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

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Segmentation Problems

Over-estimation
Segmentation Problems

Under-estimation
Local boundary artifacts
Correction Workflow

Input: segmentation mask with problems
Correction Workflow

Skeletonization

Skeleton
Correction Workflow

User selection on the skeleton

Selection tool

Selected part of the skeleton
Correction Workflow

Preview of correction operation

Selected part of the object
Correction Workflow

Output: corrected segmentation mask
From Skeleton to Segmentation Mask

Background voxel

Object voxel
From Skeleton to Segmentation Mask

Voxel $\notin$ Mask

Voxel $\in$ Mask

Skeleton voxel
From Skeleton to Segmentation Mask

Selection tool

Selected skeleton voxel
From Skeleton to Segmentation Mask
Parts of the object, corresponding to parts of the skeleton
Pipeline

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

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

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- Iteration-based
- Removes voxels on the boundary of the segmentation mask
Thinning-based Skeletonization

- Iteration-based
- Removes voxels on the boundary of the segmentation mask
Thinning-based Skeletonization

- Iteration-based
- Removes voxels on the boundary of the segmentation mask
- Leaves only skeleton voxels
Pipeline

Skeletonization → Skeleton Distance Field → Influence Zones → Interaction + Correction
- Constructed during the skeletonization
- Orders voxels with respect to the skeleton
- Constructed during the skeletonization
- Orders voxels with respect to the skeleton
- Constructed during the skeletonization
- Orders voxels with respect to the skeleton
- Constructed during the skeletonization
- Orders voxels with respect to the skeleton

\[ D_S(v) = \text{It}^{\text{max}} - \text{It}(v) \]
Pipeline

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

Shortest path $D_{p \rightarrow q}$ from skeleton voxel $p$ to voxel $q \in \text{Mask}$

$$IZ(p) = \left\{ q \left| D_{p \rightarrow q} = \min_{r \in S} D_{r \rightarrow q} \right. \right\}$$
Influence Zones | 1\textsuperscript{st} Rule

Voxel $\in$ Mask

Skeleton voxel

$q \leftrightarrow p$

Connection in an influence zone

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Influence Zones | 1\textsuperscript{st} Rule
Influence Zones | 2\textsuperscript{nd} Rule

Voxel ∈ Mask

Voxel ∈ Mask

\( D_S(r) < D_S(q) \)

\[ \begin{array}{cccc} 
2 & 1 & 1 \\
2 & 1 & 0 \\
1 & 0 & 2 \\
\end{array} \]
### Influence Zones | 2\textsuperscript{nd} Rule

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## Influence Zones | 2\textsuperscript{nd} Rule

![Influence Zones Diagram]
Pipeline

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

User

Needle
Scalpel
Lasso
Remove Layer Operation

Before

During

After
Smooth Operation

Before  During  After
Add Layer Operation

Before

During

After
Add Part Operation

Before

During

After
Under-estimation Correction

Before correction  After correction
Over-estimation Correction

Before correction

After correction
Boundary Artifacts Correction

Before correction

After correction
Quality Measure

Ground truth
Segmentation mask

Domain expert, slice-based technique, 30 min.

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<thead>
<tr>
<th>$J$</th>
<th>Segmentation</th>
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<tr>
<td>0</td>
<td>No correctly classified voxels</td>
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<td>(0; 1)</td>
<td>Under-estimation \ over-estimation \ boundary artifacts</td>
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<tr>
<td>1</td>
<td>Perfect match</td>
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$J = \frac{|A \cap B|}{|A \cup B|}$
Quality Comparison

Automatic segmentation $t = 3.5$ min.

Correction in ViviSection $t = 1$ min.

Ground truth segmentation $t = 30$ min.

$Q_1 = 0.88$

$Q_2 = 0.93$
Quantitative Results

- 20 datasets
- Average correction time: 105 sec.
- Most used selection tool: scalpel
- “Sufficiently precise to correct major segmentation defects” [Domain Expert #2]

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<thead>
<tr>
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<th>Before correction</th>
<th>After correction</th>
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<td>Lowest quality</td>
<td>0.76</td>
<td>0.90</td>
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<tr>
<td>Average quality</td>
<td>0.86</td>
<td>0.93</td>
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Precision of Selection

Euclidean Distance Field  Skeleton Distance Field
Structural information for selection support
ViviSection

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

- 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](http://cg.tuwien.ac.at/courses/MedVis2/VU.html)
- Abgabesystem: [https://lva.cg.tuwien.ac.at/vismed2](https://lva.cg.tuwien.ac.at/vismed2)