Visualization and Virtual Reality in Medicine

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Tutorial Syllabus

Surface Visualization - Marching Cubes and its improvements - Smoothing of surface visualizations	(40 min.)
3D Vessel Visualization	(30 min.)
Labeling Medical Visualizations	(20 min.)
Break	(15 min.)
Direct Volume Visualization - Ray casting and texture-based approaches - Projection methods	(40 min.)
Multifield Medical Visualization	(30 min.)
Virtual Endoscopy	(20 min.)

Structure

- Introduction
- Foundation of Labeling Medical Visualizations
- Labeling Examples
- Guidelines for Labeling
- Future Research Directions in Labeling

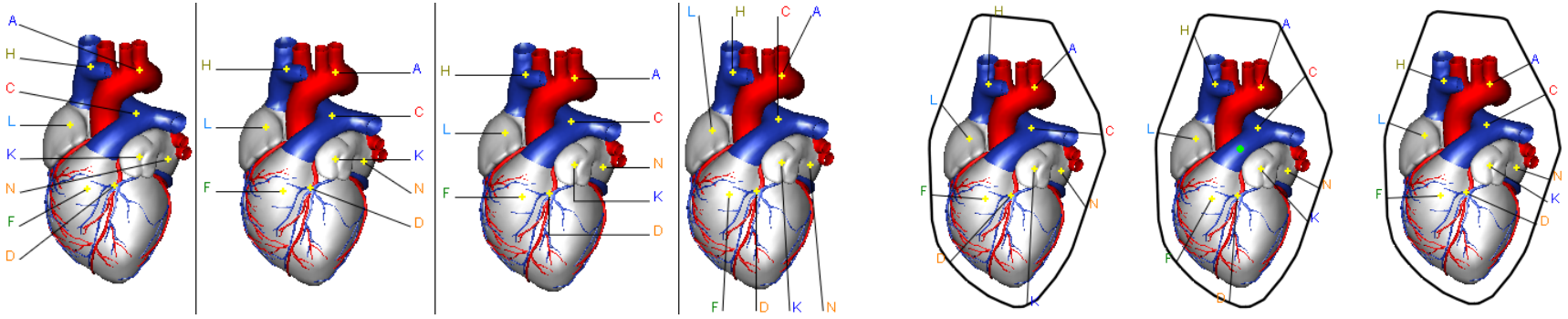
Based on Oeltze and Preim: “Survey of Labeling Techniques in Medical Visualizations”, Proc. of Eurographics Workshop on Visual Computing for Biology and Medicine (EG VCBM), pp. 199-208, 2014.

Introduction

- Labeling has long tradition in medical textbooks
- New applications in computerized medicine
  - Record and forward diagnostic findings
  - Focus discussions in team meetings for decision making
  - Support orientation in complex or unfamiliar views, e.g., (virtual) endoscopic views in sinus surgery
  - Study anatomy in computer learning systems
  - Explain an intervention in patient education
  - Practice an intervention in a surgery training system
- Challenges
  - **Automatic** labeling of **patient-individual** data
  - Labeling visualizations that are **interactive**

Foundation: Effective Labeling

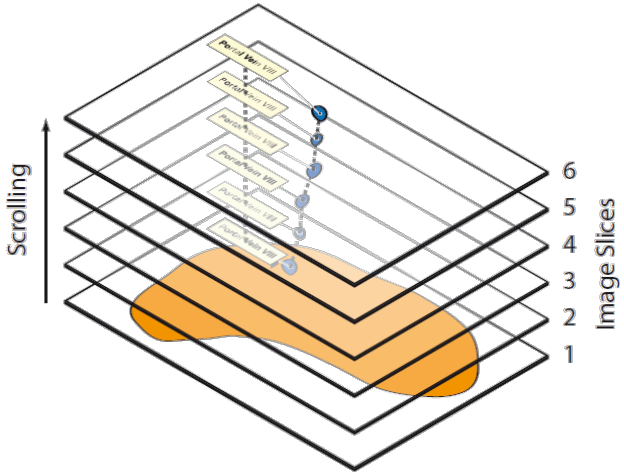
- General requirements [Ali et al. 2005, Hartmann et al. 2005]
  - *Readability* Labels must not overlap
  - *Unambiguity* Labels clearly refer to their objects
  - *Pleasing* Prevent visual clutter,
  - *Real-Time* Compute layouts at interactive rates
  - *Frame-Coherency* Prevent visual discontinuities
  - *Compaction* Reduce the layout area



[Ali2005]

Foundation: Effective Labeling

- Specific medical requirements
  - No occlusion of diagnostically relevant information
  - Indication of hidden structures for gapless evaluation
  - Labeling structures inside transparent context surfaces
  - In volume-rendered views, consider transparency transfer function in visibility tests
  - Labeling of slice-based visualizations
    - Slice-coherency of labels
    - Collective label for branching structures appearing disconnected in slice views, e.g., vessels

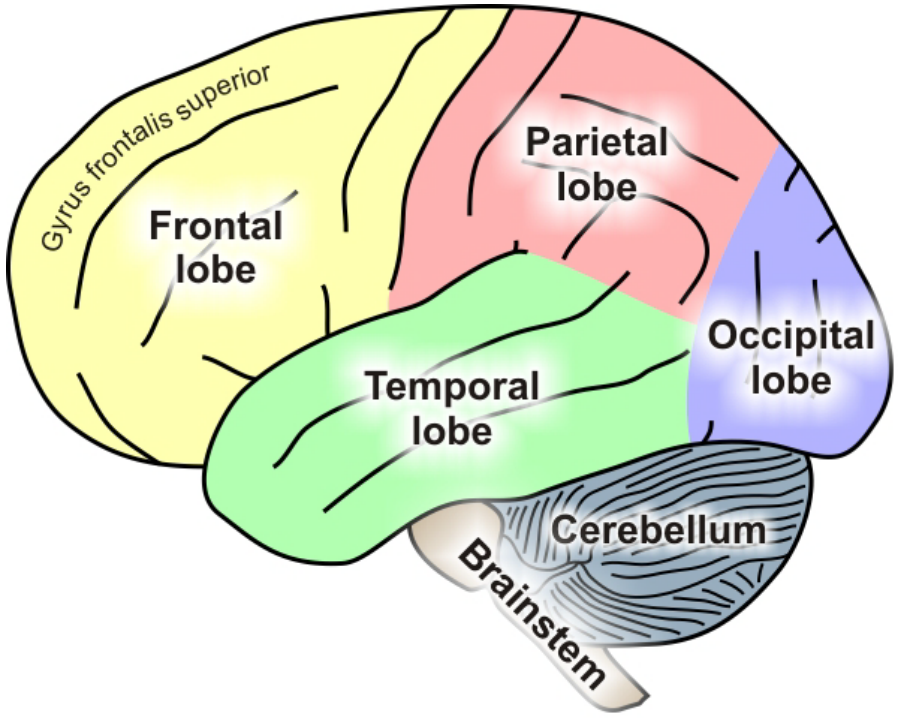


[Mühler&Preim2009]

Foundation: Labeling Techniques

Internal Labels

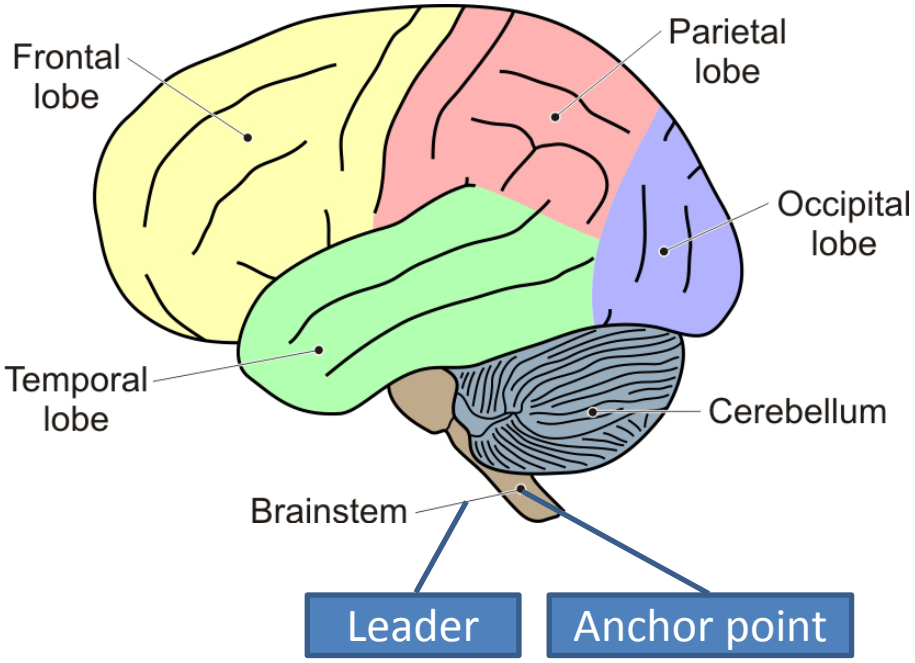
- Superimposed on structures
- Should fit in structure's screen projection
- Sufficient font size and contrast to background
- Horizontal alignment is preferred



Foundation: Labeling Techniques

External Labels

- Positioned on empty screen space
- Connected via *leaders* to *anchor points*
- Often aligned along silhouette of structures
- Automatic placement is an optimization problem

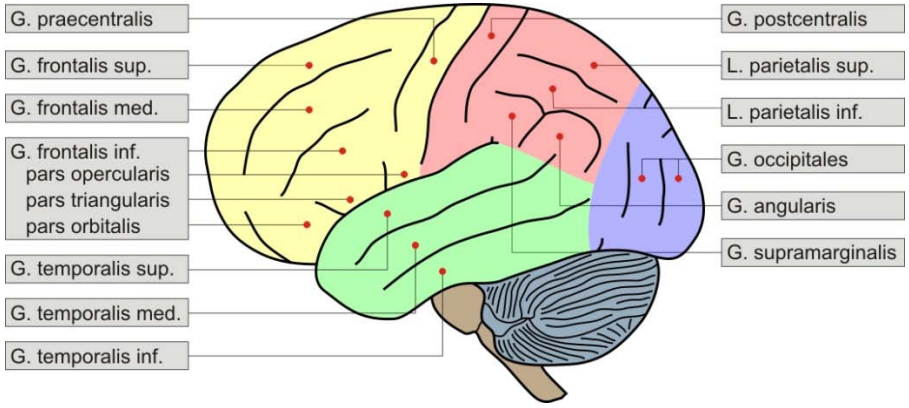


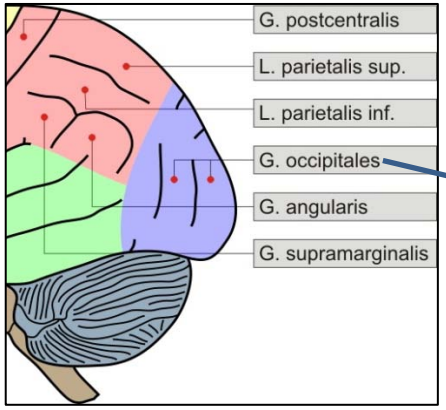
Foundation: Labeling Techniques

Boundary Labeling

term coined in [Bekos et al. 2005]

- Label alignment along bounding rectangle
- Very tidy layout
- Label positions remain fixed in interactive views
- Again, placement requires optimization
- *Many-to-one labeling*





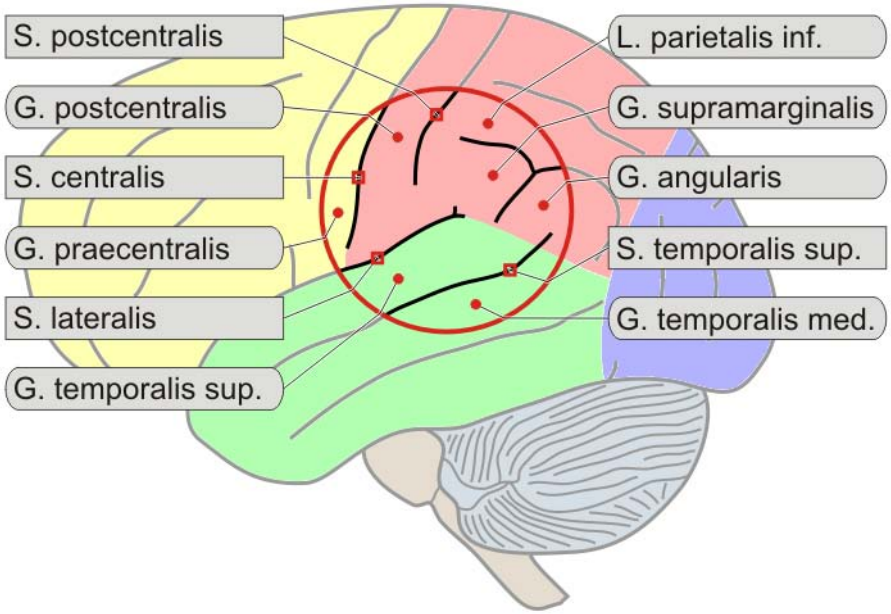
Many-to-one labeling

Foundation: Labeling Techniques

Excentric Labeling

[Fekete&Plaisant 1999]

- Label subsets of dense data, not entire scene
- Moveable, flexible focus region dragged by user
- Labels stacked to left and right of region

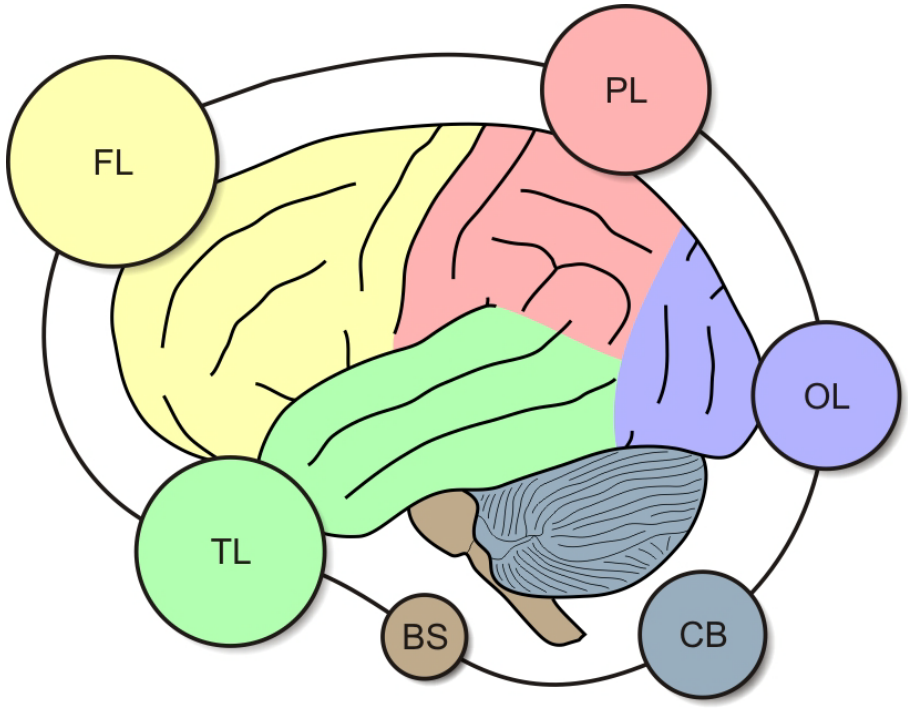


Foundation: Labeling Techniques

Necklace Maps

[Speckmann&Verbeek 2010]

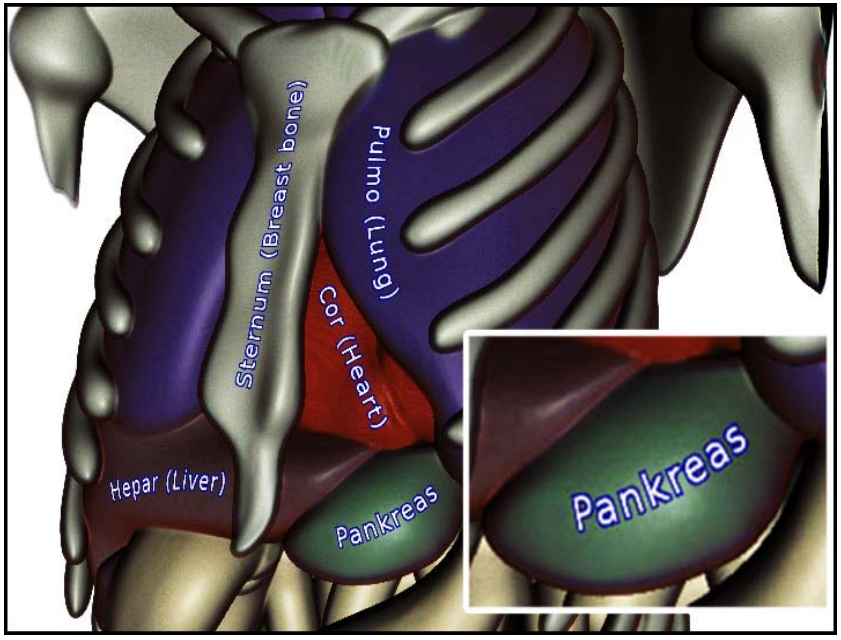
- Abandon leaders
- Relation of labels and structures via color and spatial proximity
- *Symbols* (labels) strung on 1D-curve (necklace)
- Symbol size encodes data attribute



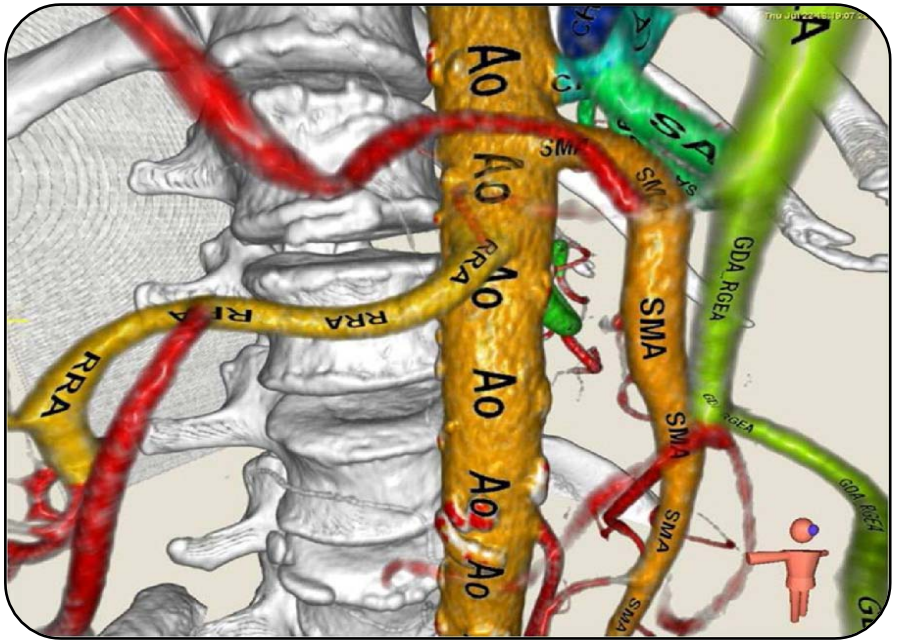
Labeling Examples

Internal labels

- Ropinski et al. 2007
- Convey 3D shape of surface by label projected onto it



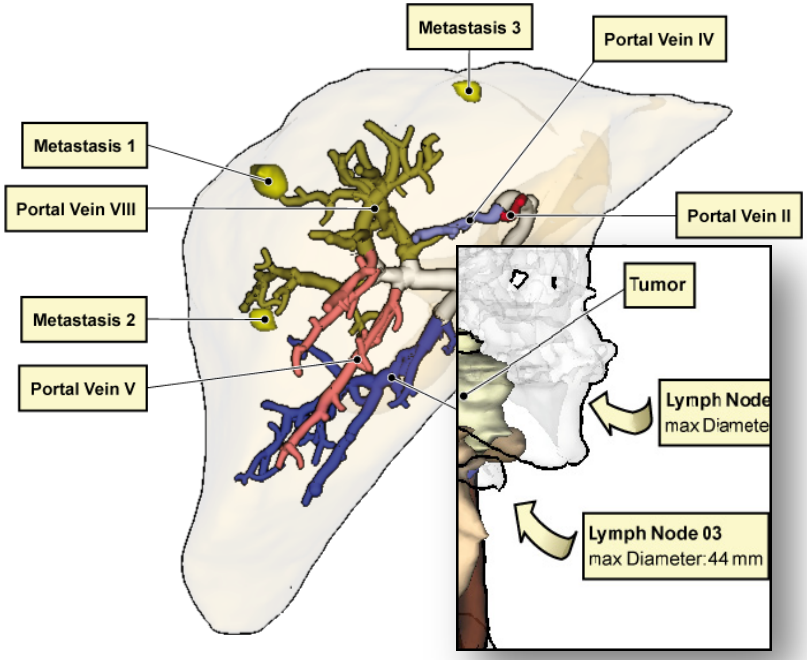
- Jiang et al. 2013
- Multiple labels for branching, mutually occluding structures



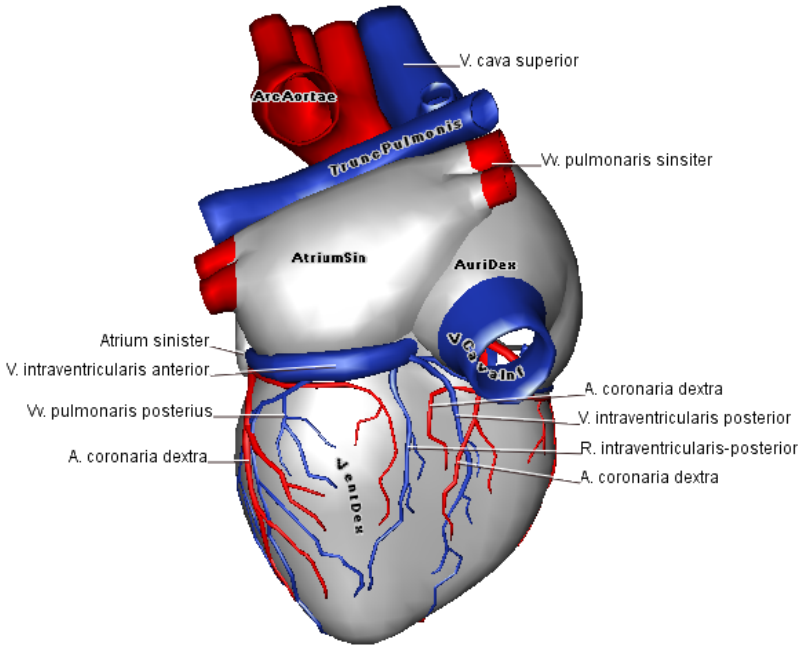
Labeling Examples

External labels

- Mühler and Preim 2009
- Transparency-aware labeling and labeling hidden objects



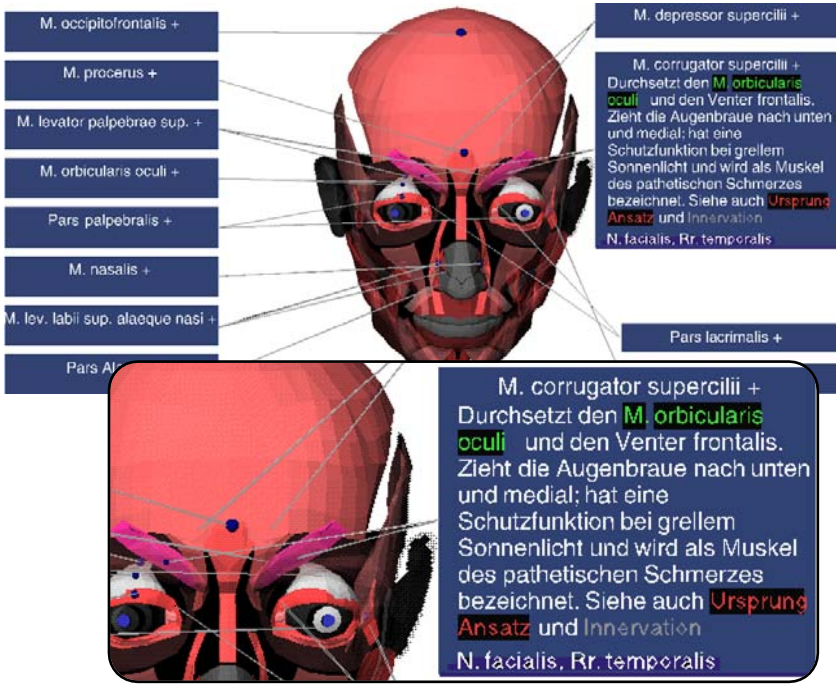
- Götzelmann et al. 2005
- Hybrid label layout combining internal and external labels



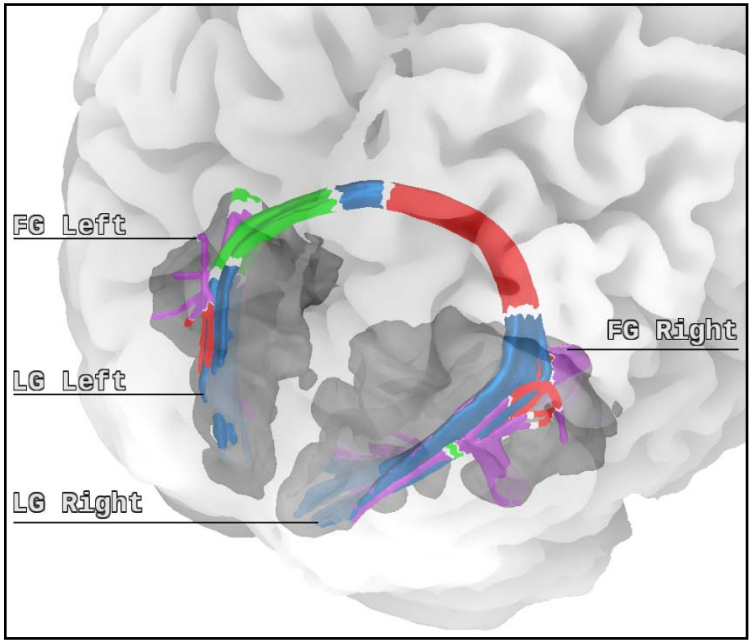
Labeling Examples

Boundary Labeling

- Preim et al. 1997
- Interactive labels combined with fisheye zooming



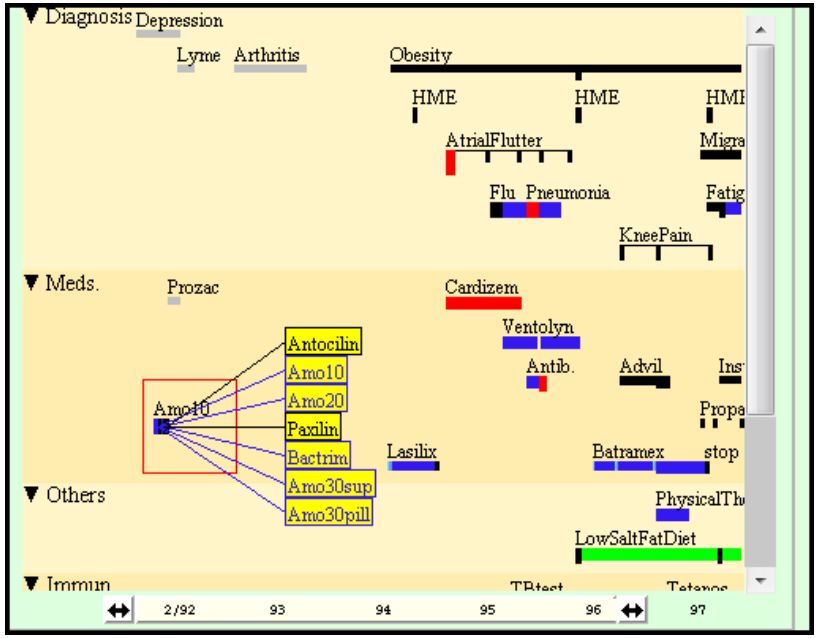
- Eichelbaum et al. 2010
- Label positions not restricted to reserved screen area



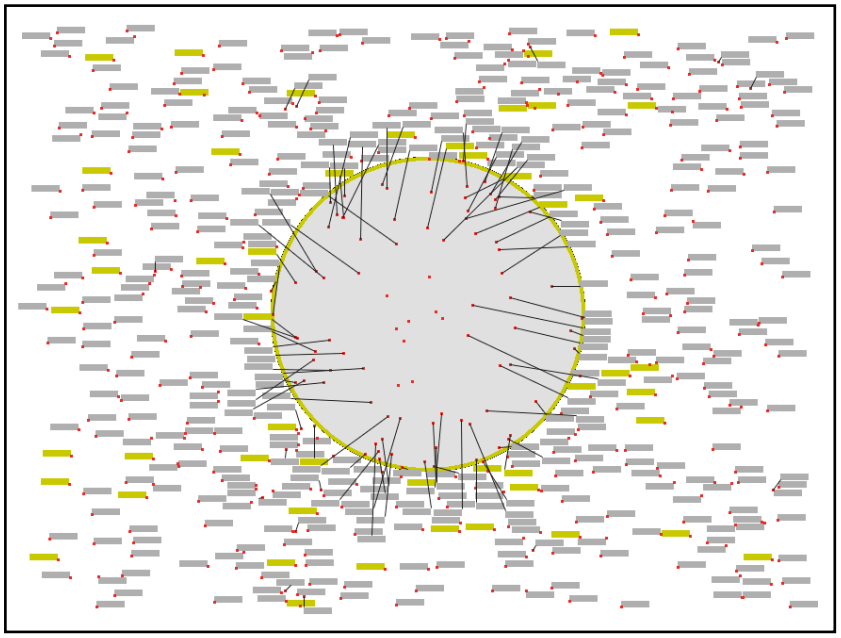
Labeling Examples

Excentric labeling

- Fekete and Plaisant 1999
- Labeling of dense, point-based data representations



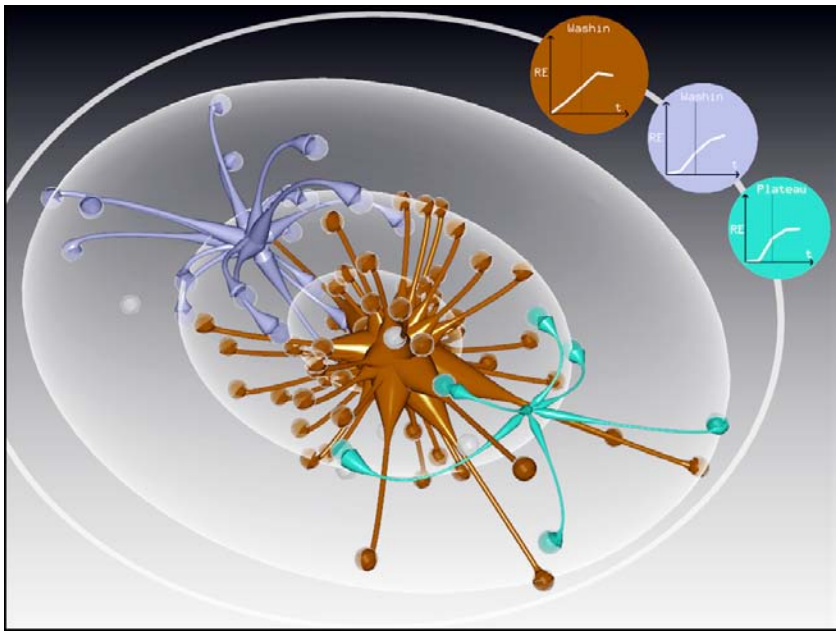
- Luboschik et al. 2008
- Avoidance of labels occluding other visual features



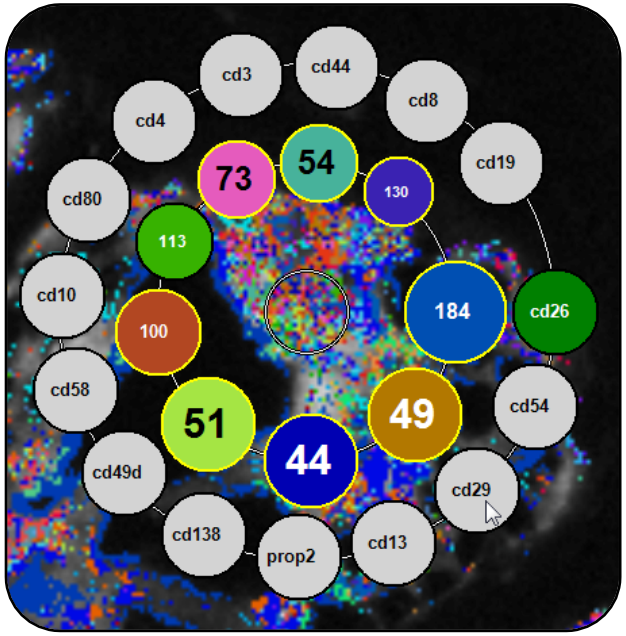
Labeling Examples

Necklace maps

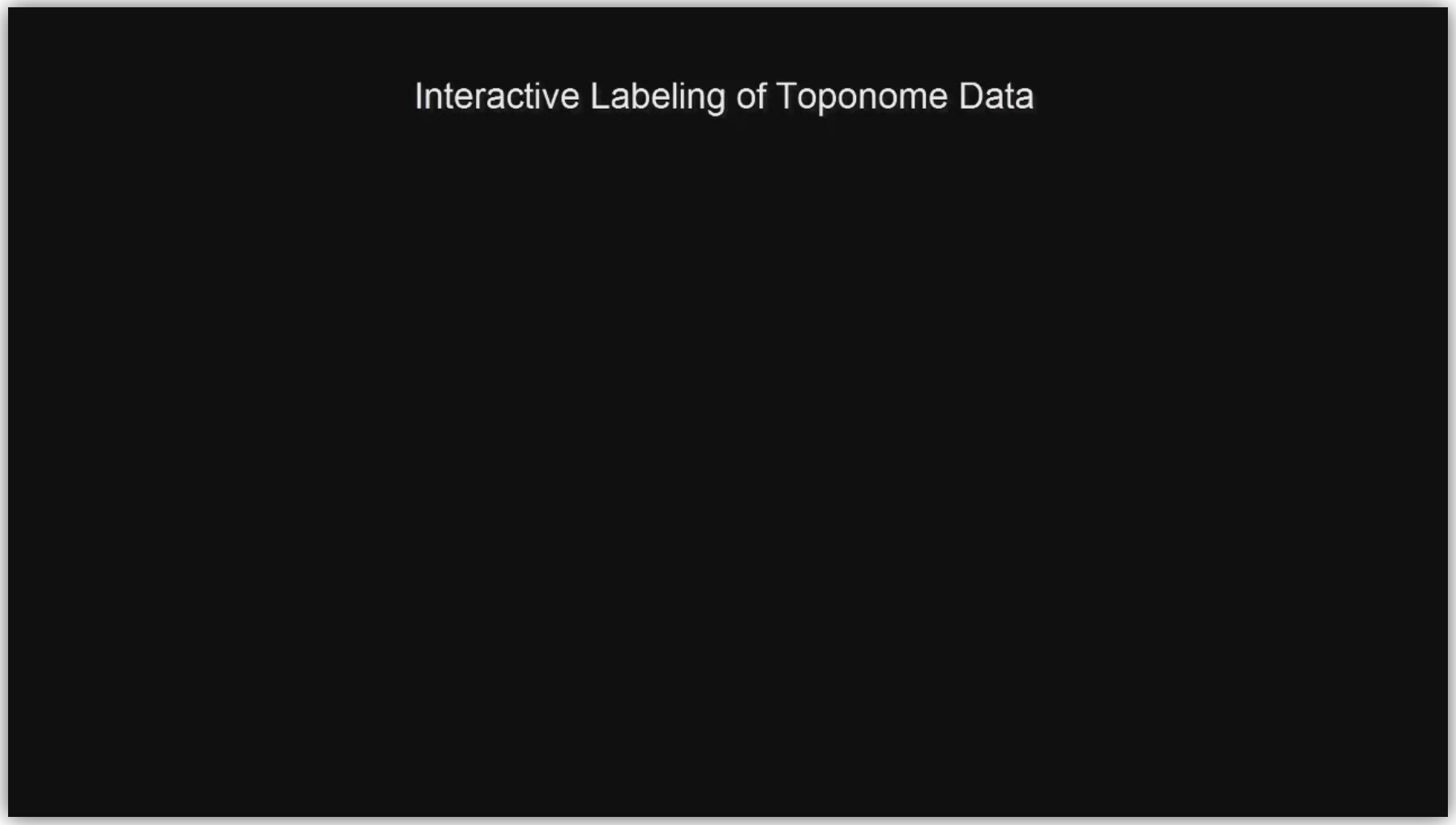
- Glaßer et al. 2014
- Abstract vis. of breast tumor regions and their perfusion



- Oeltze-Jafra et al. 2014
- Nested necklaces for vis. of protein colocalization patterns



Labeling Examples

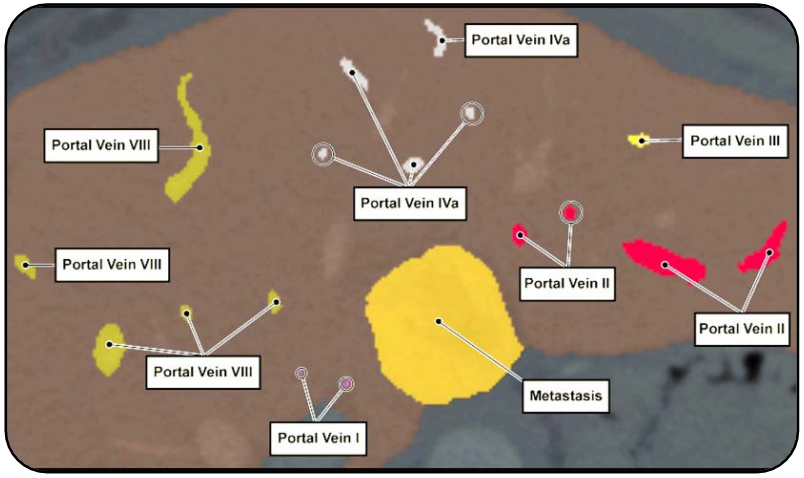


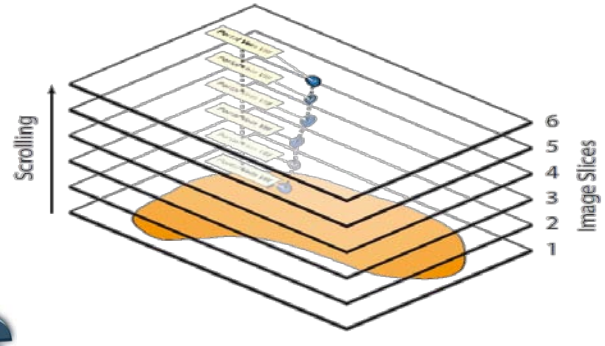
Oeltze-Jafra et al.: “Interactive Labeling of Toponome Data”, Proc. of Eurographics Workshop on Visual Computing for Biology and Medicine (EG VCBM), pp. 79-88, 2014

Labeling Examples

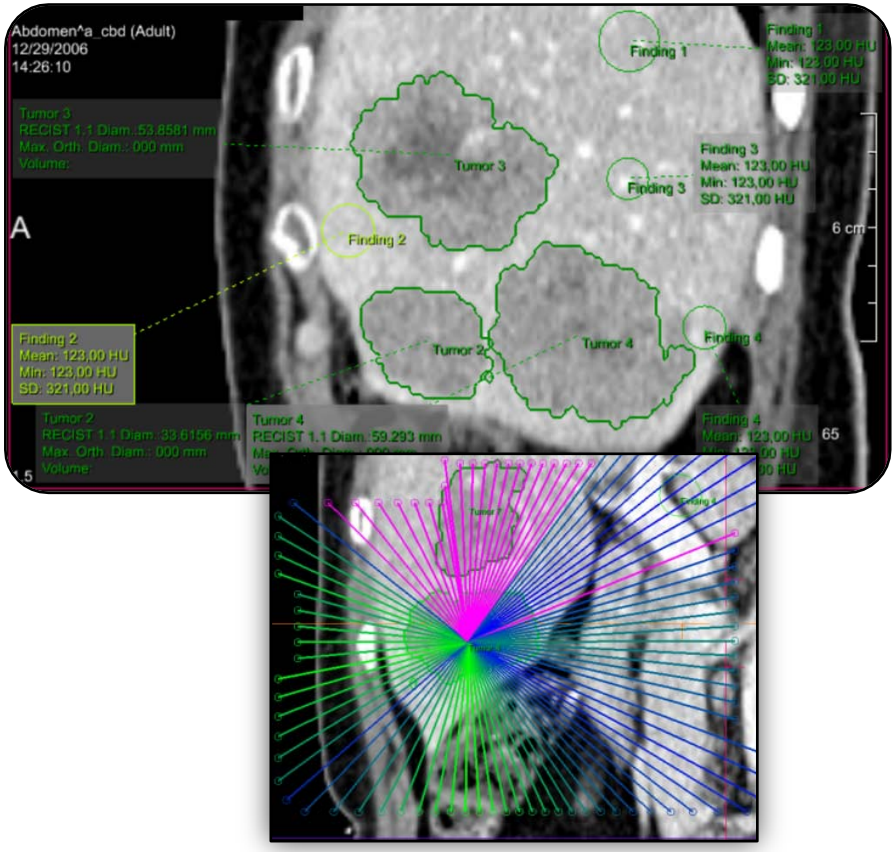
Labeling slice-based visualizations

- Mühler and Preim 2009
- Many-to-one labeling and slice coherency



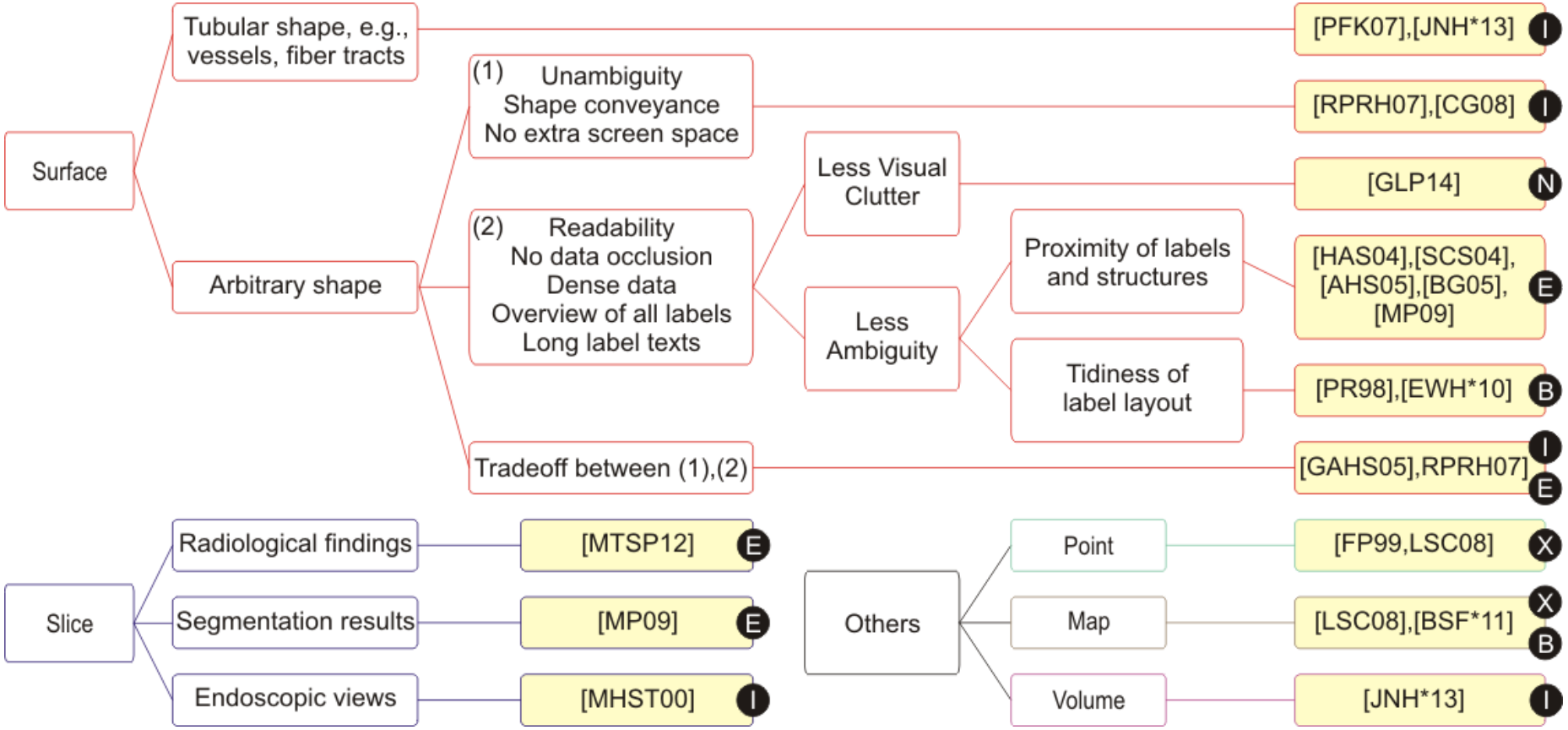


- Mogalle et al. 2012
- Optimal label placement for reading images in radiology



Guidelines for Labeling

Decision diagram



I = internal labels, E = external labels, B = boundary labeling,
X = excentric labeling, N = necklace maps

Future Research Directions of Labeling

- Labeling volume rendered data [Jiang et al. 2013]
  - Take transfer functions into account
- Learn from labeling of (street) maps [Been et al. 2006]
  - Level-of-detail labeling
    - Show less/more labels dependent on zoom level
  - Label only currently visible portion of the data
    - Seamlessly update during interaction
    - Example: high-resolution microscopy images
- Labeling data with high local entropy, e.g., microscopy data [Oeltze-Jafra et al. 2014] or biological networks [Heinsohn et al. 2014]
- Compute label layout in 3D object instead of 2D image space to resolve frame-coherency issues [Tatzgern et al. 2014]

Literature

To get an overview:

Oeltze and Preim: “Survey of Labeling Techniques in Medical Visualizations”, Proc. of Eurographics Workshop on Visual Computing for Biology and Medicine (EG VCBM), pp. 199-208, 2014.

For more details:

See list of references in the abovementioned survey paper, which includes all references used in the tutorial, except for:

[Heinsohn2014] “Boundary Labeling Methods for Dynamic Focus Regions”. Proc. of PacificVis, pp. 243-247, 2014.

[Tatzgern2014] “Hedgehog Labeling: View Management Techniques for External Labels in 3D Space”. Proc. of iEEE Virtual Reality (VR), pp. 27-32, 2014.