Importance-Driven Expressive Visualization

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Motivation

iso-surface outer structure

iso-surface inner structure

semi-transparent outer structure

ghosted view showing both - outer and inner structure
Traditional Illustration

http://www.medigraphics.com/
http://www.khulsey.com/
Thesis Contribution

- Model for Importance-Driven Visualization
- Validation of feature visibility

- Thesis based on publications
  - IEEE Visualization 2004
  - IEEE TVCG 2005
  - SIGGRAPH 2005 Sketch
  - EG Tutorial on Illustrative Visualization
Importance-Driven Visualization
Model for Importance-Driven Visualization

[Viola et al. ’04 ’05]

importance specification

importance compositing

levels of sparseness

importance-driven feature enhancement

[Viola et al. ’04 ’05]
Determines the representation

Automatic specification
- Feature classification
- Value range
- Distance to other feature
- Distance to focal point

User-steered assignment to segmented objects
Levels of Sparseness
Levels of Sparseness

- Smooth transitions in representation

![Diagram showing levels of sparseness with smooth transitions in representation.](Image)

representation

0

importance

max

dense

importance max

0
Opacity and Color Modulation

- High importance: opaque, color
- Low importance: transparent, desaturated
Screen-Door Transparency

- High importance: dense, small grid spacing
- Low importance: big grid spacing
Volume Thinning

- High importance: low gradient magnitude
- Low importance: high gradient magnitude
Sharp Levels of Sparseness

- Sharp transitions between different levels
  - Using different feature representations
  - Using different rendering techniques
Sharp Levels of Sparseness

contour rendering
Importance Compositing
Importance Compositing

- Connects importance to levels of sparseness
- Focus features – dense representation
- Context features
  - If occluding – sparse representation
  - Else – dense representation
Importance Compositing

- Maximum importance projection
- Average importance compositing
Maximum Importance Projection

- Only feature with highest importance along the ray is rendered

![Diagram showing maximum importance projection with values 0.1 and 0.7]
Occluding context information is suppressed
Not entirely removed
Sum-up importance of intersected features along the ray

\[
\sum_{\text{importance}} = 0.8
\]

Level of sparseness = \( \frac{0.1}{0.8} = 0.125 \)
Improving the Spatial Arrangement
Examples

maximum importance projection

average importance compositing
Visibility Validation
Visibility Validation

- Avg. imp. compositing preserves thickness
- Visibility of focus is not guaranteed
- Visibility validation useful for partial suppression
Local Visibility-Preserving Imp. Compositing

\[ \sum \alpha(o_0, r_{x0}) \rightarrow \alpha_{avg} \sim l_{\text{norm}}(o_0) \]
Local Visibility-Preserving Imp. Compositing

average importance compositing

visibility preserving importance compositing
Global Visibility-Preserving Imp. Compositing

initial transfer function

equal visibility

Ivan Viola
Visibility Evaluation

\[ o_0 = \text{object 0} \]
\[ o_1 = \text{object 1} \]
\[ r = \text{ray} \]
\[ r_0 = \text{sub-ray 0} \]
\[ r_1 = \text{sub-ray 1} \]
\[ r_2 = \text{sub-ray 2} \]

\[ \nu(o_1, r) = (1 - \alpha(o_0, r_0)) \alpha(o_1, r_1) \]
\[ \nu(o_0, r) = \alpha(o_0, r_0) \]
\[ \nu(o_0, r) = \alpha(o_0, r_0) + (1 - (\alpha(o_0, r_0) + \nu(o_1, r))) \alpha(o_0, r_2) \]
Global Visibility-Preserving Imp. Compositing

initial transfer function

visual representation

visibility evaluation

$v(o_x) \sim I_{\text{norm}}(o_x)$

final visual representation
Global Visibility-Preserving Imp. Compositing

Initial transfer function:
- rind = 1.0
- pulp = 2.0
- seeds = 0.5
Applications
Lung Nodules Visualization
Visualization of MR Mammograms
VolumeShop: Interactive IDV
Conclusions

- New focus+context visualization technique
  - Importance specification
  - Levels of sparseness
  - Importance compositing
- Validation of feature visibility
- High potential of visualization applications
- New research possibilities
Thank you!

Questions???