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 technique per category**
- Choose others to reach **at least 40 points** in total
- All sub-types listed in brackets have to be implemented
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**Note**

A technique counts as implemented if and only if the described exercises are done. Declaring self-chosen exercises as solutions is not acceptable without confirmation!
Topics

- Analysis of tumors
- Analysis of blood vessels (e.g., lung, brain)
- Segmentation of organs (e.g., lung, liver, heart, brain)
- Segmentation of bones and blood vessels (e.g., lower extremities runoffs)
- Metal artifact correction in CT data sets
- ... or choose a custom topic!
### Points | Technique
--- | ---
(5) | Thresholding
(5) | Hysteresis thresholding
(5) | Gaussian filtering
(5) | Median filtering
(5) | Orthogonal slices (axial, coronal, sagittal)
(5) | Oblique slices
(5) | Clipping planes
(5) | Maximum Intensity Projection (MIP)
(5) | Local Maximum Intensity Projection (LMIP)
(5) | Windowing function
C1 | Thresholding

- One value differentiates fore- from background
- Simple & effective
- **Example:** Vessel & bone segmentation
- **Problem:** Tissue types not distinctly separable with a single threshold (e.g., bone marrow)

Original  Threshold  Active Contour
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 | Gaussian Filtering

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

- Reduces salt and pepper noise
- Blurs the image & smooths edges
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)
C1 | Clipping Planes

- 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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- Depicts maximum intensity along viewing ray
- Spatial & depth perception deteriorate

![Image of bone structure with Maximum Intensity Projection (MIP) examples]
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
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<th>Technique</th>
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<td>(10)</td>
<td>Morphological operations (erosion, dilation, opening, closing)</td>
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<td>(10)</td>
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<td>Glyphs in medical visualization</td>
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<td>(10)</td>
<td>Labeling of medical data</td>
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Bilateral Filtering

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

(Preim et al. 2002)  (Oeltze and Preim 2004)
C2 | 1D Transfer Function

- 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)

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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)
C3 | Direct Volume Rendering (DVR)

- Realistic visualizations
- Shading offers better depth perception
- Requires specification of a transfer function
C3 | 2D Transfer Functions

- 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)
C3 | Iso-surface Rendering

- 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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- Displays the blood flow of the aorta
- Color-code different flow properties
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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.
Implementation

- Use your own framework, tools, libraries
- VolumeShop (provided on the webpage)
- Techniques **must** be implemented by yourself!
- Matlab: E.g. `imfilter` is not allowed!
- Implementations not necessarily interactive
- CPU implementations sufficient
- For all 3D visualizations (MIP, LMIP, MIDA, DVR) axis-aligned viewing directions are sufficient
+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)
- Analysis of tumors
- Segmentation with hysteresis thresholding (5 pts)
- Visualization with MIP or slices (5 pts)
- Region growing (10 pts) to obtain tumor object
- Measurements of segmented tumor object (10 pts)
- MIDA or DVR (10 pts)


