Visualisierung Medizinischer Daten 2

TOPICS INTRODUCTION

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Webpage:
http://cg.tuwien.ac.at/courses/MedVis2/VU.html

Abgabesystem:
https://lva.cg.tuwien.ac.at/vismed2/
General Information

- **At least one topic per category**
- Choose others to reach **at least 35 points** in total
- **All sub-types listed in brackets have to be implemented**
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- Choose others to reach **at least 35 points** in total
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**Note**

A topic counts as implemented if and only if the described exercises are done. Declaring self-chosen exercises as solutions, is not acceptable without confirmation!
### Category 1 (C1)

<table>
<thead>
<tr>
<th>Points</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(5)</td>
<td>Thresholding</td>
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<tr>
<td>(5)</td>
<td>Hysteresis thresholding</td>
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<tr>
<td>(5)</td>
<td>Gaussian filtering</td>
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<tr>
<td>(5)</td>
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<tr>
<td>(5)</td>
<td>Orthogonal slices (axial, coronal, sagittal)</td>
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<td>(5)</td>
<td>Oblique slices</td>
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<td>(5)</td>
<td>Clipping planes</td>
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<td>(5)</td>
<td>Maximum Intensity Projection (MIP)</td>
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<td>(5)</td>
<td>Local Maximum Intensity Projection (LMIP)</td>
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<tr>
<td>(5)</td>
<td>Windowing function</td>
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One value differentiates foreground from background

Simple & effective

**Example:** Vessel & bone segmentation

**Problem:** Tissue types not distinctly separable with a single threshold (e.g., bone marrow)
Two thresholds: low and high value
Below low threshold background
Above high threshold strong foreground
Between candidates
Walk along candidates until a foreground is reached
If a foreground is encountered, mark all as foreground
No foreground touched, mark all as background
C1 | Hysteresis Thresholding
C1 | Gaussian Filtering

- Reduces noise
- Blurs the image & smooths edges
C1 | Median Filtering

- Reduces salt and pepper noise
- Blurs the image & smooths edges
**C1 | Orthogonal Slices**

- **Axis-aligned slices**
  - Axial
  - Coronal
  - Sagittal
- **Linked views**

(Bruckner and Gröller 2005)
C1 | Oblique Slices

- Oblique planar cuts through the volume data set
- Multi-planar Reformation (MPR)
- Arrangement in exploded views

(Pelt et al. 2010)
Cutaway planes
Clipping planes / geometry
Provide insight into the data

(Weiskopf, Engel, and Ertl 2002)
C1 | Maximum Intensity Projection (MIP)

- Depicts maximum intensity along viewing ray
- Spatial & depth perception deteriorate
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C1 | Maximum Intensity Projection (MIP)

- Depicts maximum intensity along viewing ray
- Spatial & depth perception deteriorate
C1 | Local MIP (LMIP)

- Depicts first maximum intensity above a user-defined threshold
- Reveals obstructed objects

(Sato et al. 1998)
C1 | Windowing Function

- Simple transfer function
- Two parameters: window center & width
- Essential tool in medical visualization
<table>
<thead>
<tr>
<th>Points</th>
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<tr>
<td>(10)</td>
<td>Bilateral filtering</td>
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<tr>
<td>(10)</td>
<td>Gradient filter</td>
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<tr>
<td>(10)</td>
<td>Region growing</td>
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<tr>
<td></td>
<td>Morphological operations (erosion, dilation, opening, closing)</td>
</tr>
<tr>
<td>(10)</td>
<td>Measurements (length, area, volume)</td>
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<td>(10)</td>
<td>1D transfer functions</td>
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<td>(10)</td>
<td>Glyphs in medical visualization</td>
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<tr>
<td>(10)</td>
<td>Labeling of medical data</td>
</tr>
</tbody>
</table>
- Reduces noise, but preserves edges
- Two parameters: $\sigma_{domain}$ & $\sigma_{range}$
C2 | Gradient Filter

- Forward/Backward or central differences
- Sobel filter
C2 | Region Growing

- Detects a homogeneous region
- Requires placement of seed point

Original  Filtered image  Region growing  Region mask

seed point
C2 | Morphological Operations

- Usually image, \( I \), post-processing
- Requires a structuring element (disk, sphere, etc.)
- Dilation \( d(I) \)
- Erosion \( e(I) \)
- Opening = \( d(e(I)) \)
- Closing = \( e(d(I)) \)

Original | Bilateral | Region growing | Opening & closing

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C2 | Measurements

- Measurements in medical visualization
- Length & size of a vessel stenosis
- Volume & surface regularity of a tumor

(Preim et al. 2002)  
(Oeltze and Preim 2004)
Mapping between intensity (x) and color & opacity (y)
Glyphs represent certain aspects of the data
- Information encoded in shape, size, color, etc.
- **Example:** Super-ellipsoids aligned with the gradient
C2 | Labeling of Medical Data

- Annotate anatomical data
- Optimal label placement & arrangement

(Pommert et al. 2001)
## Category 3 (C3)

<table>
<thead>
<tr>
<th>Points</th>
<th>Topic</th>
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<tbody>
<tr>
<td>(10)</td>
<td>Skeletonization</td>
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<tr>
<td>(10)</td>
<td>Maximum Intensity Difference Accumulation (MIDA)</td>
</tr>
<tr>
<td>(10)</td>
<td>Direct Volume Rendering (DVR)</td>
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<td>(10)</td>
<td>2D Transfer functions</td>
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<td>(10)</td>
<td>Iso-surface rendering</td>
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<tr>
<td>(10)</td>
<td>Combined volume &amp; surface rendering</td>
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<tr>
<td>(15)</td>
<td>DICOM export – DICOM library allowed</td>
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<td>(15)</td>
<td>Volume editing</td>
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<td>Vessel enhancement</td>
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<td>(15)</td>
<td>Curved Planar Reformation (CPR)</td>
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<td>(15)</td>
<td>Blood flow visualization</td>
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</tbody>
</table>
- Determines the medial axis of a segmented object
- **Example:** Vessel centerline detection

(Selle et al. 2002)
C3 | Max. Intensity Difference Accumulation

- Better spatial cues than MIP
- No transfer function required
- Artificial data value due to accumulation

(Bruckner and Gröller 2009)
Direct Volume Rendering (DVR)

- Realistic visualizations
- Shading offers better depth perception
- Requires specification of a transfer function
- Use gradient magnitude in addition to the intensity value
- Allows better visual separation of different tissue types

(a) A 1D histogram. The black region represents the number of data value occurrences on a linear scale, the grey is on a log scale. The colored regions (A,B,C) identify basic materials.

(b) A log-scale 2D joint histogram. The lower image shows the location of materials (A,B,C), and material boundaries (D,E,F).

(c) A volume rendering showing all of the materials and boundaries identified above, except air (A), using a 2D transfer function.

(Kniss, Kindlmann, and Hansen 2002)
Surface representation of a specific intensity value
Marching cubes
Marching tetrahedra

(Labsik et al. 2002)  (Schreiner, Scheidegger, and Silva 2006)
Embedded surfaces into a volume rendering

(Tietjen, Isenberg, and Preim 2005)
Scale space analysis/theory

Hessian matrix (second-order partial derivatives)
C3 | Vessel Enhancement

- Scale space analysis/theory
- Hessian matrix (second-order partial derivatives)
C3 | Curved Planar Reformation (CPR)

- Requires vessel centerline representation
- Curved cut along the centerline of a vessel
- Displays the interior (or lumen) of a vessel
- Used to assess vascular pathologies

(Kanitsar et al. 2002)
C3 | Curved Planar Reformation (CPR)

- Requires vessel centerline representation
- Curved cut along the centerline of a vessel
- Displays the interior (or lumen) of a vessel
- Used to assess vascular pathologies
- Generated for a number of viewing directions

(Kanitsar et al. 2002)
C3 | Blood Flow Visualization

- Displays the blood flow of the aorta
- Color-code different flow properties
- Streamlines for flow visualization

(Pelt et al. 2010)
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(Pelt et al. 2010)
Recommended Software

- MITK – http://www.mitk.org/
- ITK – http://itk.org/
- VTK – http://www.vtk.org/
- DCMTK – http://dicom.offis.de/dcmtk.php.en
- OpenGL – http://nehe.gamedev.net/
- VolumeShop – http://cg.tuwien.ac.at/courses/MedVis2/Resources/Volumeshop-VisMed2.exe
- WebGL – https://www.khronos.org/webgl/wiki/Main_Page
- etc.
Possible Choices

- Orthogonal slices (C1/5), MIP (C1/5), LMIP (C1/5), 1D TFs (C2/10), and DVR (C3/10)
- Gaussian filter (C1/5), Sobel filter (C2/10), DVR (C3/10) and 2D TFs (C3/10)
- Median filter (C1/5), Thresholding (C1/5), Sobel filter (C2/10) and DICOM export (C3/15)
Implementation Remarks

- The implementations need not necessarily be interactive
- CPU implementations are sufficient
- For all 3D visualizations (MIP, LMIP, MIDA, DVR) axis-aligned viewing directions are sufficient
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Bonus points:

+5 for any GPU implementation
+5 for arbitrary viewing directions (e.g., camera)
+5 for interactive 3D rendering (MIP, LMIP, MIDA, DVR, CPR, Iso-surface)
+5 for nice user interface widgets (e.g., 1D or 2D transfer function widgets)
References


