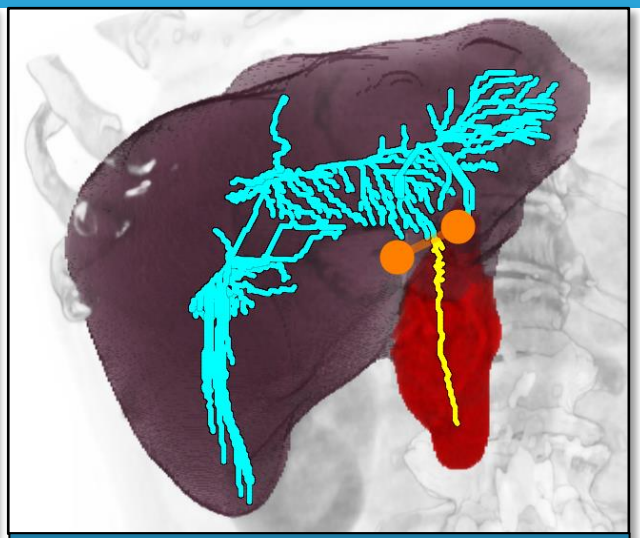




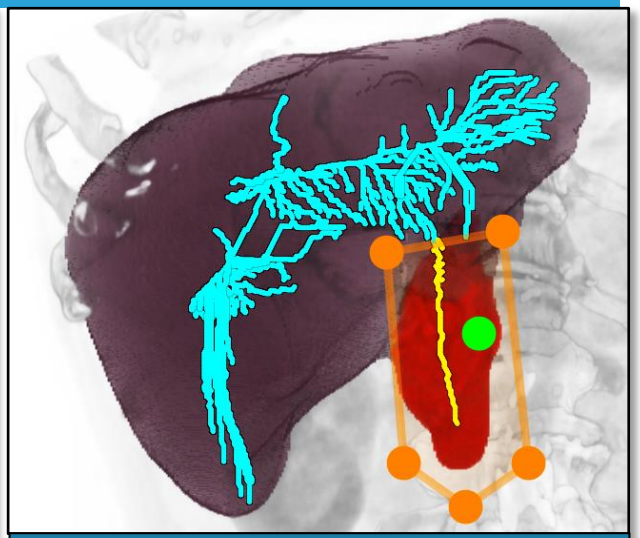
Selection Tools



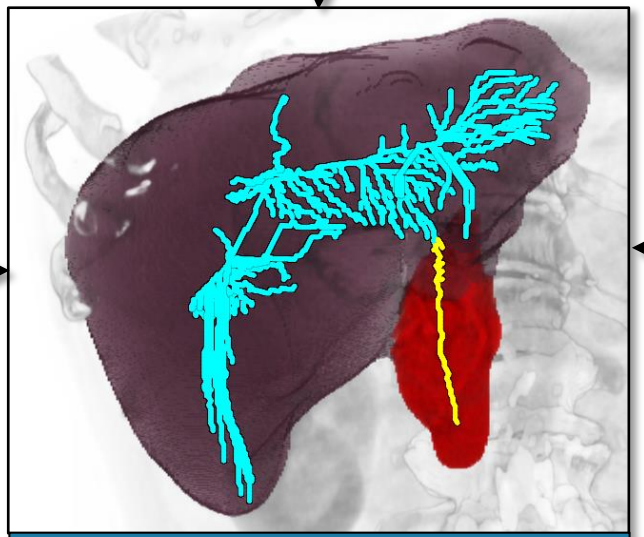
Needle



Scalpel

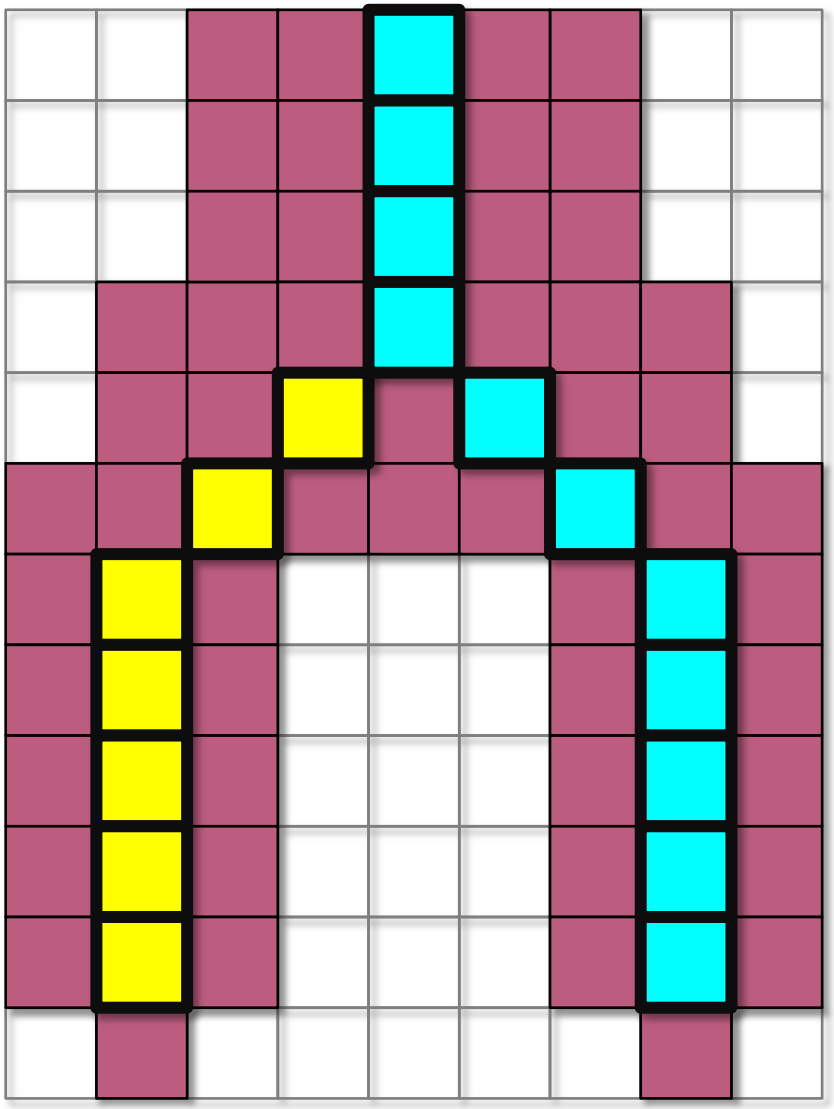


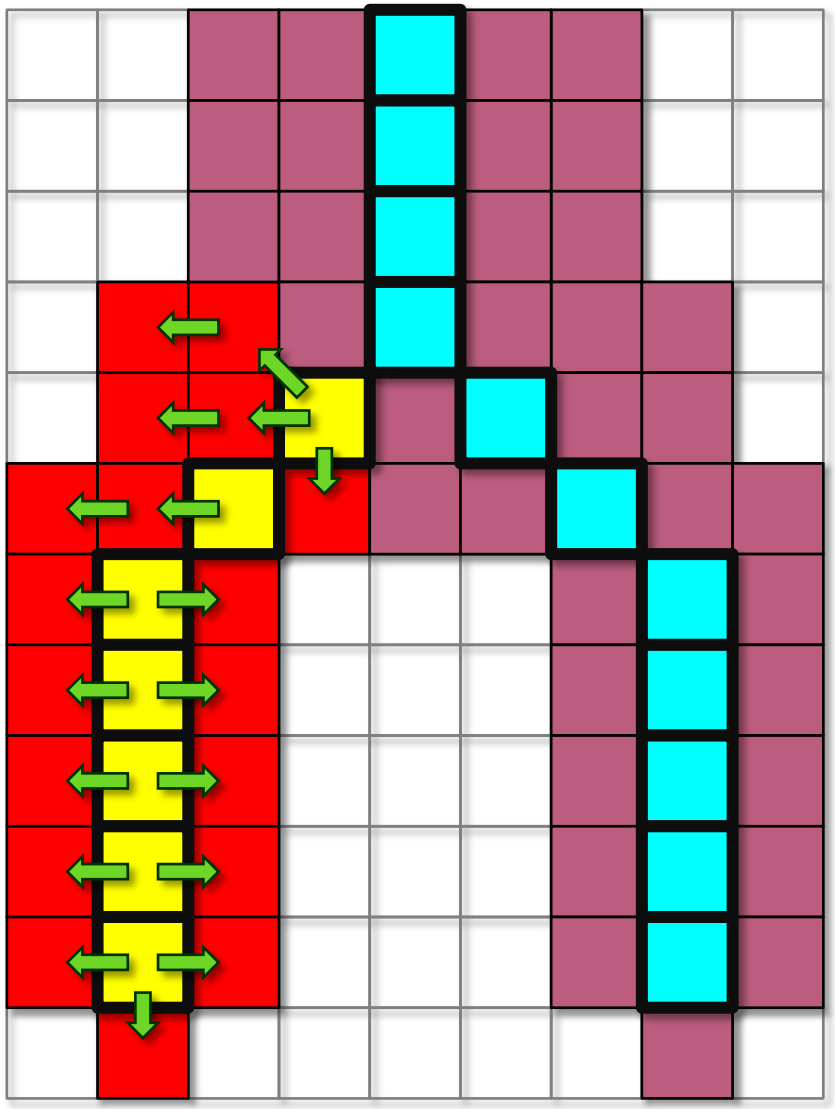
Lasso



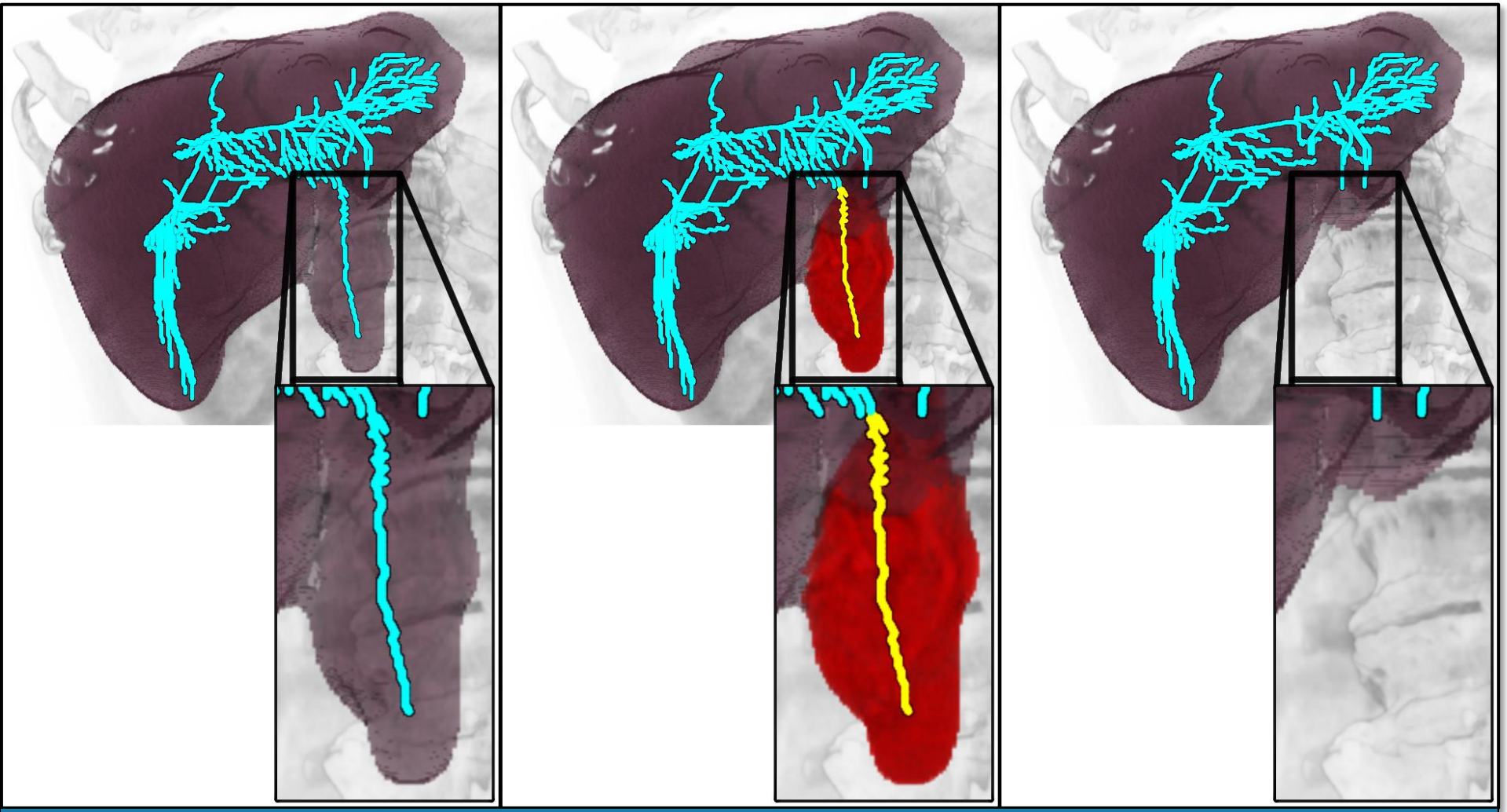
Selection

Interaction + Correction

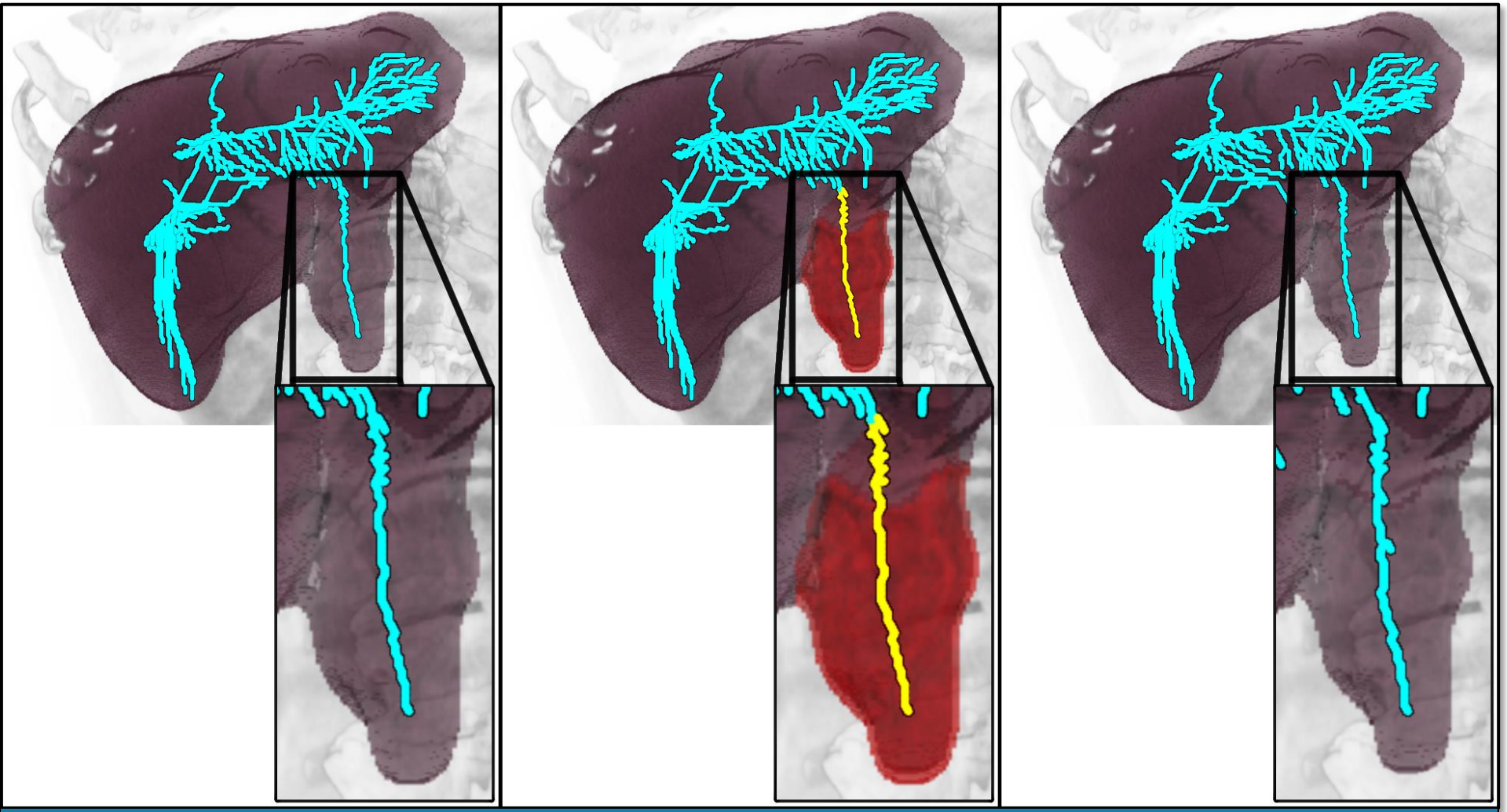




Remove Part Operation

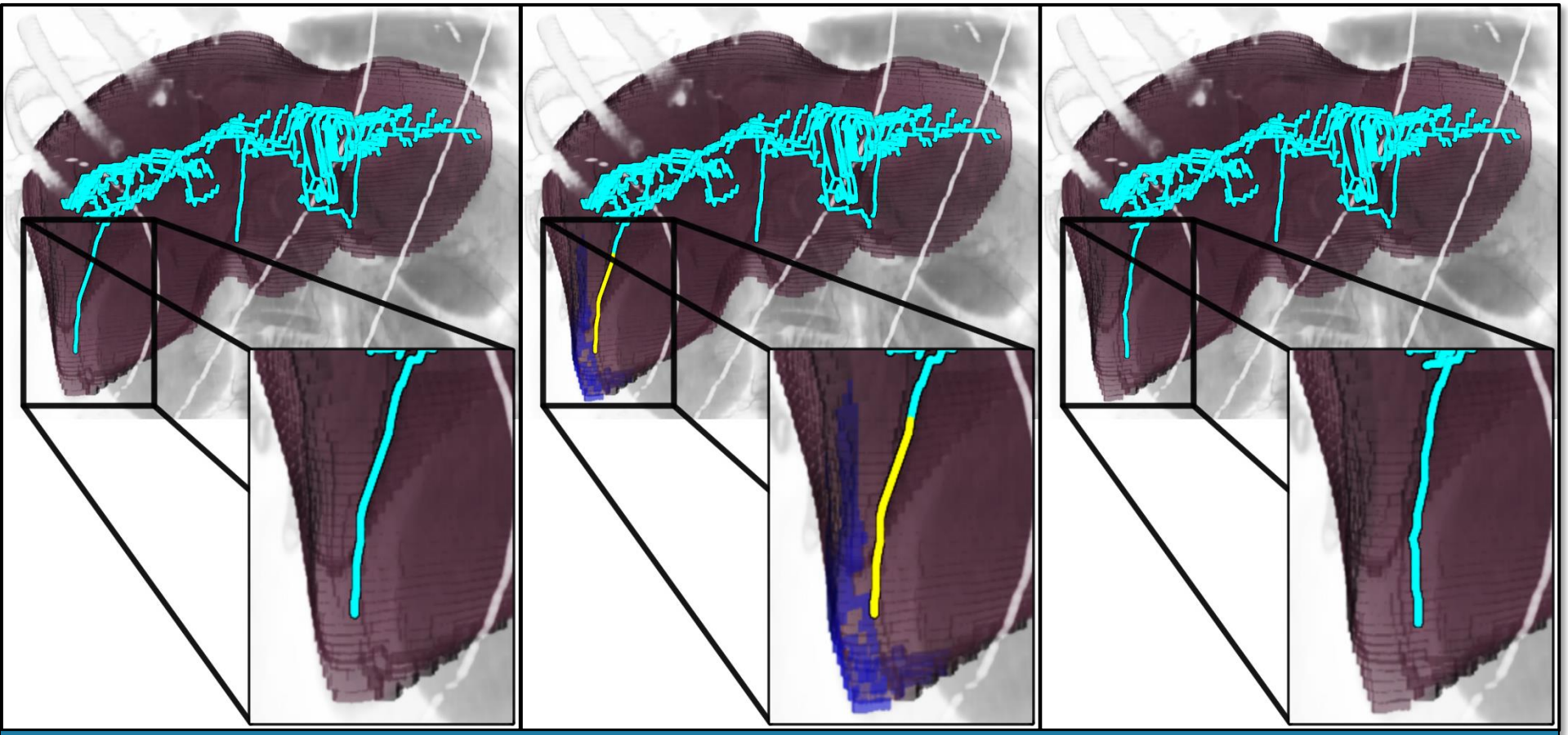


Remove Layer Operation



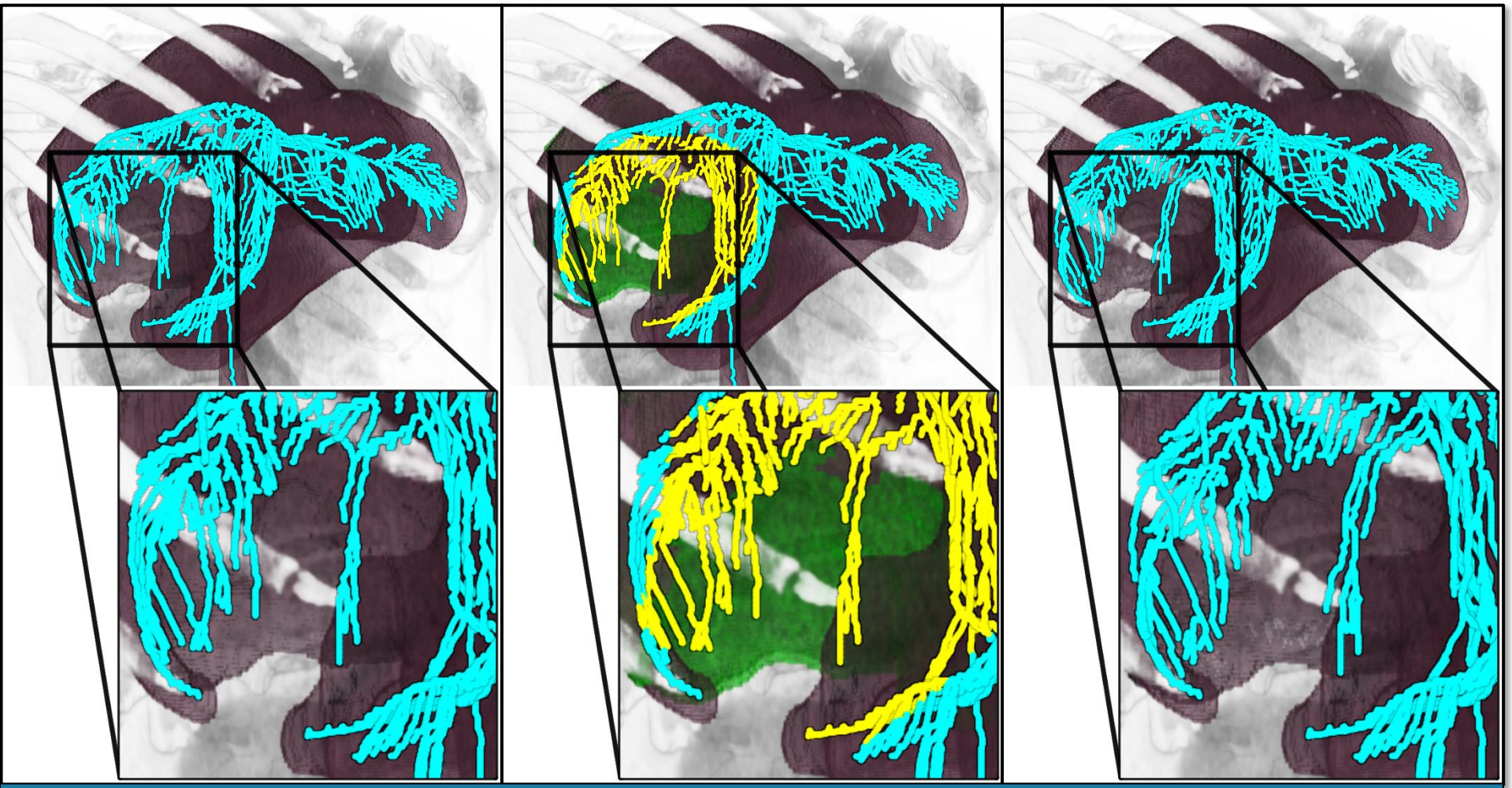
Before | During | After

Smooth Operation



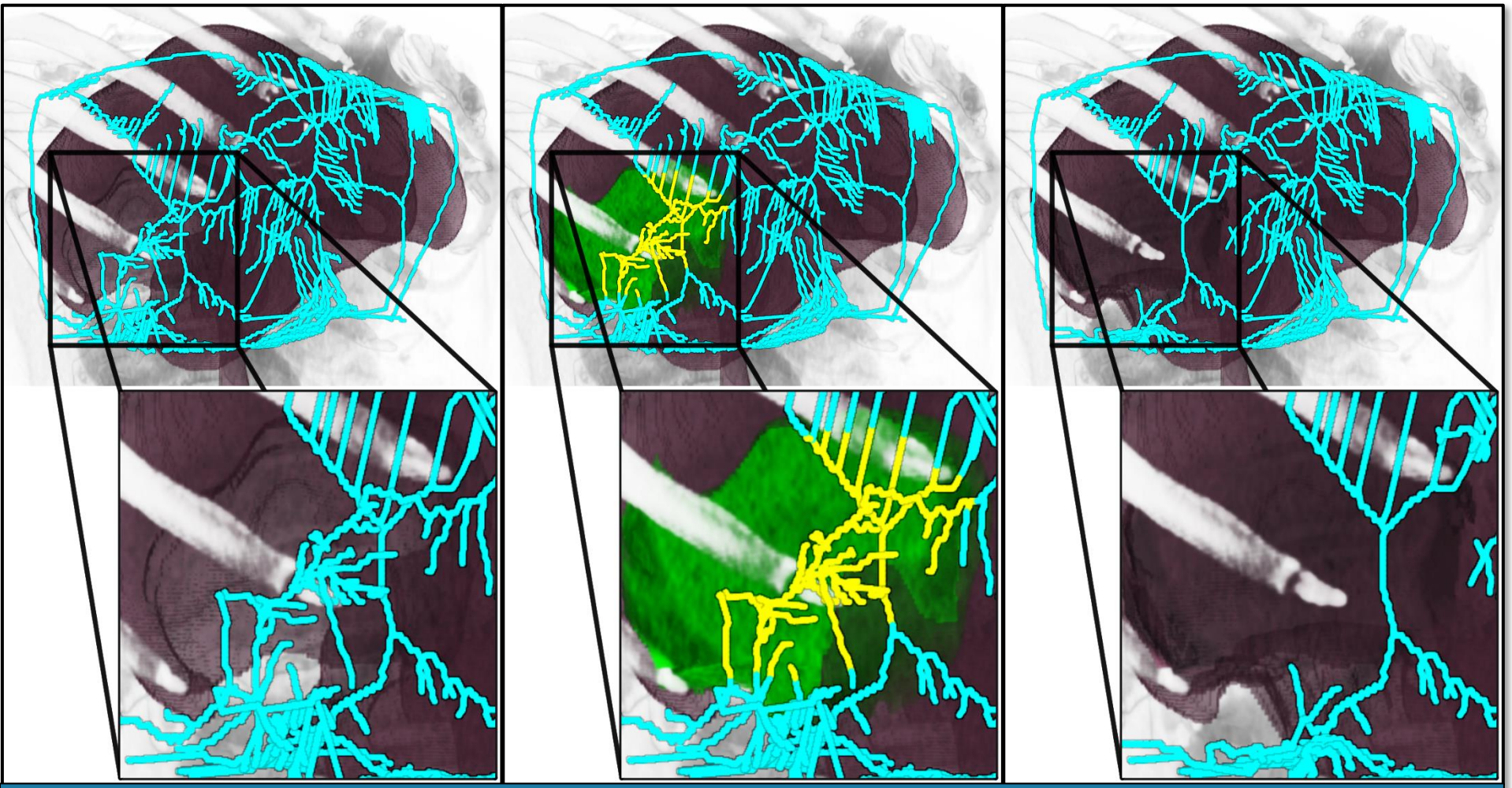
Before | During | After

Add Layer Operation



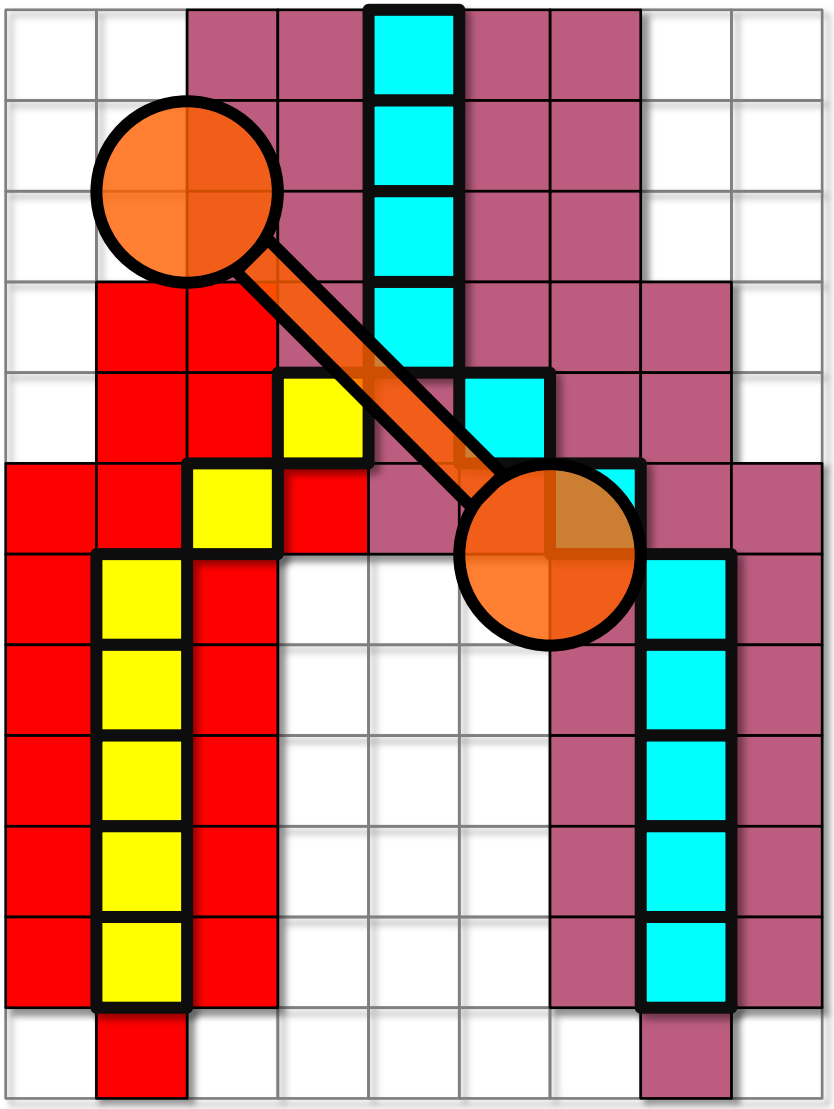
Before During After

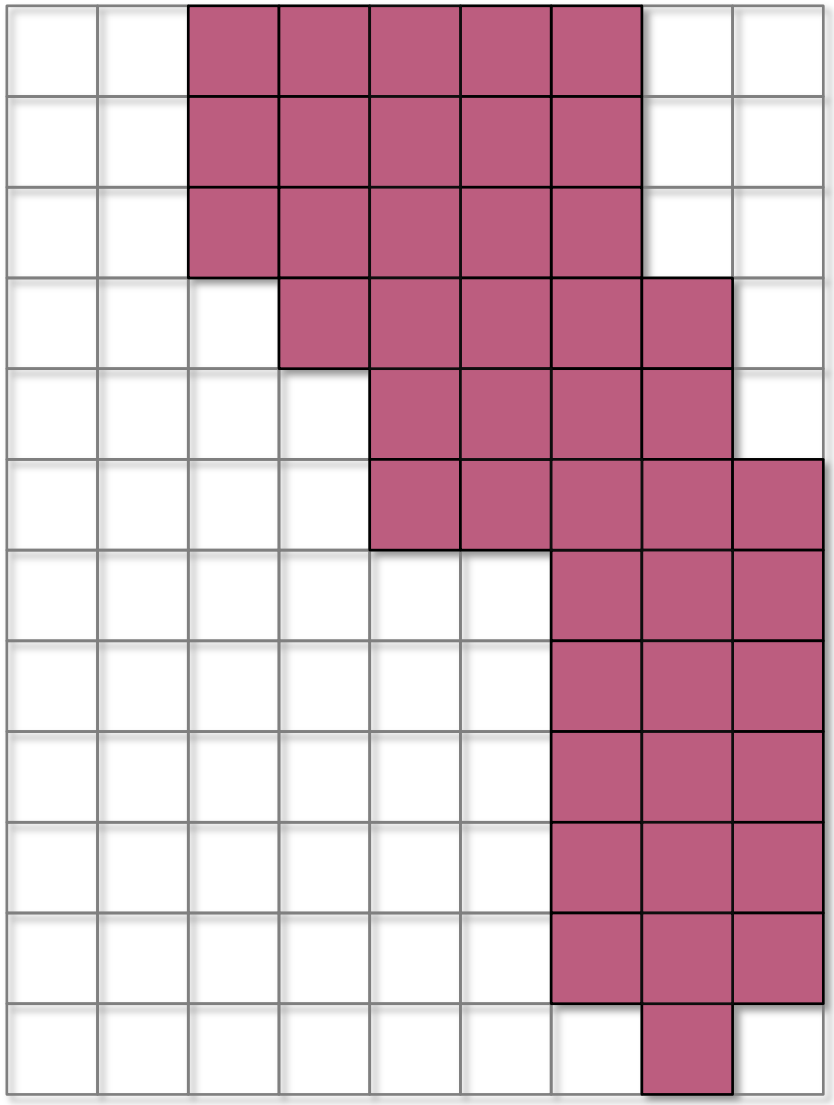
Add Part Operation



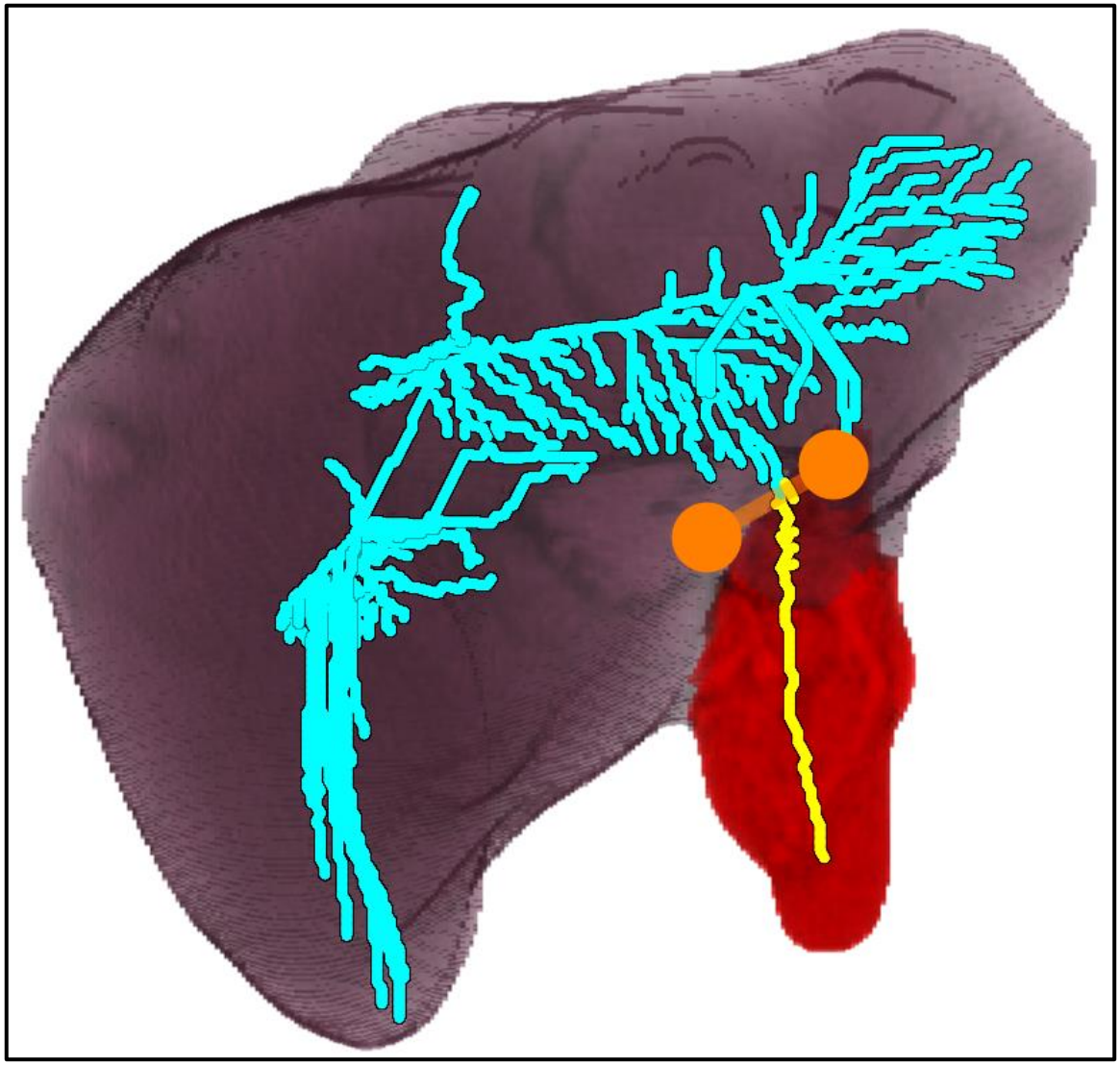
Before During After

Interaction + Correction

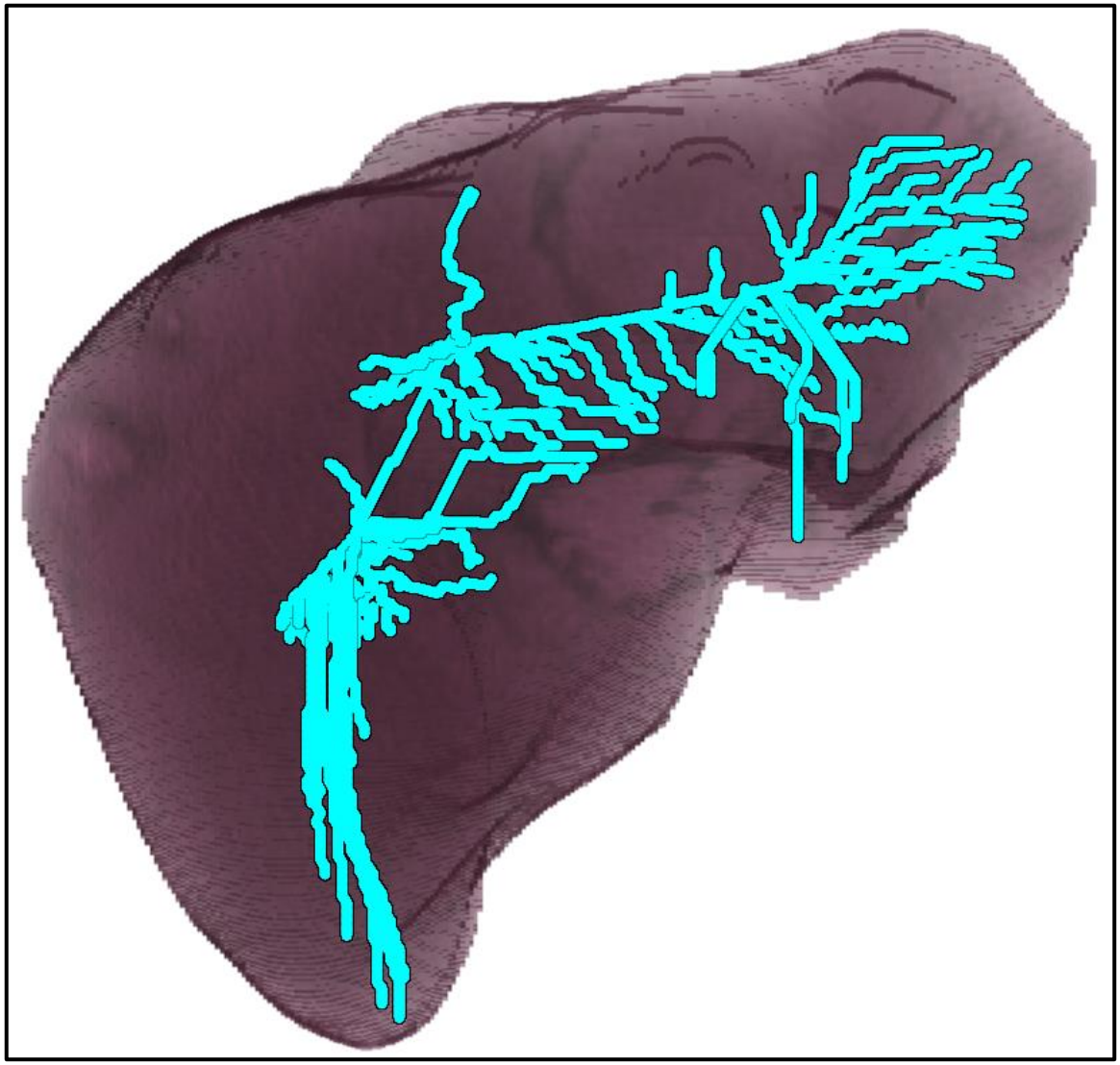




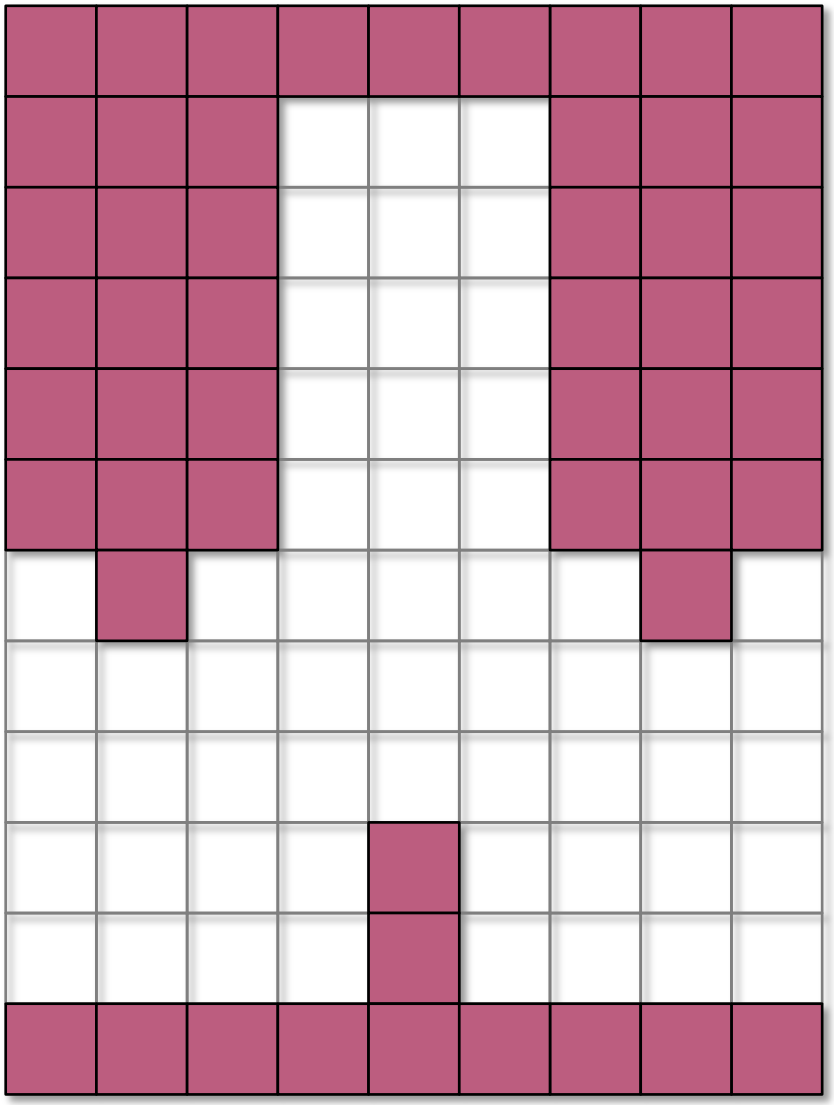
Remove Part by Scalpel

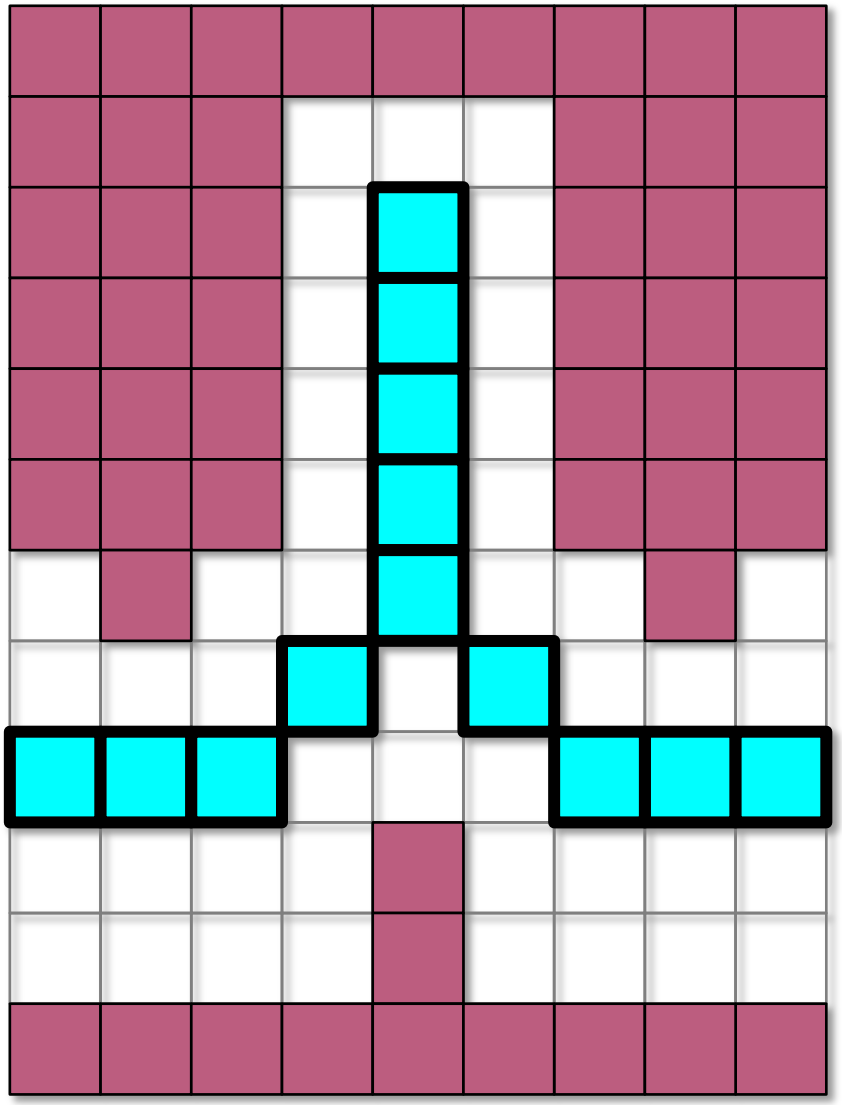


Remove Part by Scalpel

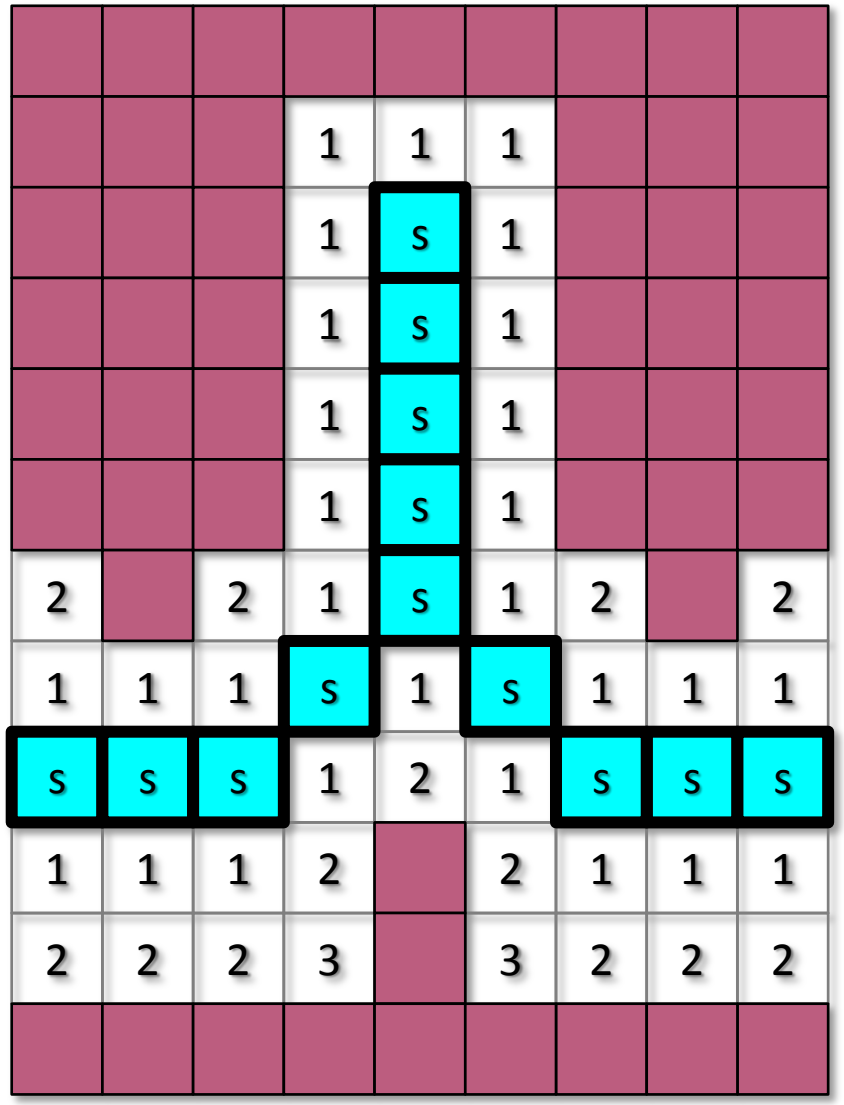


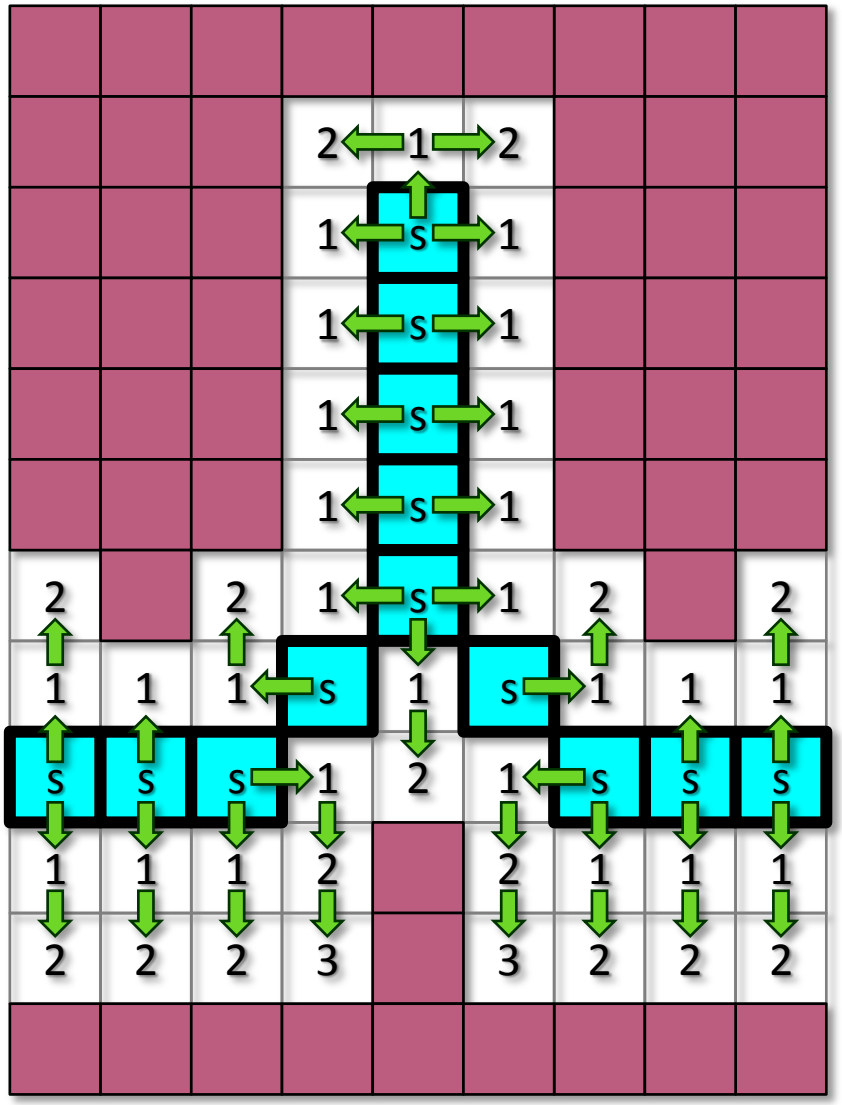
Under-segmentation Correction



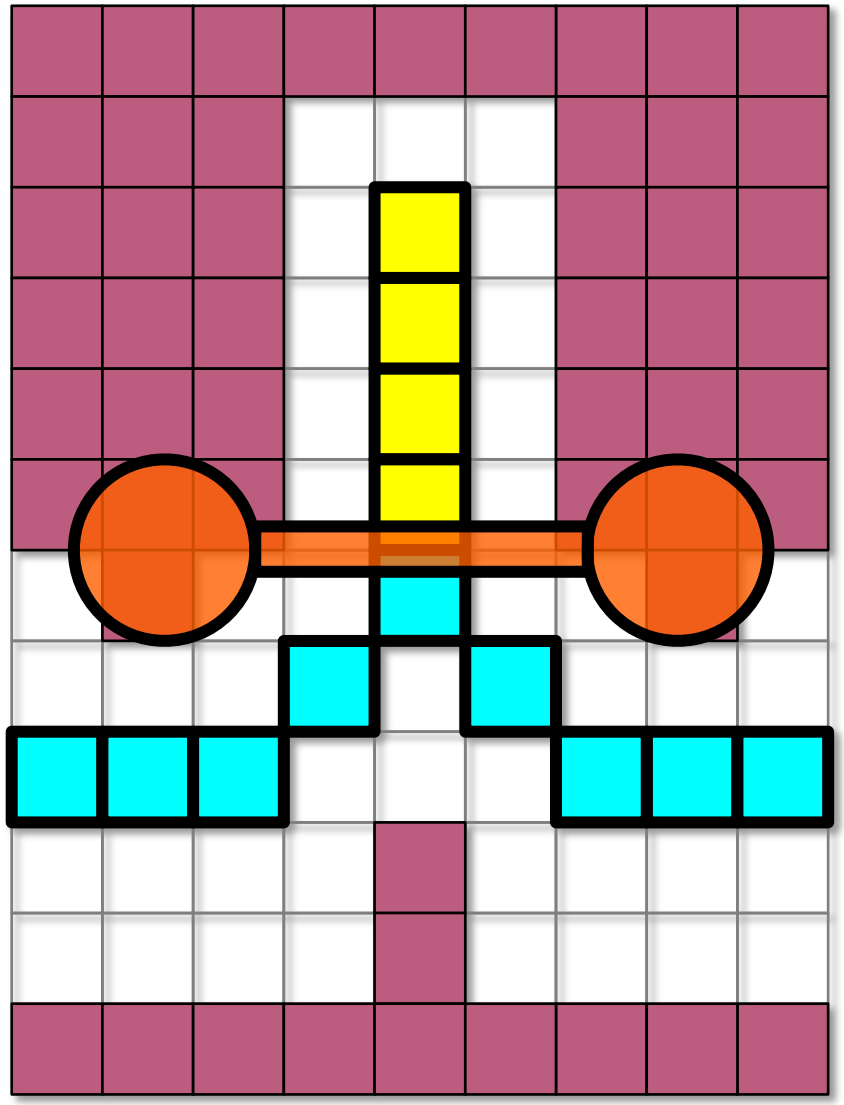


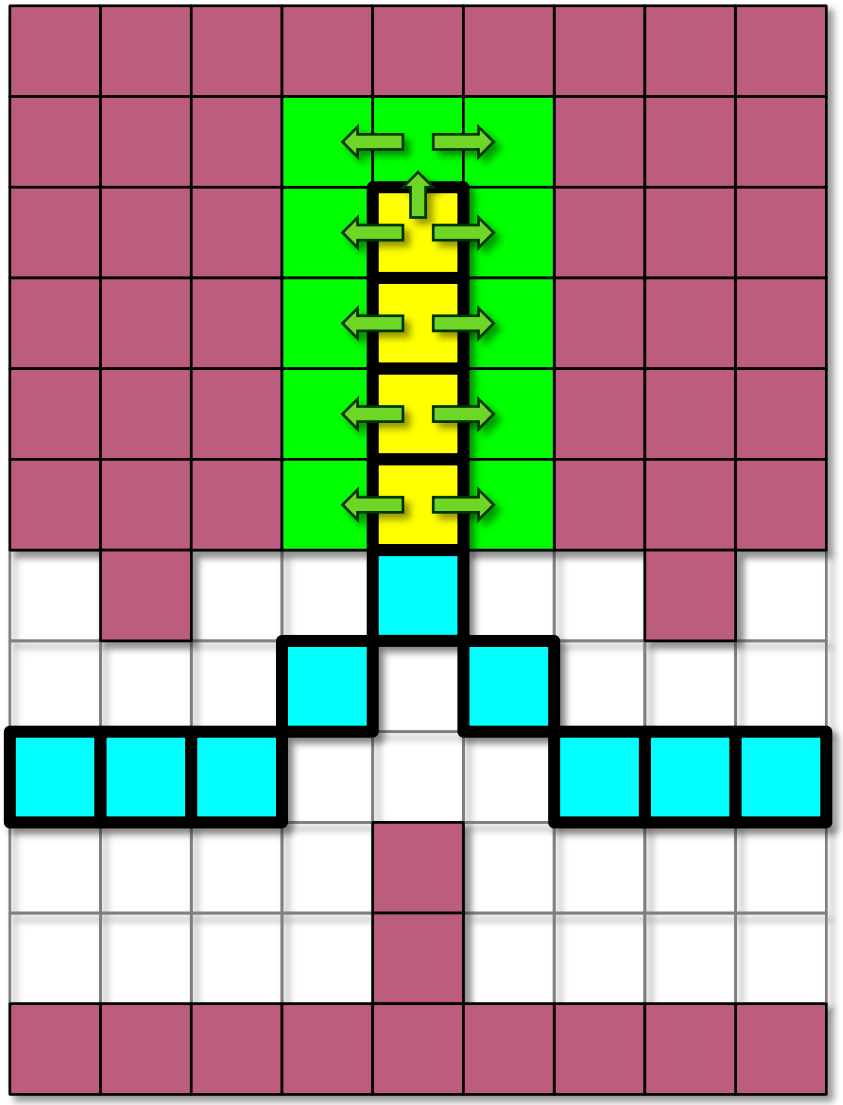
Under-segmentation Correction



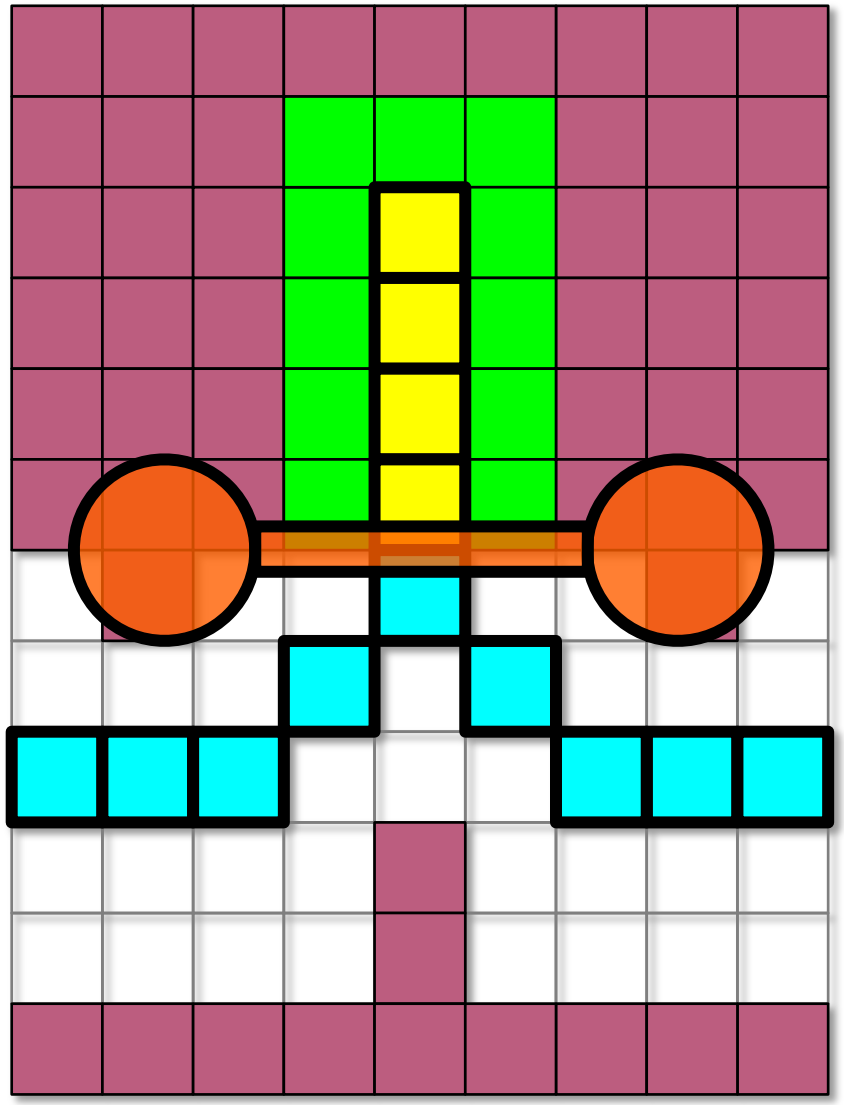


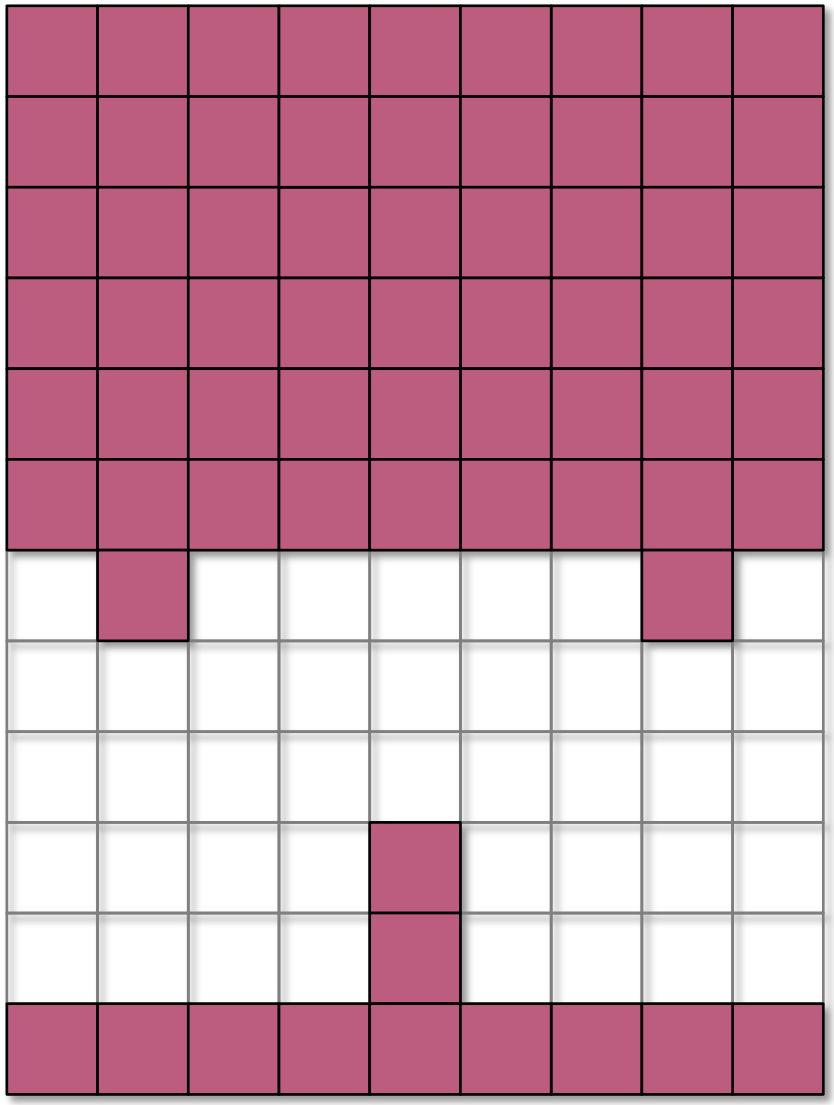
Under-segmentation Correction



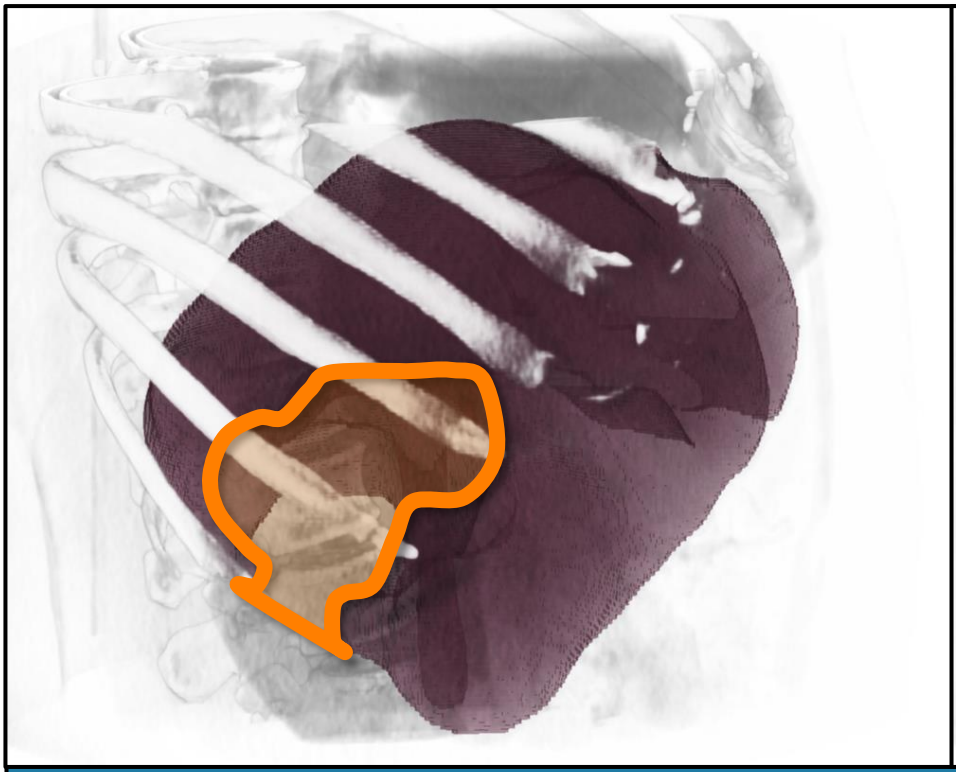


Under-segmentation Correction

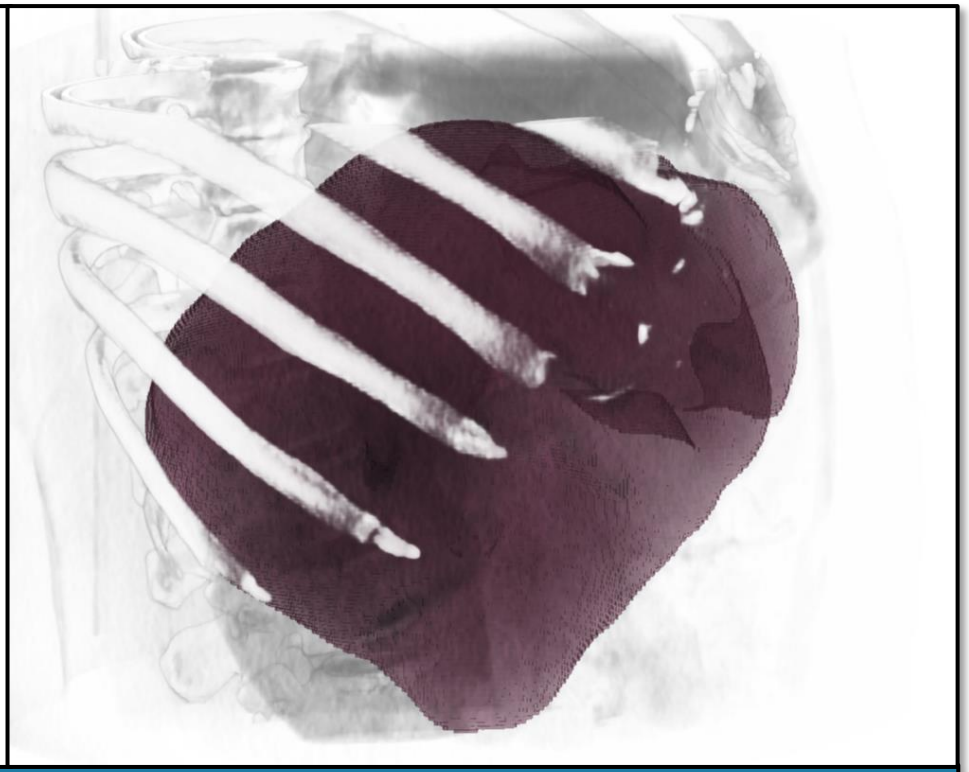




Under-segmentation Correction

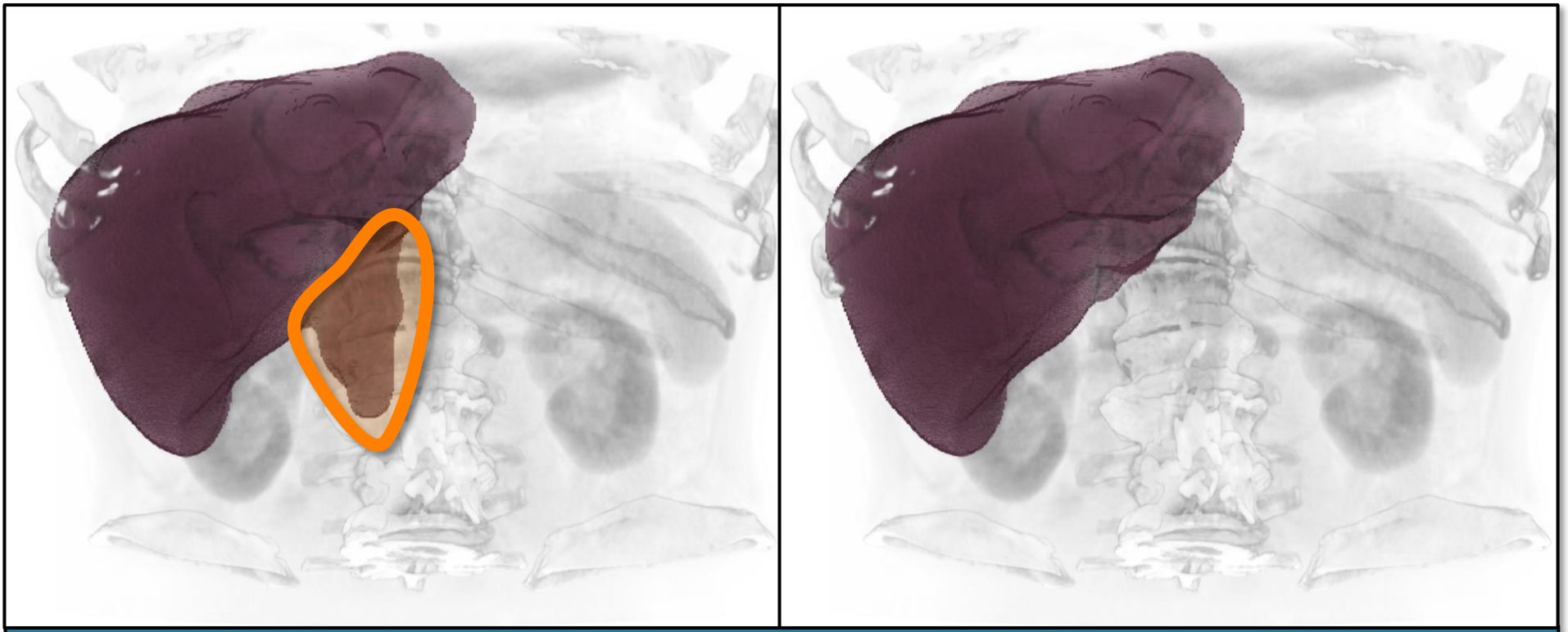


Before correction



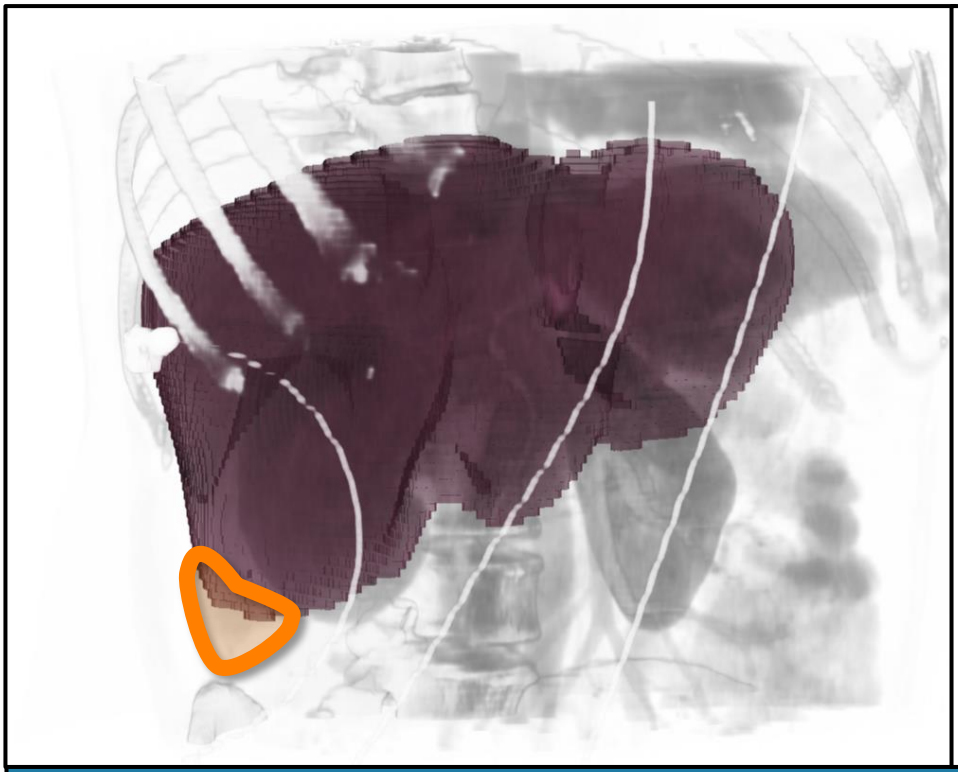
After correction

Over-segmentation Correction

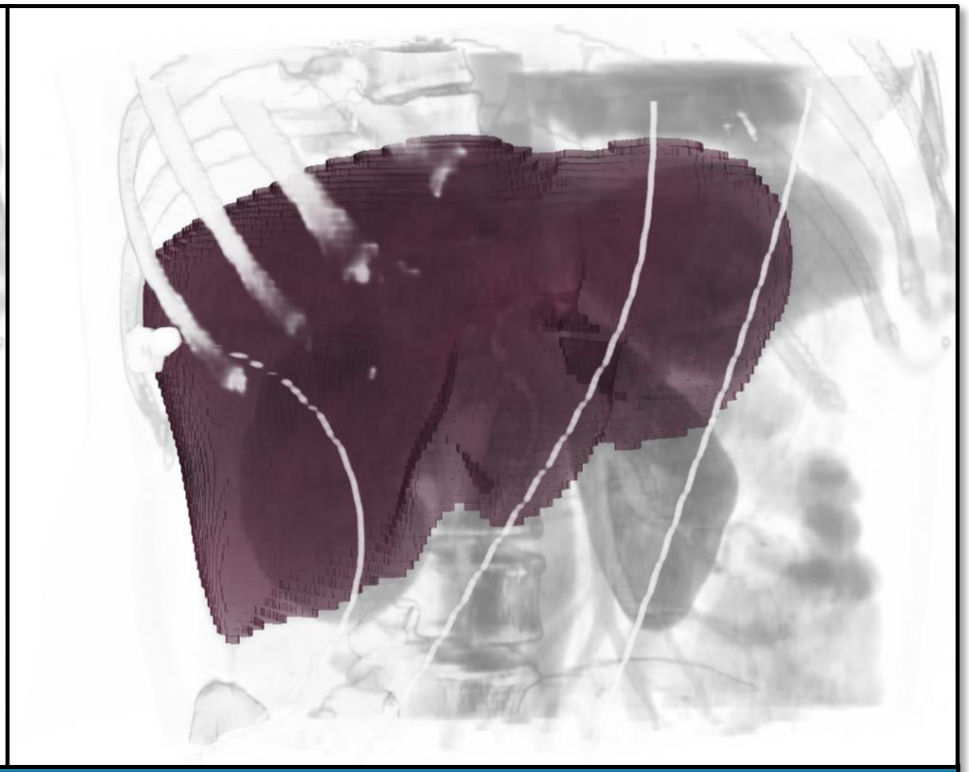


Before correction | After correction

Boundary Artifacts Correction



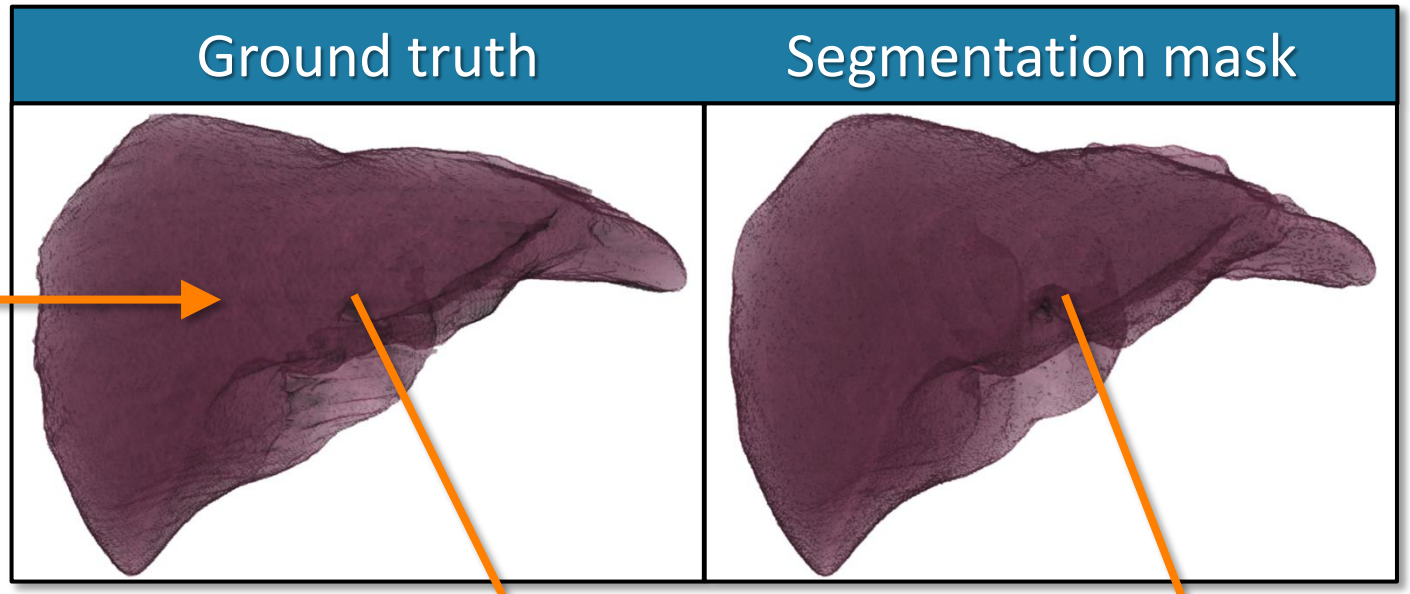
Before correction



After correction

Quality Measure

Domain expert, slice-based technique, 30 min.



A (*set of voxels*)

B (*set of voxels*)

$$Q = \frac{|A \cap B|}{|A \cup B|}$$

Q	Segmentation
0	No correctly classified voxels
$(0; 1)$	Under-segmentation \ over-segmentation \ boundary artifacts
1	Perfect match

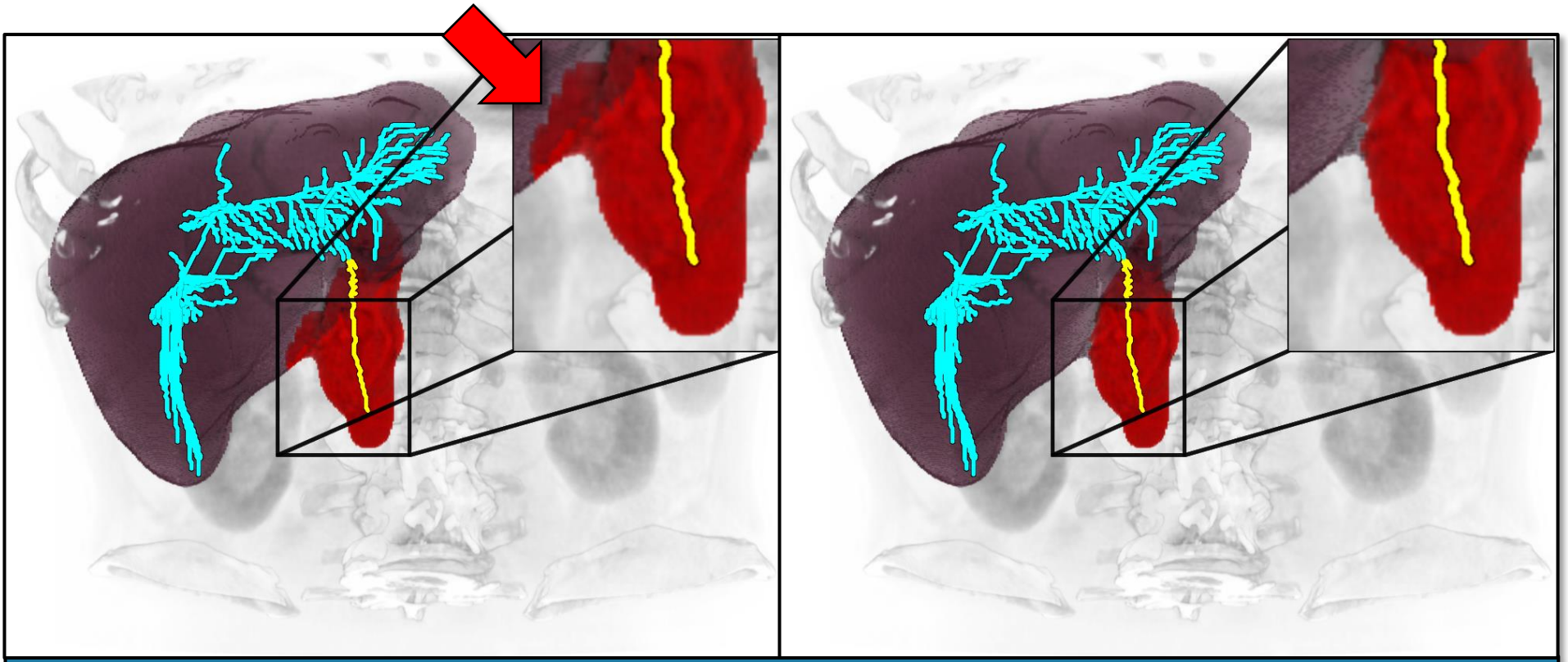
Quality Comparison

Automatic segmentation $t = 3.5$ min.	Correction in ViviSection $t = 1$ min.	Ground truth segmentation $t = 30$ min.

$Q_1 = 0.88$

$Q_2 = 0.93$

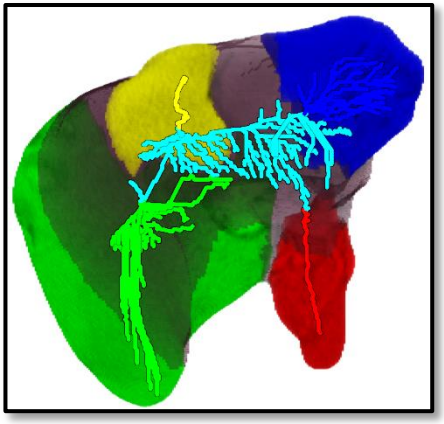
Precision of Selection



Euclidean Distance Field | Skeleton Distance Field

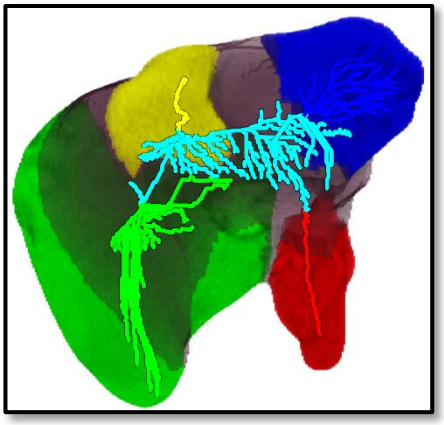
Summary

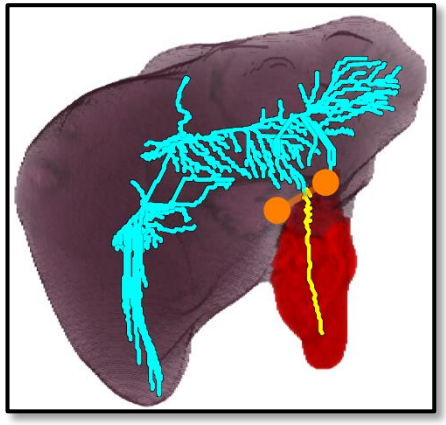
- Structural information for selection support



Summary

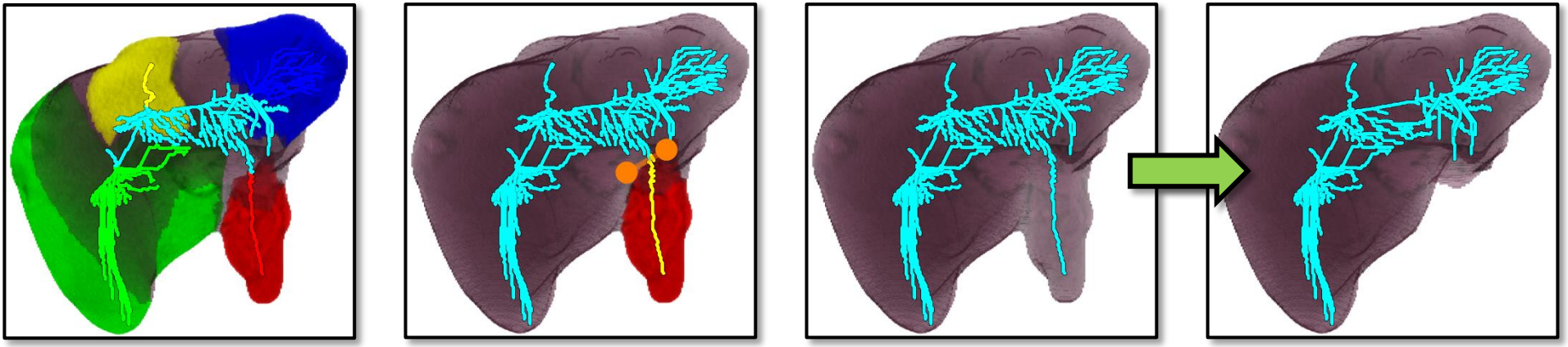
- Structural information for selection support
- Intuitive selection tools and operations for rapid correction of major segmentation defects





Summary

- Structural information for selection support
- Intuitive selection tools and operations for rapid correction of major segmentation defects
- Robustness to severe segmentation defects



Questions?

- Webpage: http://cg.tuwien.ac.at/courses/MedVis2/VU.html
- Abgabesystem: https://lva.cg.tuwien.ac.at/vismed2/