Spatial data

Data Visualization

Amit Chourasia

Why arrange?

We are given spatial information, thus usual design choices (express, separate, order, align) are not available.

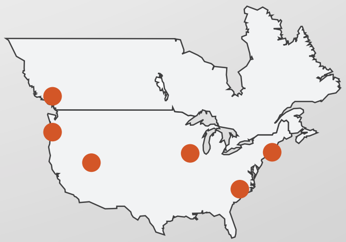
Spatial data types

- Geometry
- Spatial fields

Arrange Spatial Data

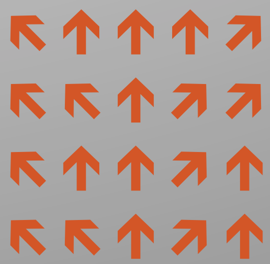
➔ Use Given

- ➔ Geometry
  - ➔ *Geographic*
  - ➔ *Other Derived*



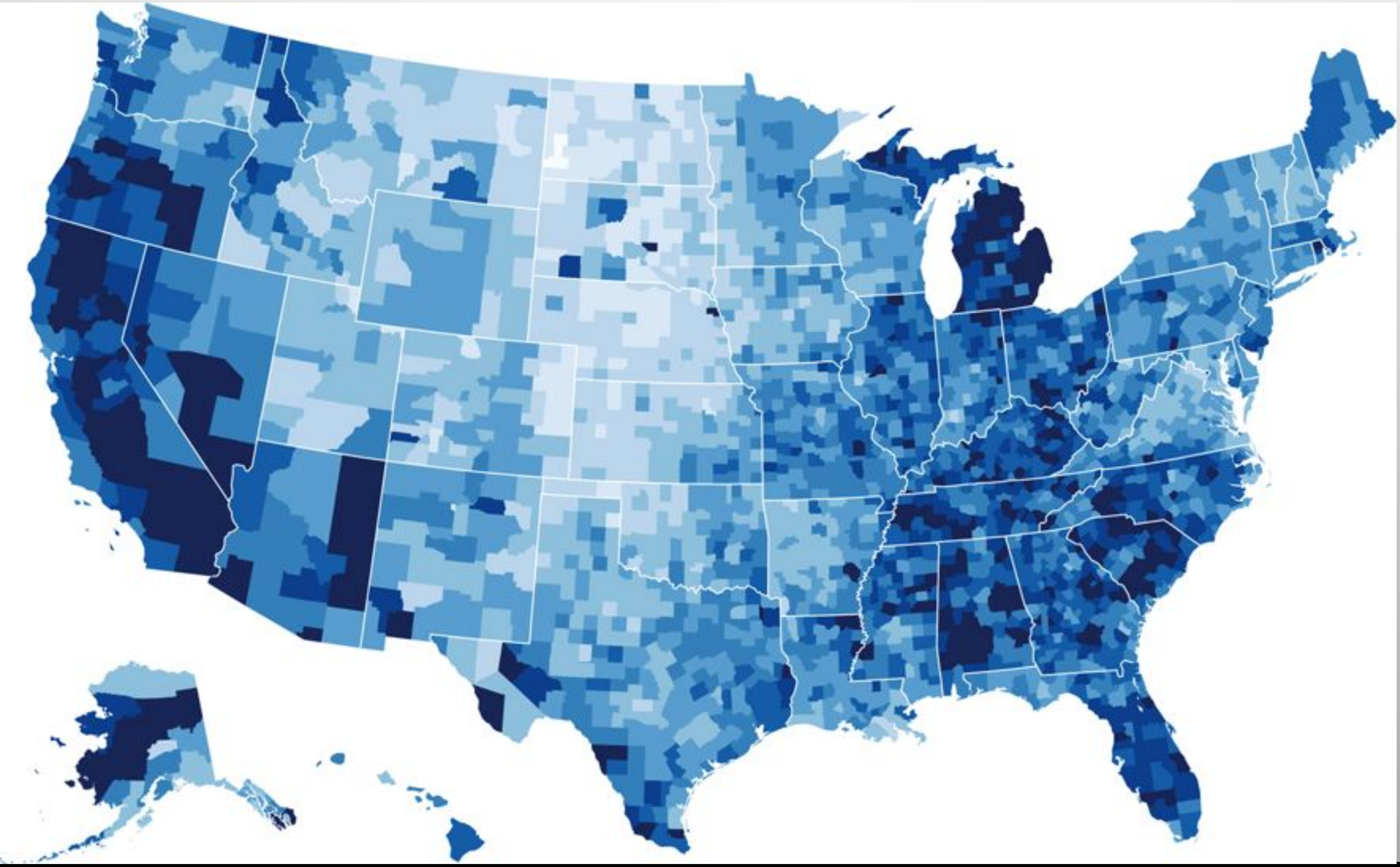
- ➔ Spatial Fields
  - ➔ *Scalar Fields (one value per cell)*
    - ➔ *Isocontours*
    - ➔ *Direct Volume Rendering*

  - ➔ *Vector and Tensor Fields (many values per cell)*
    - ➔ *Flow Glyphs (local)*
    - ➔ *Geometric (sparse seeds)*
    - ➔ *Textures (dense seeds)*
    - ➔ *Features (globally derived)*



Figures by Eamonn Maguire

Choropleth map



US unemployment rates (2008)
0 % - 15%
(light to dark)

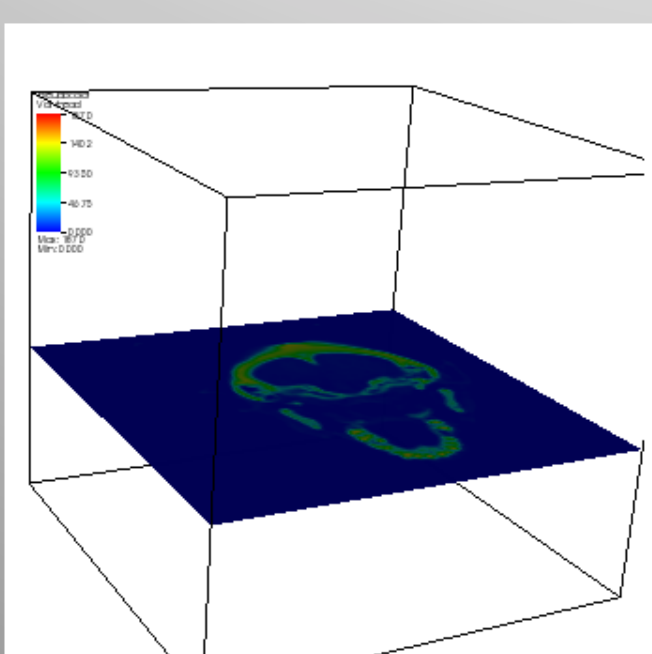
Idiom	Choropleth Map
What: Data	Geographic geometry data. Table with one quantitative attribute per region.
How: Encode	Space: use given geometry for area mark boundaries. Color: sequential segmented colormap.

Figures by Mike Bostock

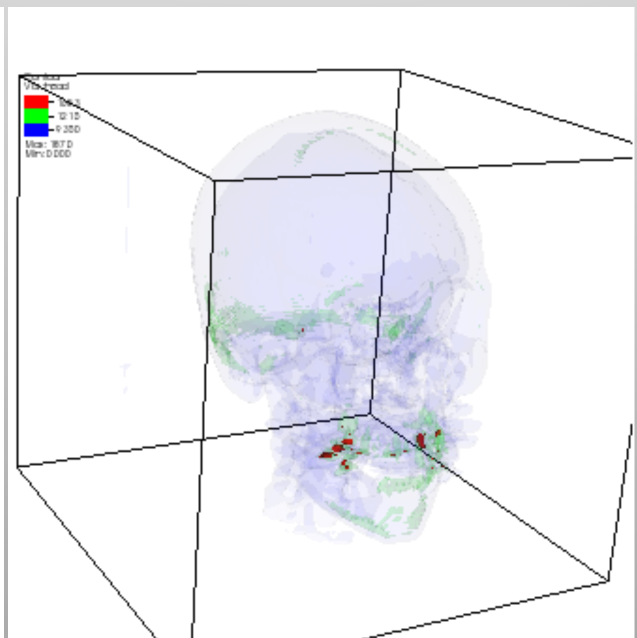
Design choices: Spatial - Scalar fields

Single value per spatial cell

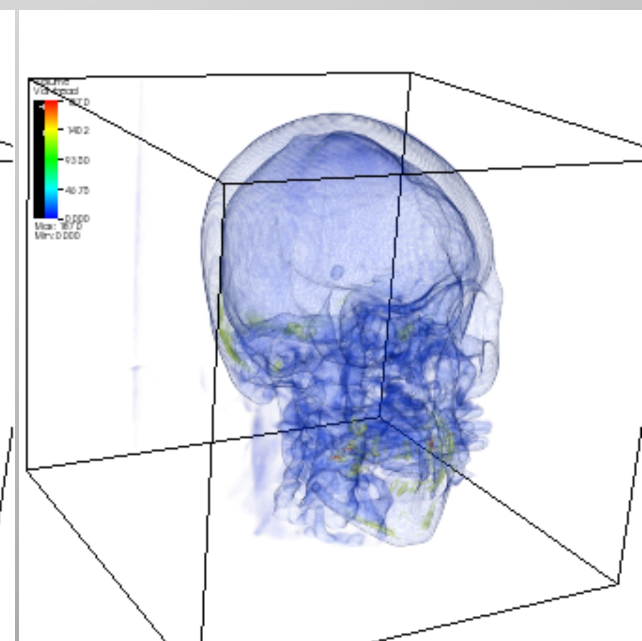
- Slice
- Isocontours/Isosurfaces (3d data only)
  - Isocontours – set of isolines that represents contours of a specific scalar value. Isolines are always closed and usually never overlap.
- Volume rendering (3d data only)



Slice



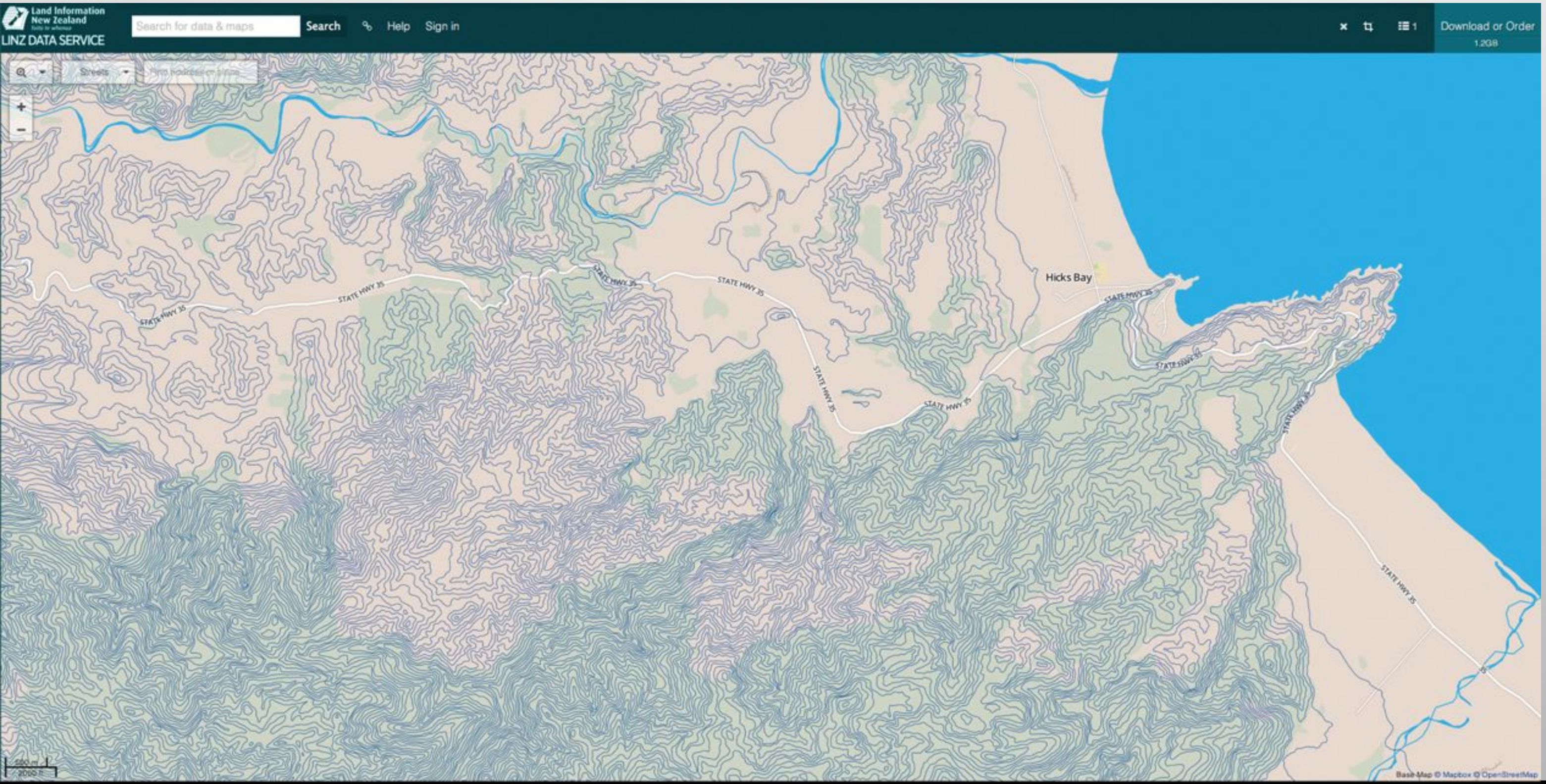
Isosurfaces



Volume rendering

Topographic terrain map

Displays levels of equal elevation on a map

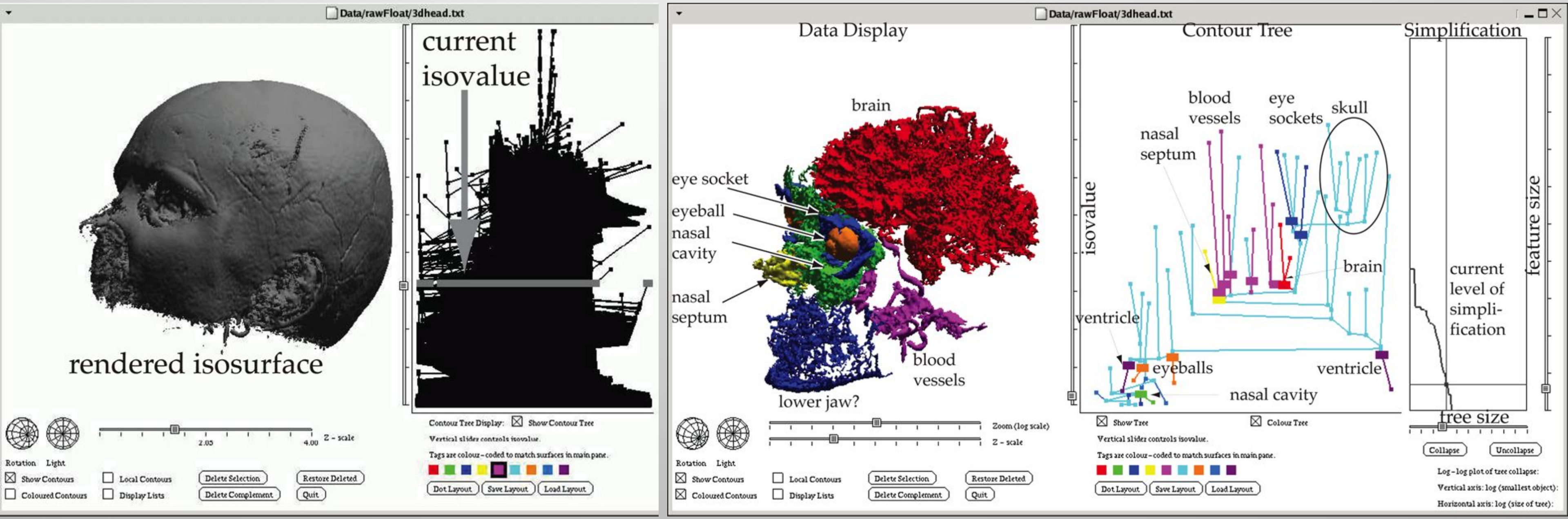


Idiom	Topographic terrain map
What: Data	2D spatial field; geographic data.
What: Derived	Geometry: set of isolines computed from field.
How: Encode	Use given geographic data geometry of points, lines, and region marks. Use derived geometry as line marks (blue).
Why Tasks	Query shape.
Scale	Dozens of contour levels.

Figures by [New Zealand LINZ data service]

Flexible isosurfaces

Derive a simplified contour tree which tracks join, split, disappearance and appearance of individual components as the isovalue changes.

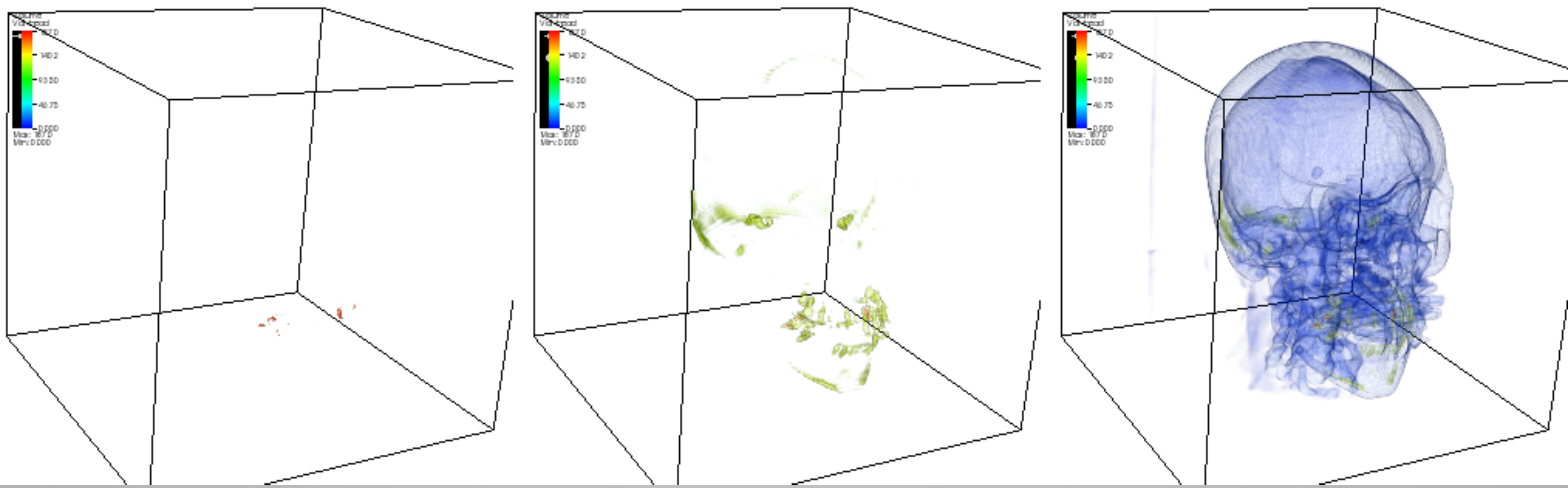


Idiom	Flexible Isosurfaces
What: Data	Spatial field.
What: Derived	Geometry: surfaces. Tree: simplified contour tree.
How: Encode	Surfaces: use given. Tree: line marks, vertical spatial position encodes isovalue.
Why Tasks	Query shape.
Scale	One dozen contour levels.

Figures by Carr et al.

Volume rendering

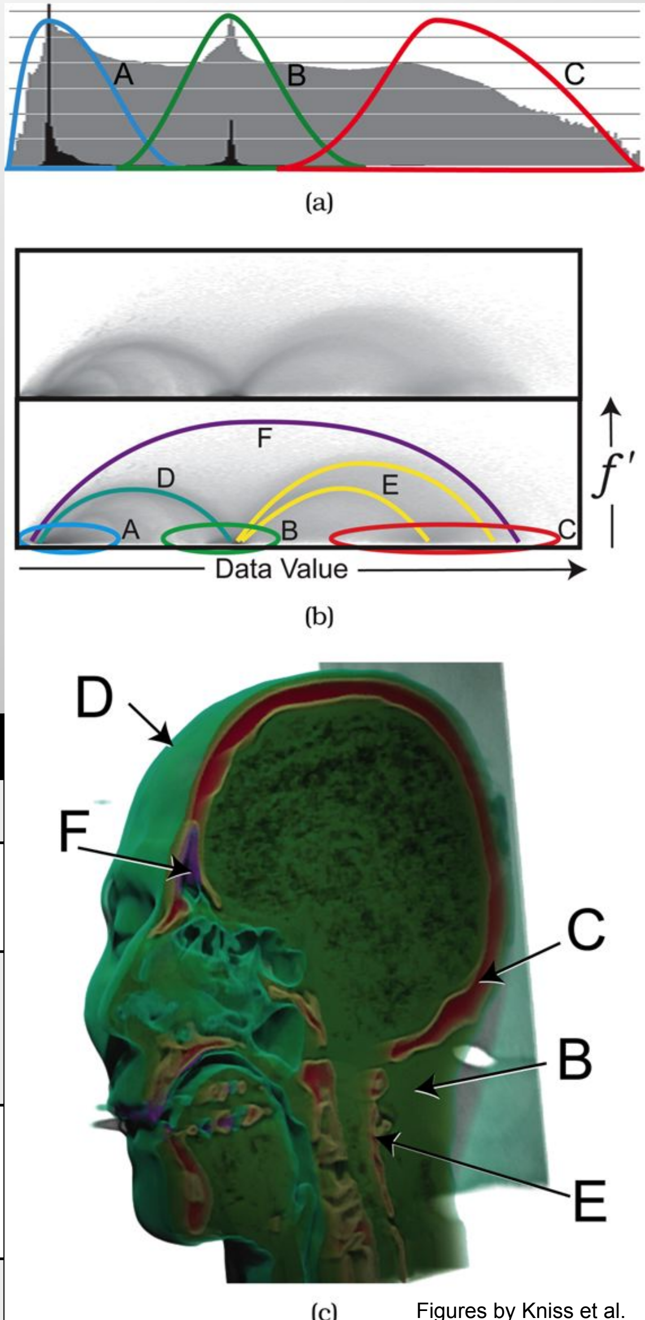
Creation of an image directly from scalar data using a model (transfer function) that mimics accumulation of light transport through a volume.



Idiom	Volume rendering
What: Data	Spatial field.
How: Encode	Volume rendering with specified transfer function
Why Tasks	Investigate volume

Volume rendering – Multidimensional transfer function

Idiom	Volume rendering
What: Data	3D spatial field.
What: Derived	3D spatial field: gradient of original field.
What: Derived	Table: two key attributes, values binned from min to max for both data and derived data. One derived quantitative value attribute (item count per bin).
How: Encode	3D view: use given spatial field data, color and opacity from multidimensional transfer function. Joint histogram view: area marks in 2D matrix alignment, grayscale sequential colormap.
Why Tasks	Investigate volume



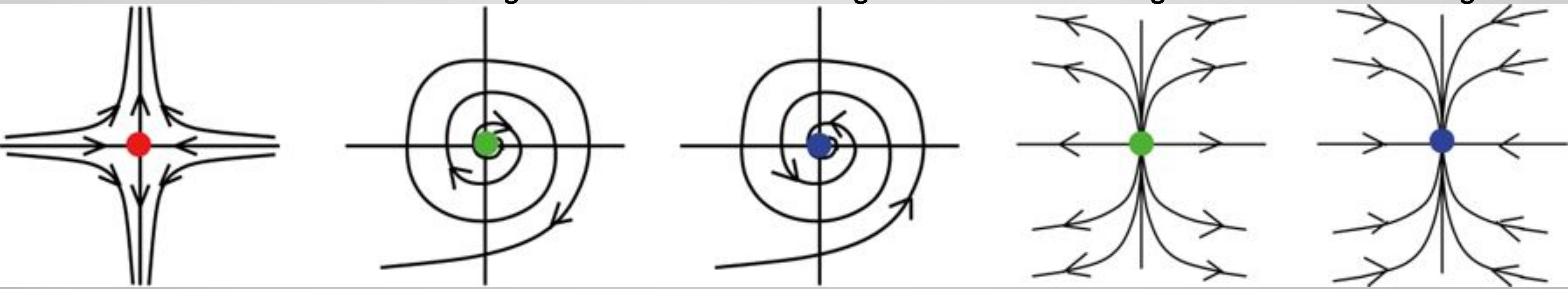
Figures by Kniss et al.

Design choices: Spatial - Vector fields

Multiple value per spatial cell

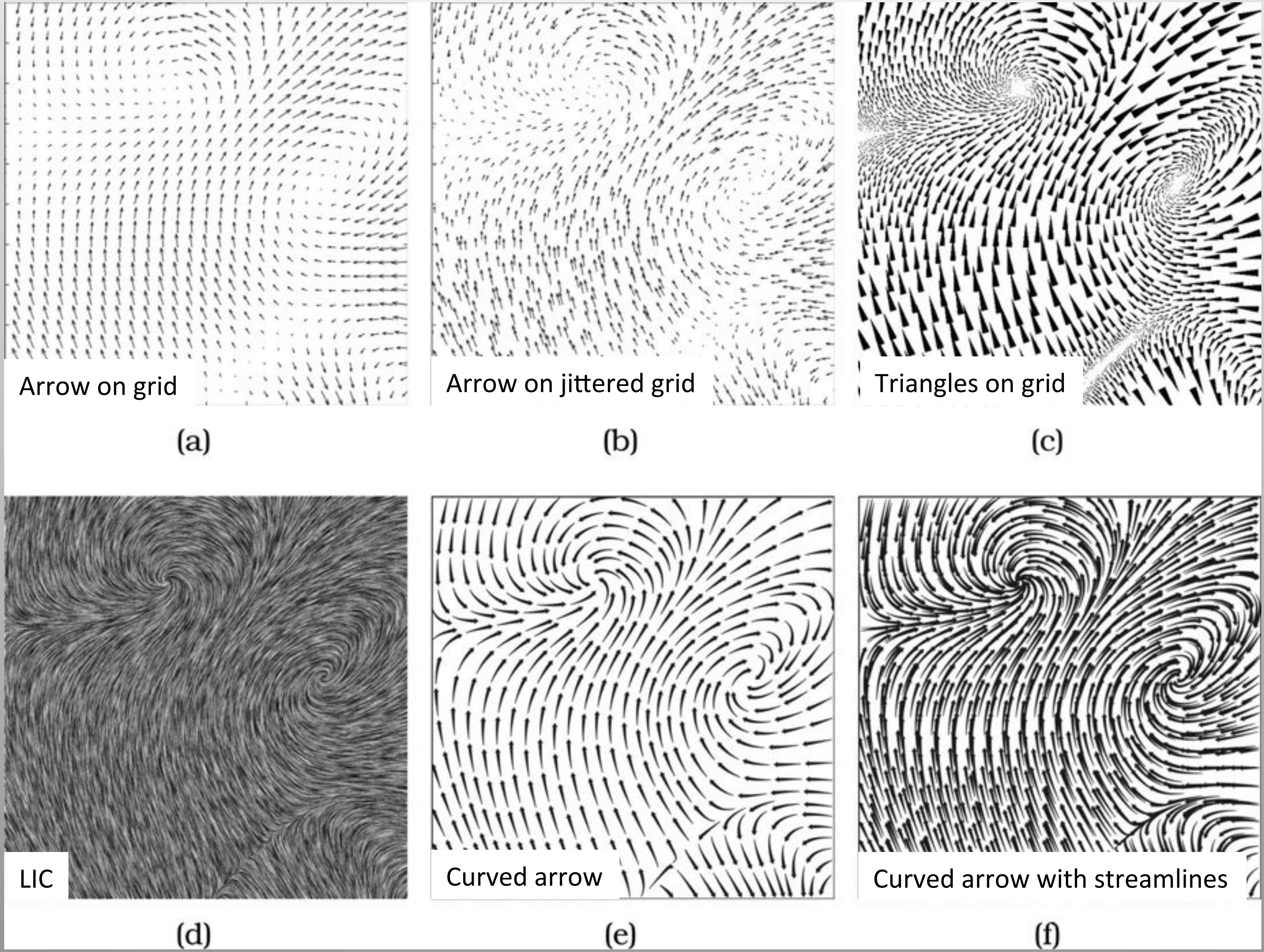
Flow vectors have five critical points (where flow field vanishes) of first order

Saddle **Circulating source** **Circulating sink** **Noncirculating source** **Noncirculating sink**



Figures by Tricoche et al.

Flow glyph study



LIC example by Suoqing Ji

Figures by Laidlaw et al.

Geometric flow

Compute derived geometric data from source.

Streamline – trajectory a particle will follow in steady state

Pathline – trajectory a particle will follow in (unsteady) time varying field

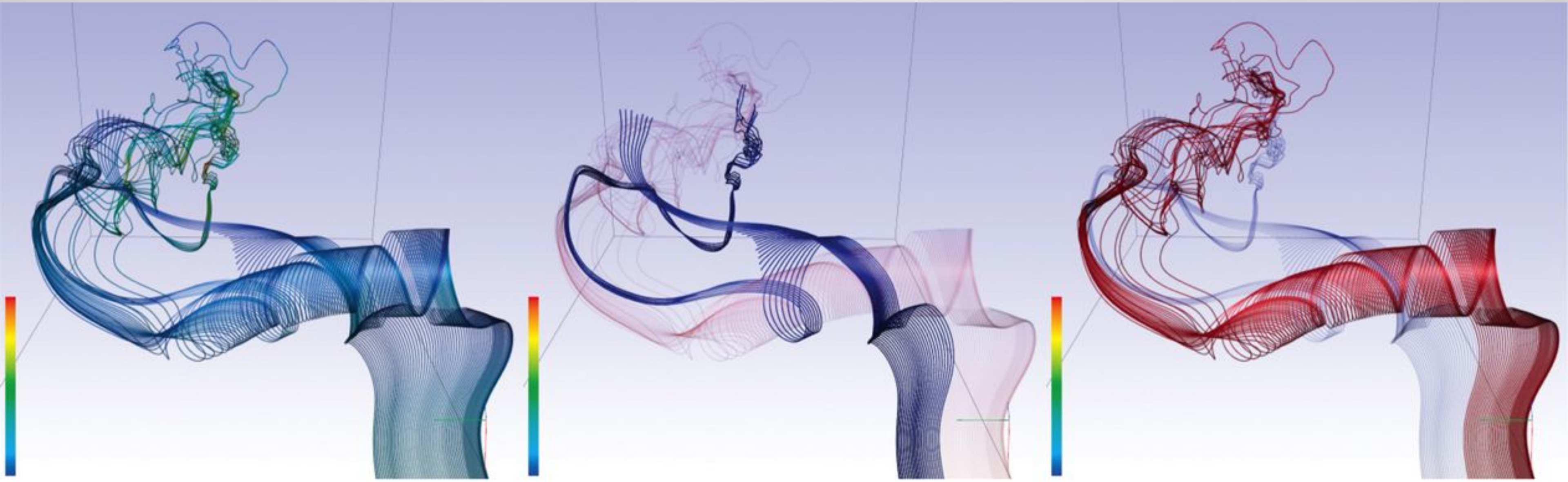
Streakline – trajectory of all particles that pass through specific point in space

Timeline – Connecting front of pathlines over time

Similarly stream surfaces, path surfaces, streak surfaces and time surfaces.

Similarity-Clustered Streamlines

Compute streamline and path line, then derive signature attribute based on curvature (deviation from line), torsion (bend out of plane) and tortuosity (twistedness). Construct a similarity matrix and then a hierarchy.



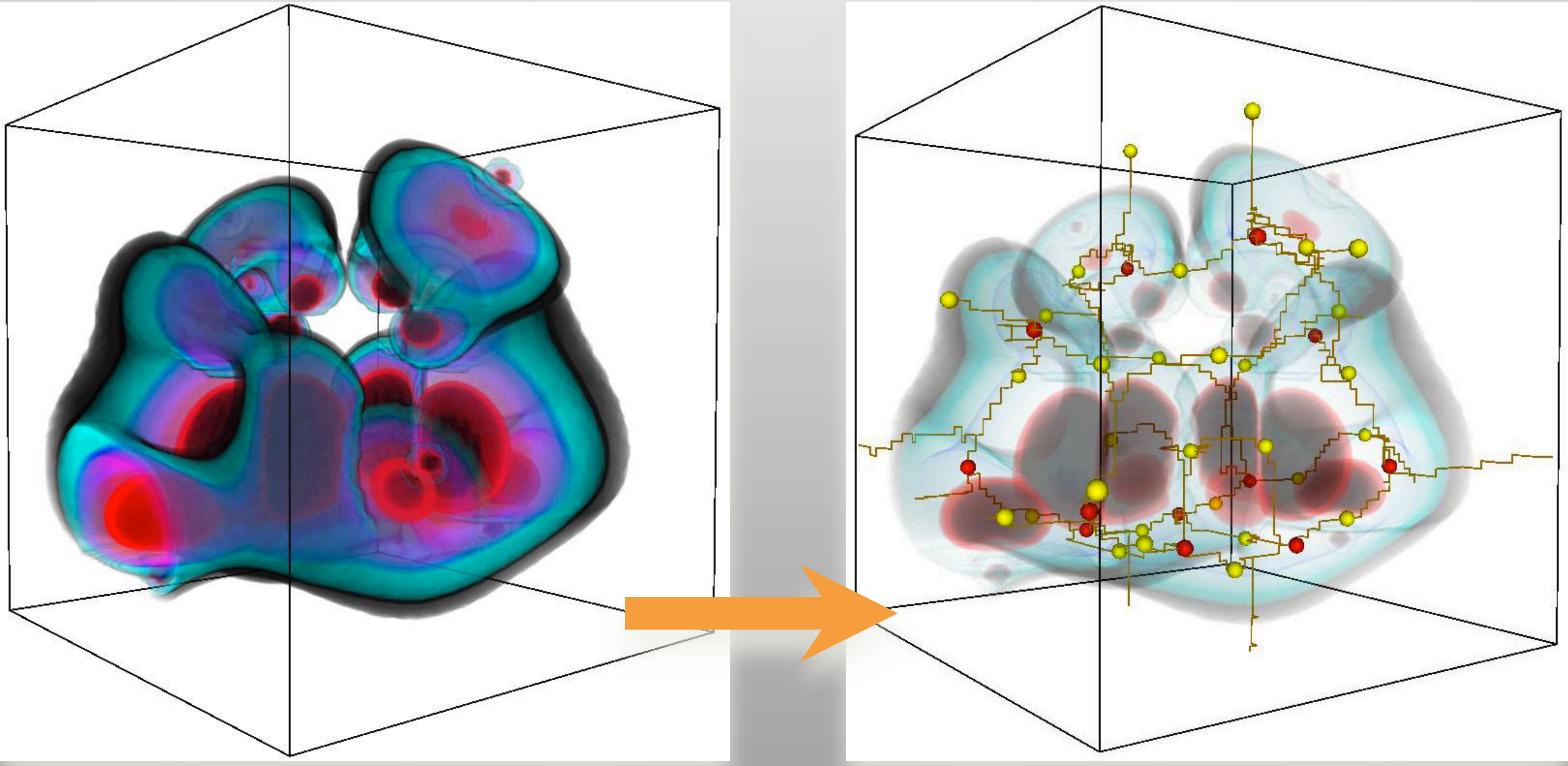
Idiom	Volume rendering
What: Data	Spatial field: 3D vector field.
What: Derived	Geometry: streamlines or pathlines.
What: Derived	One attribute per streamline/pathline (signature).
What: Derived	Cluster hierarchy of streamlines/pathlines.
How: Encode	Use derived geometry of lines, color, and opacity according to cluster.
Why Tasks	Find features, query shape.
Scale	Field: millions of samples. Geometry: hundreds of streamlines.

Figures by McLoughlin et al.

Design Choice: Vector field - Topological

Compute topology of underlying data

Utility: To investigate local maxima, minima, saddle points, etc.



Images: Courtesy of Sean Ahern, NICS

Design choices: Spatial – Tensor fields

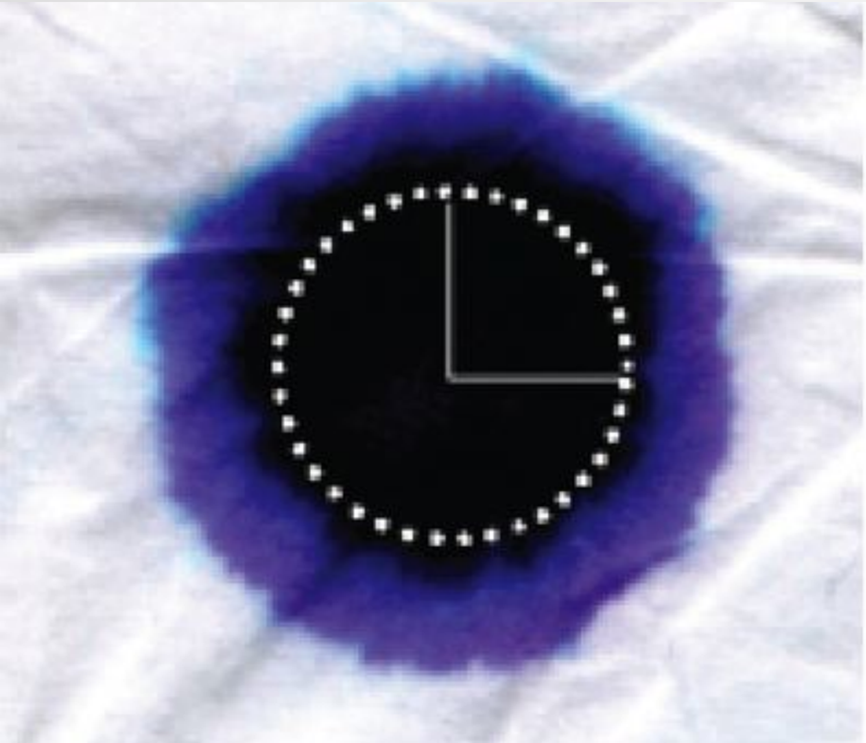
Matrix per spatial cell e.g. PCA, Stress, Strain

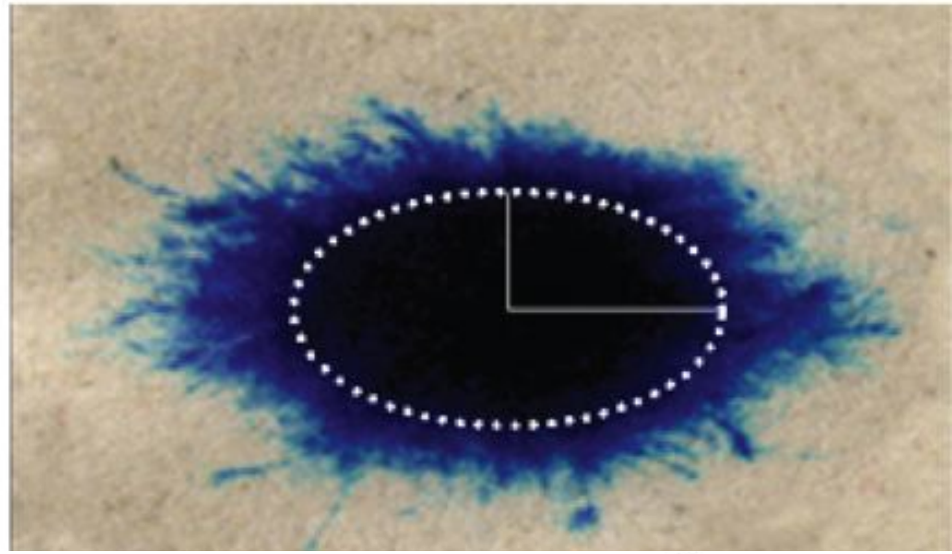
Same idiom as vector data using glyphs

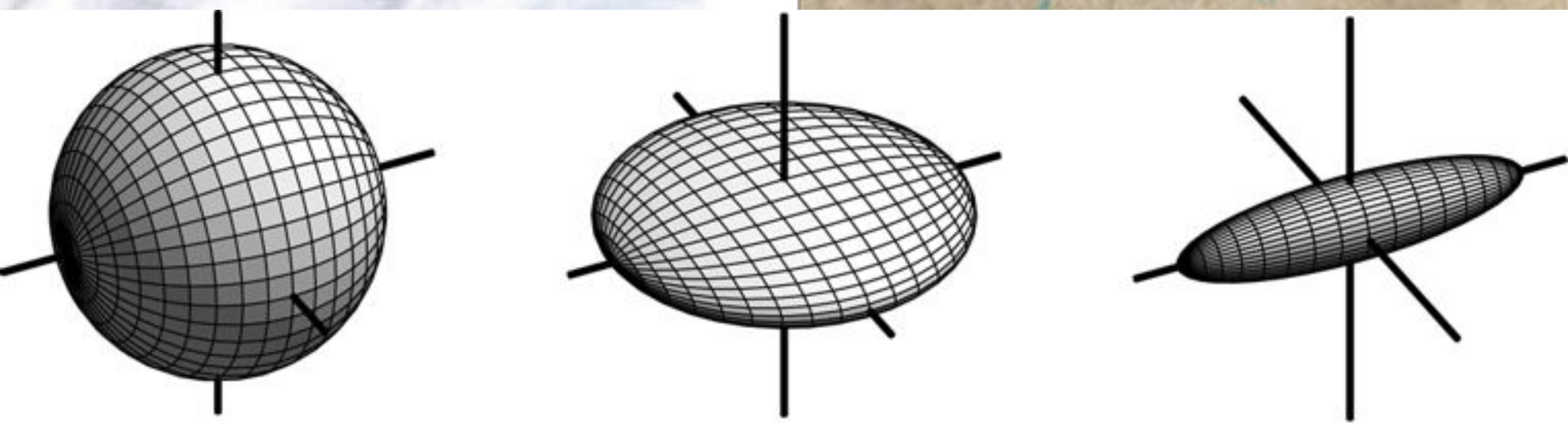
Control shape, orientation, appearance to encode tensor field

Figures by Tricoche et al.

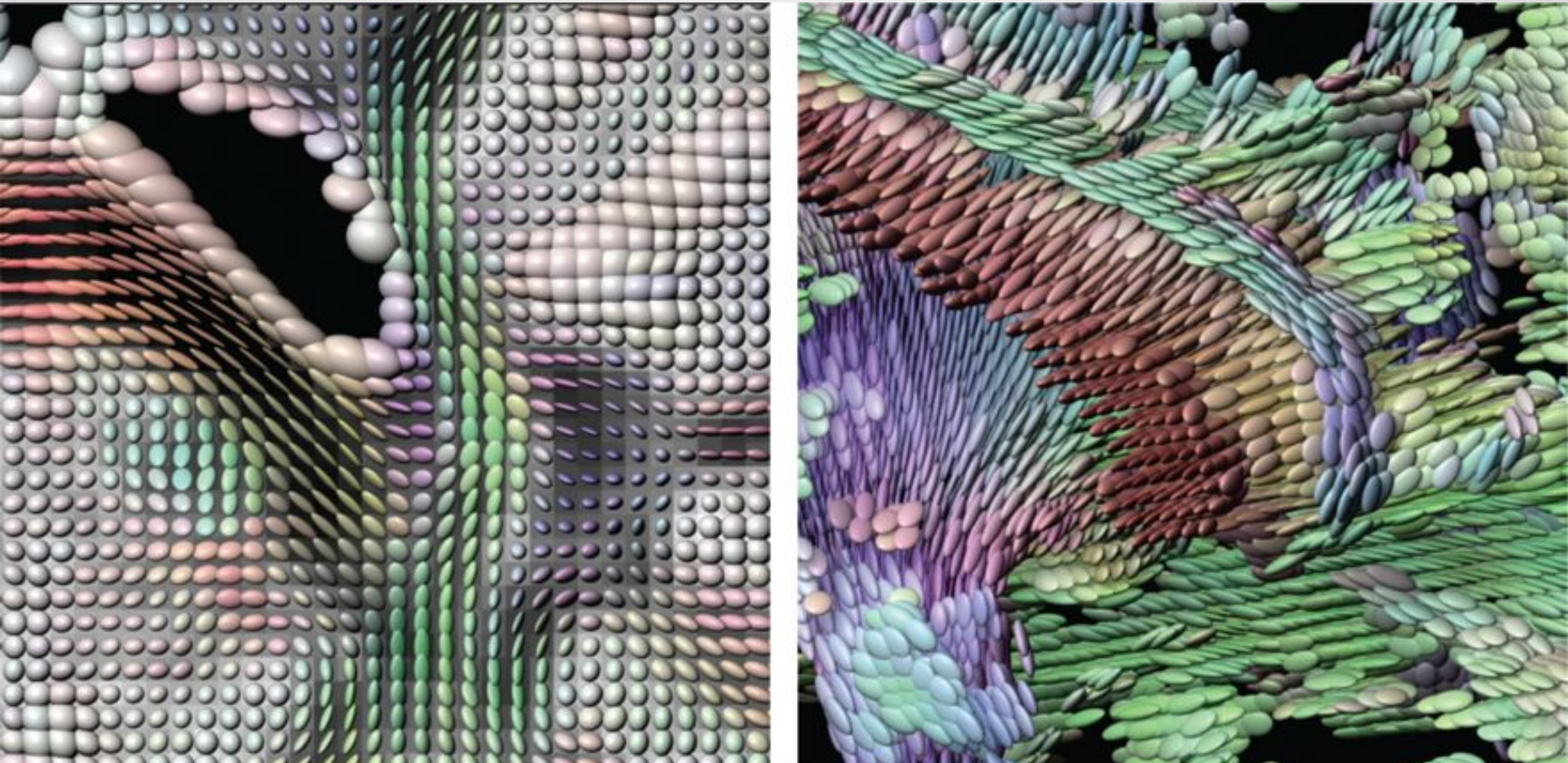
Symmetric tensor glyphs motivation (Diffusion)







Diffusion Tensor MRI



Idiom	Ellipsoid tensor glyphs
What: Data	Spatial field: 3D tensor field.
What: Derived	Three quantitative attributes: tensor shape. Three vectors: tensor orientation.
How: Encode	Glyph showing six derived attributes, color and opacity according to cluster.

Figures by Kindlmann et al.

Asymmetric tensor visualization (2D)

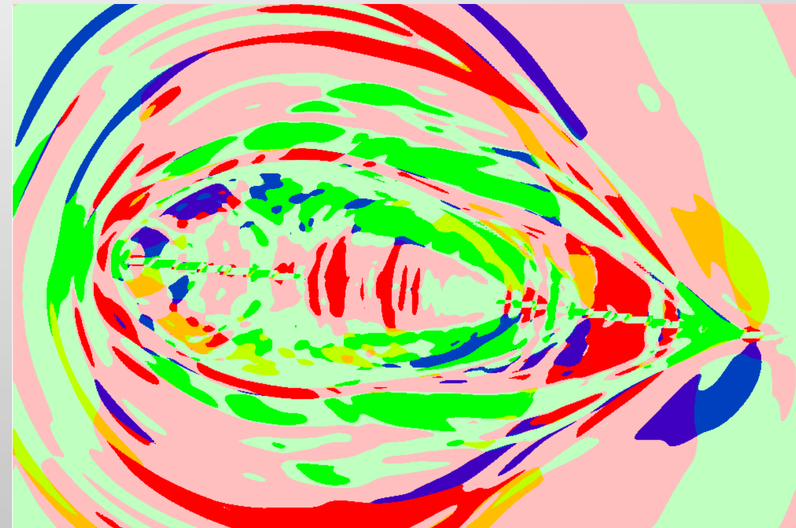
References

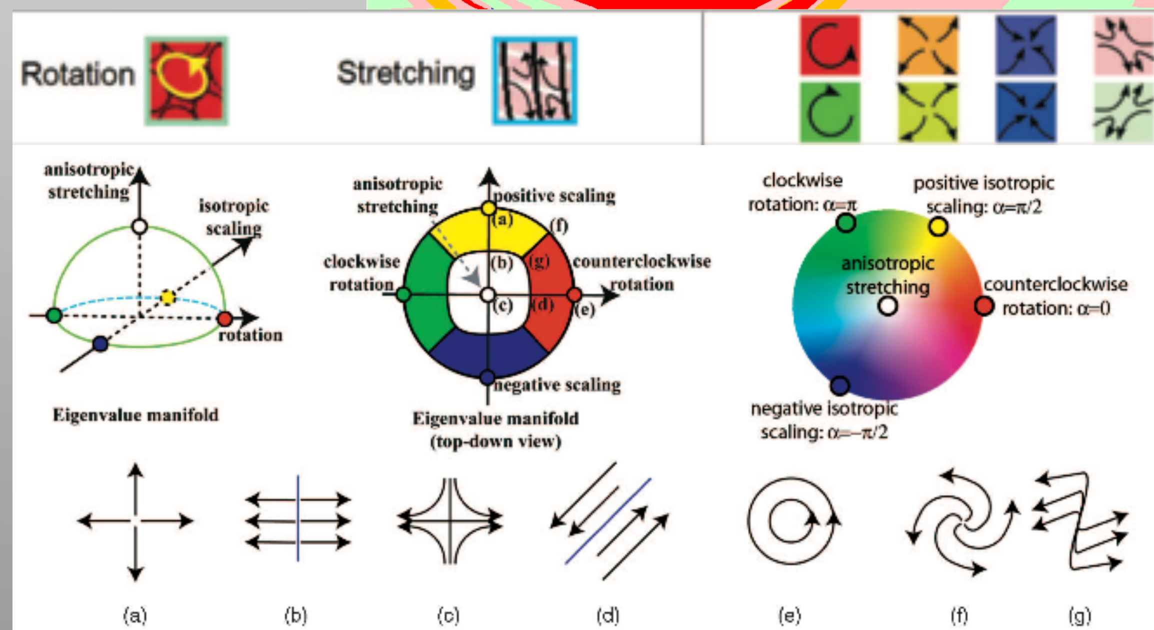
Asymmetric Tensor Analysis for Flow Visualization

Eugene Zhang, Harry Yeh, Zhongzang Lin, and Robert S. Laramee

Asymmetric Tensor Field Visualization for Surfaces

Guoning Chen, Darrel Palke, Zhongzang Lin, Harry Yeh, Paul Vincent, Robert S. Laramee and Eugene Zhang





Visualization Techniques

- **COLOR MAP (Pseudocolor)***
- **CONTOURS***, **ISOSURFACE*** AND EXPLICIT GEOMETRY
- **VOLUMETRIC***
- STREAMLINES
- LINE INTEGRAL CONVOLUTION
- GLYPHS
- TOPOLOGICAL (advanced)
- **PARALLEL COORDINATES***, NETWORKS, ETC.

* We will create these plots using VisIt in the hands-on session.

Readings

- Visual Analysis and Design – Chapter 8