

Data Visualization (CSCI 627/490)

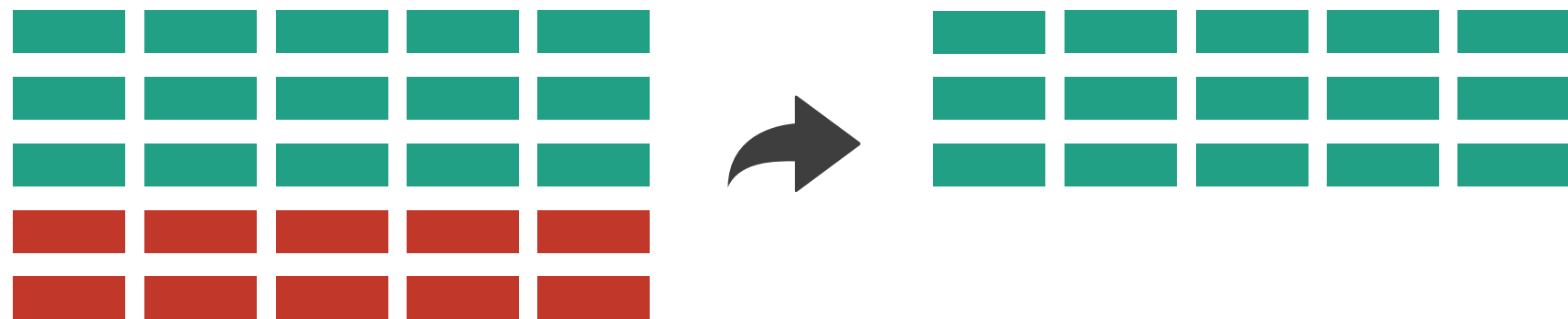
Isosurfacing

Dr. David Koop

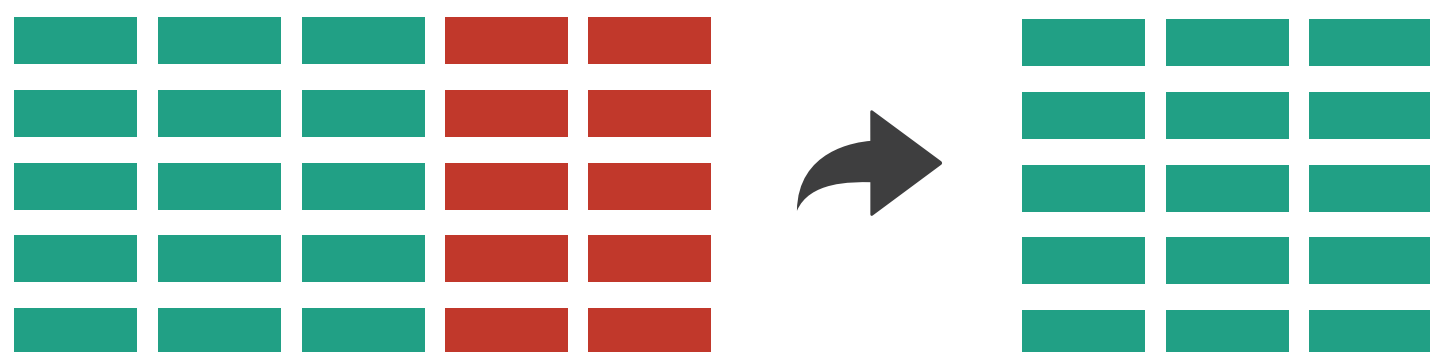
Overview: Reducing Items & Attributes

➔ Filter

➔ Items

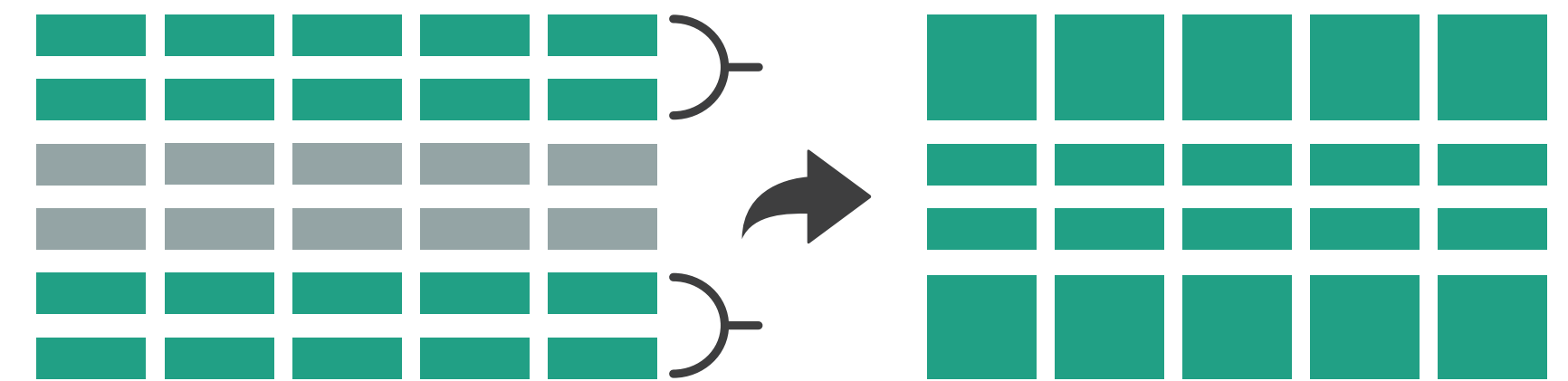


➔ Attributes

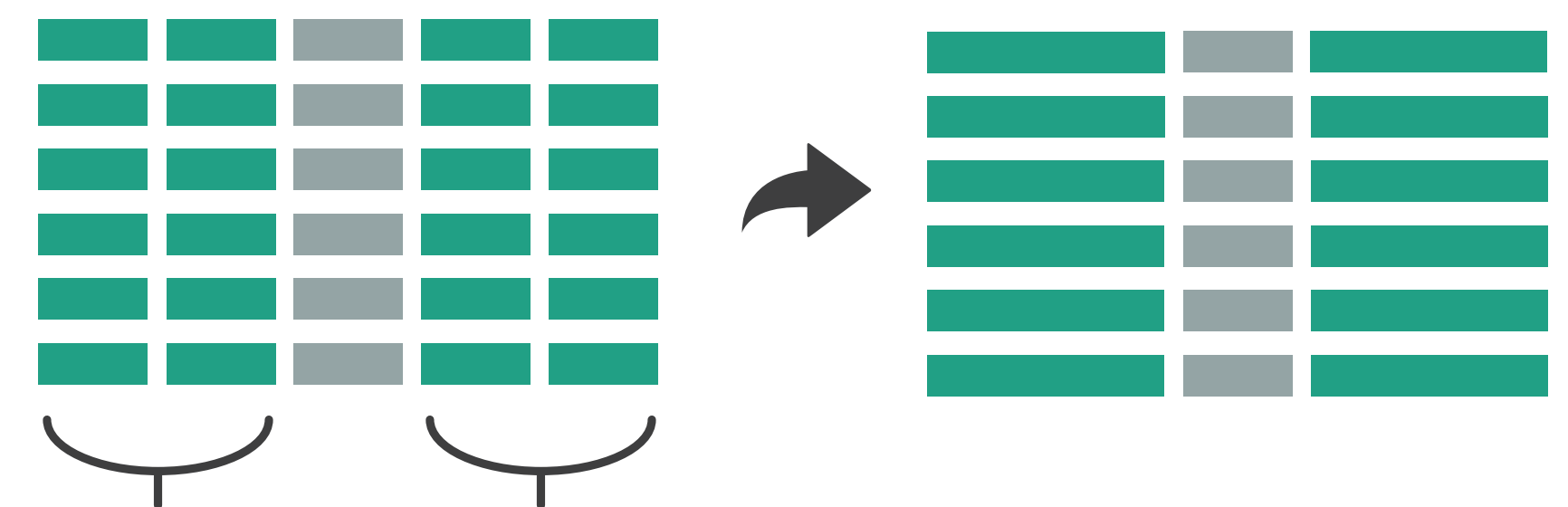


➔ Aggregate

➔ Items

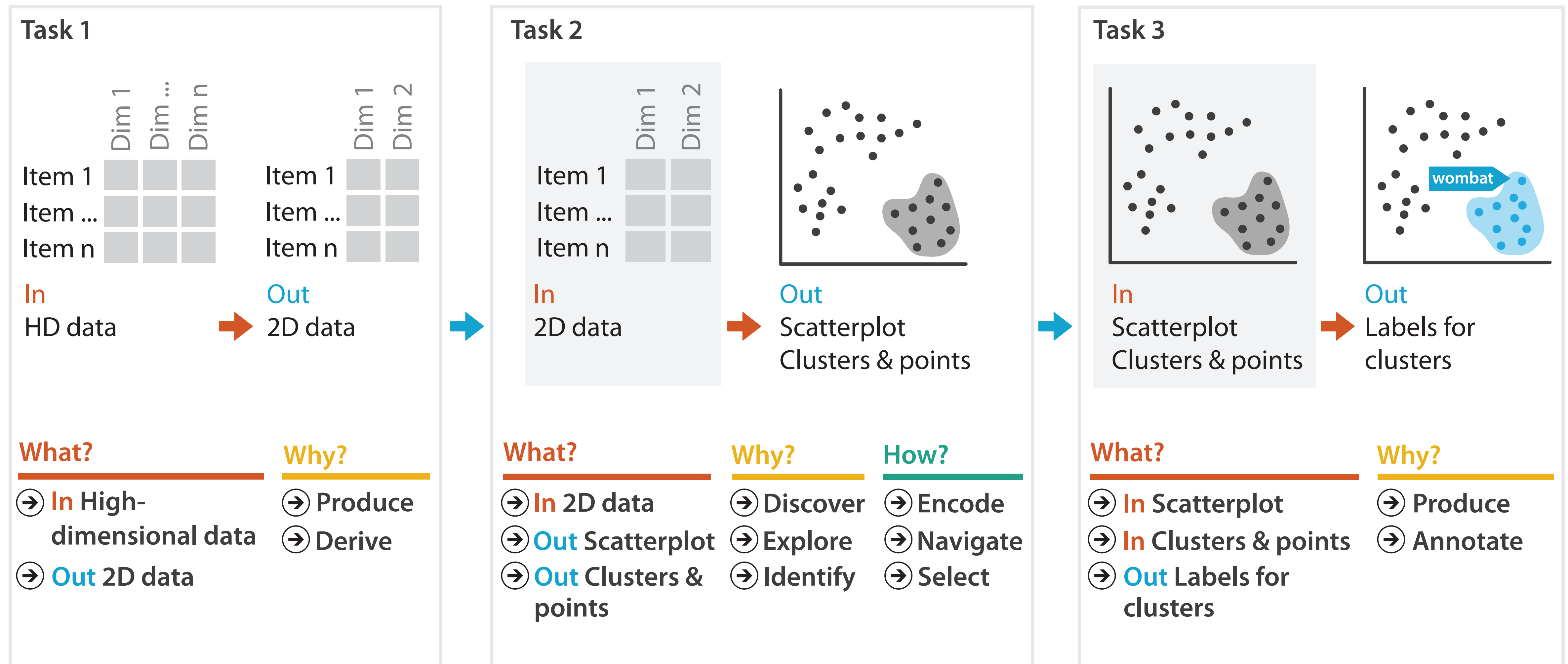


➔ Attributes



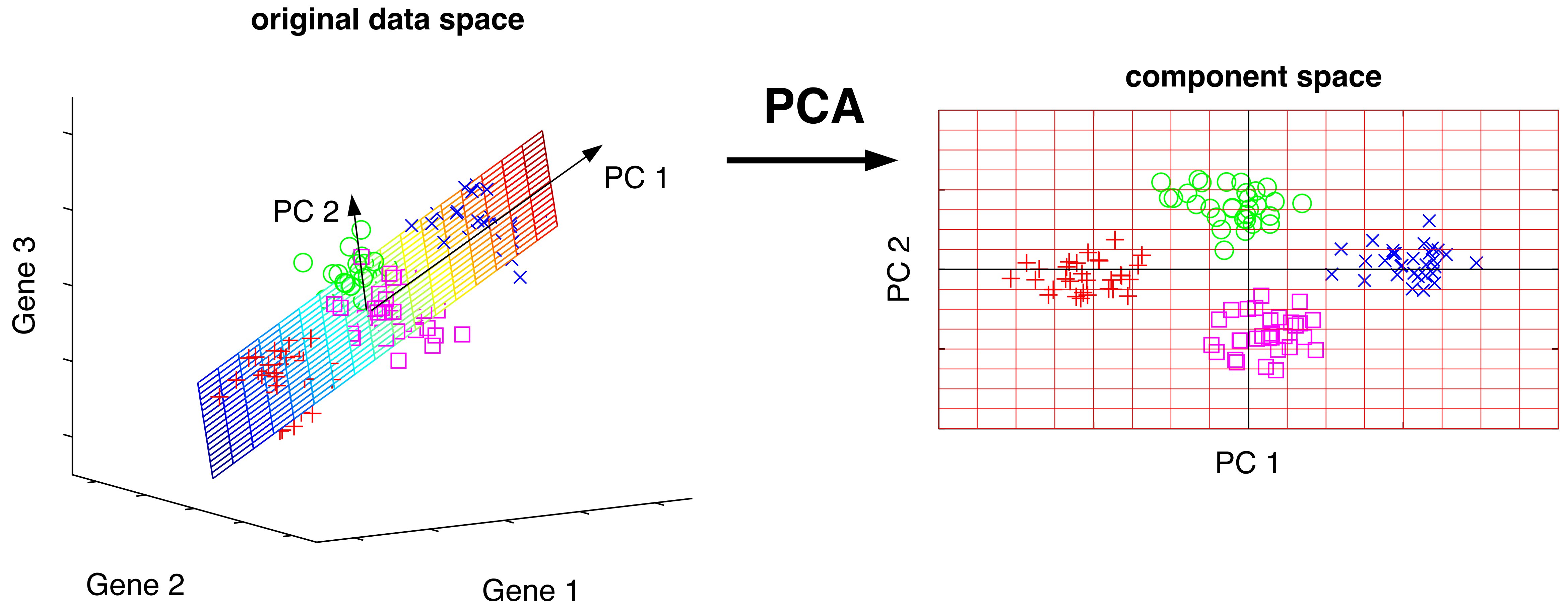
[Munzner (ill. Maguire), 2014]

Tasks in Understanding High-Dim. Data



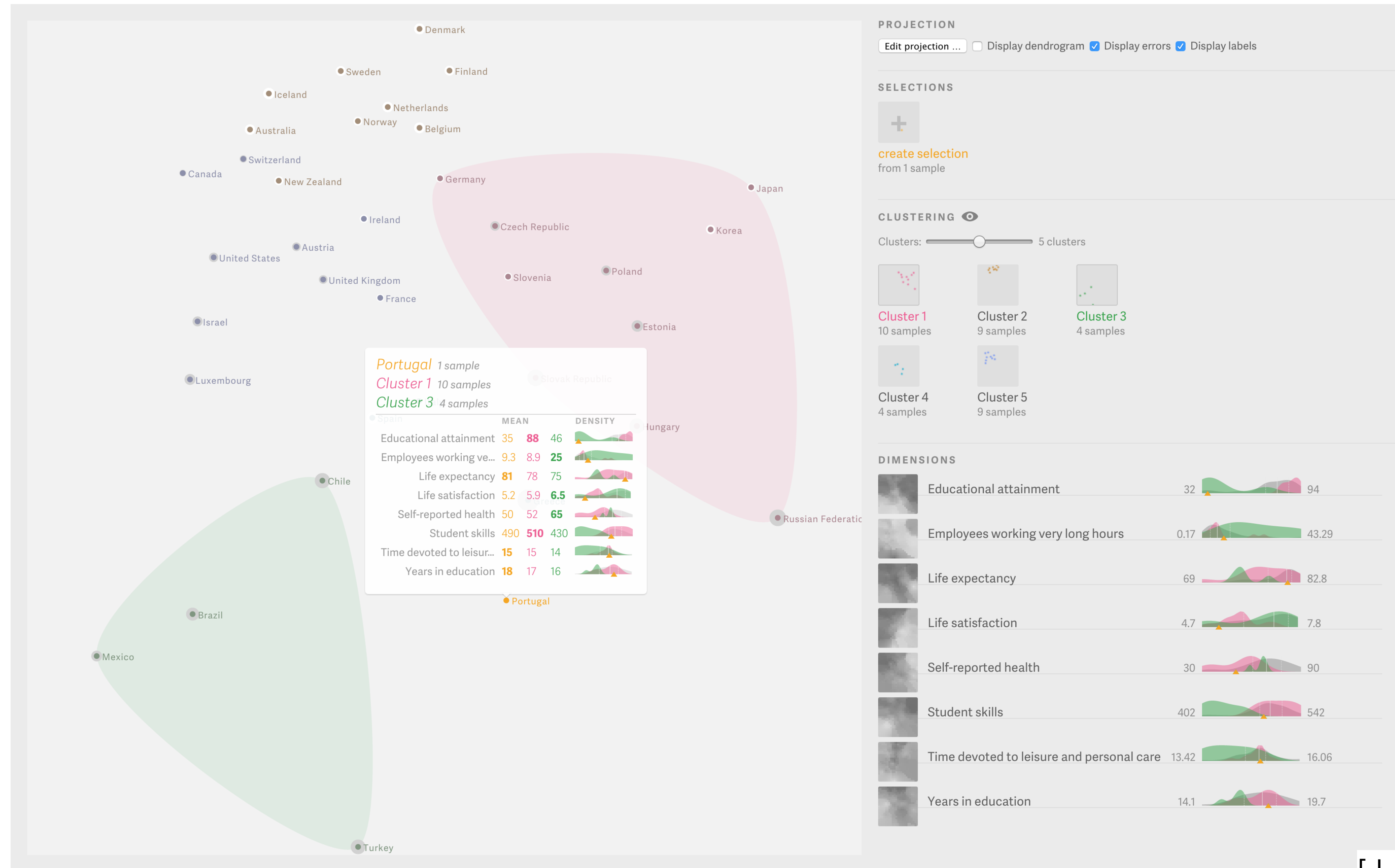
[Munzner (ill. Maguire), 2014]

Principle Component Analysis (PCA)



[M. Scholz, CC-BY-SA 2.0]

Probing Projections



[J. Stahnke et al., 2015]

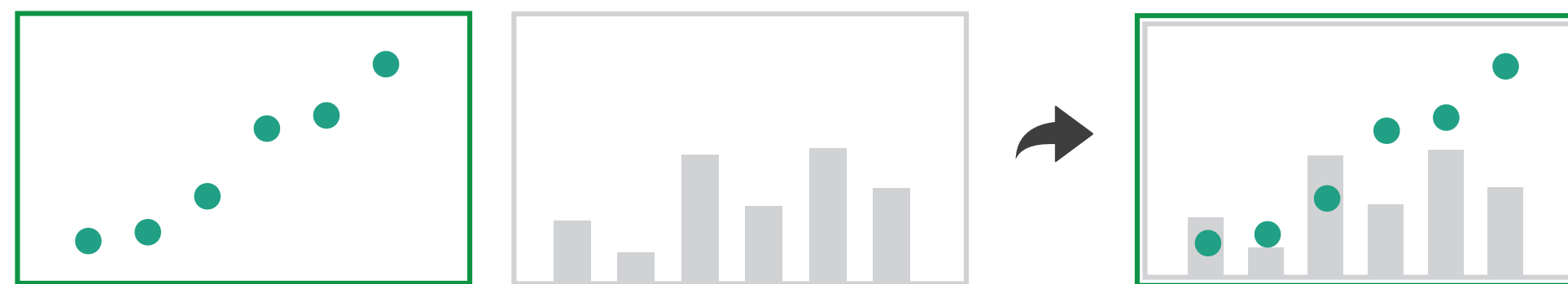
Focus+Context Overview

➔ Embed

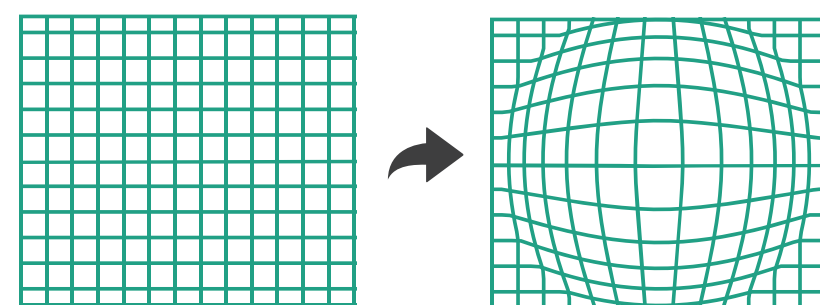
➔ Elide Data



➔ Superimpose Layer



➔ Distort Geometry

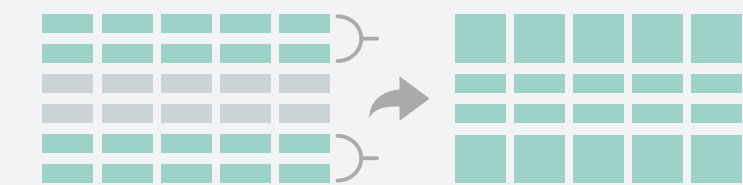


Reduce

➔ Filter



➔ Aggregate



➔ Embed



[Munzner (ill. Maguire), 2014]

Elision & Degree of Interest Function

- $DOI = I(x) - D(x,y)$
 - I: interest function
 - D: distance (semantic or spatial)
 - x: location of item
 - y: current focus point
 - Interactive: y changes

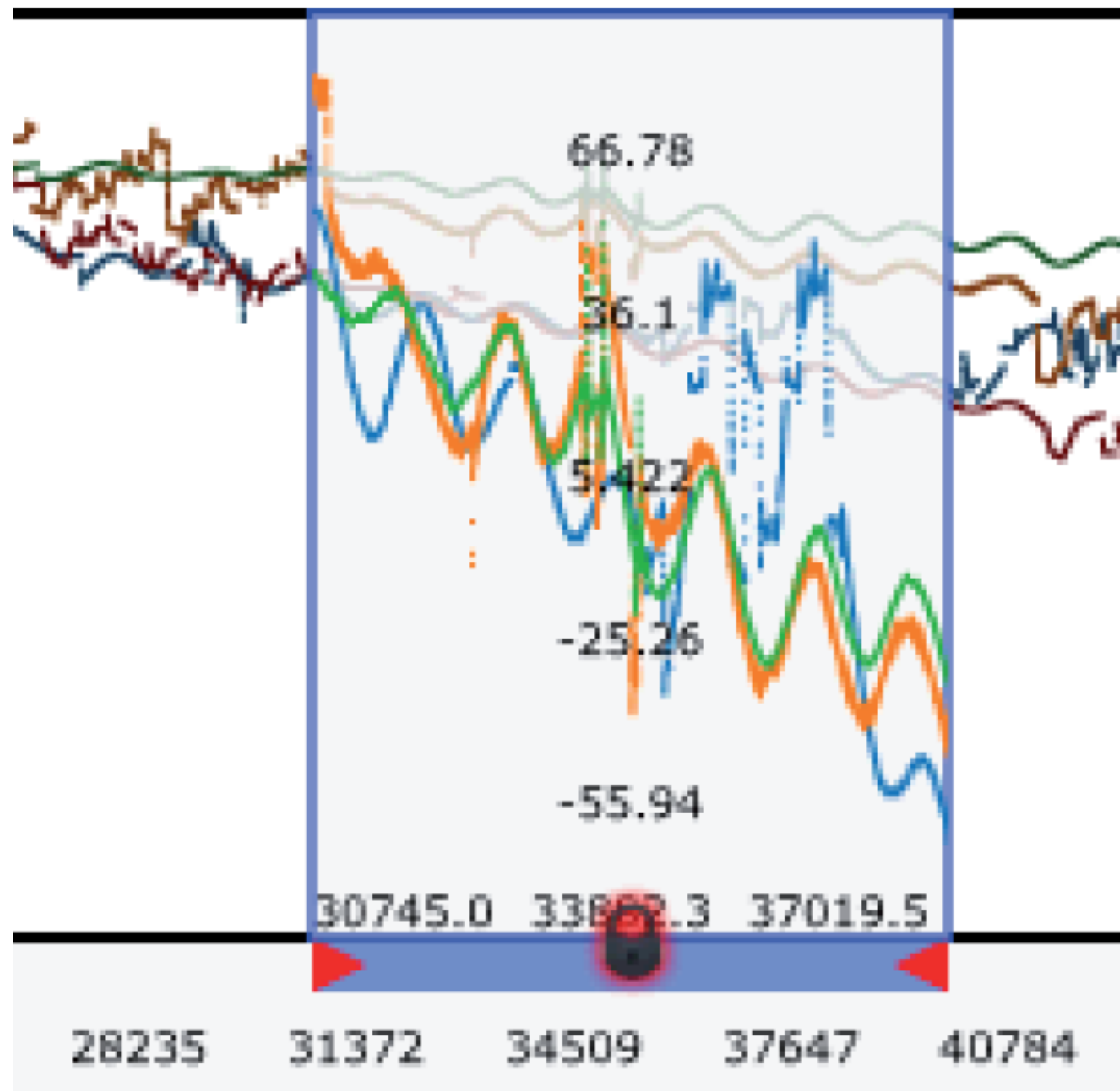


[Heer and Card, 2004]

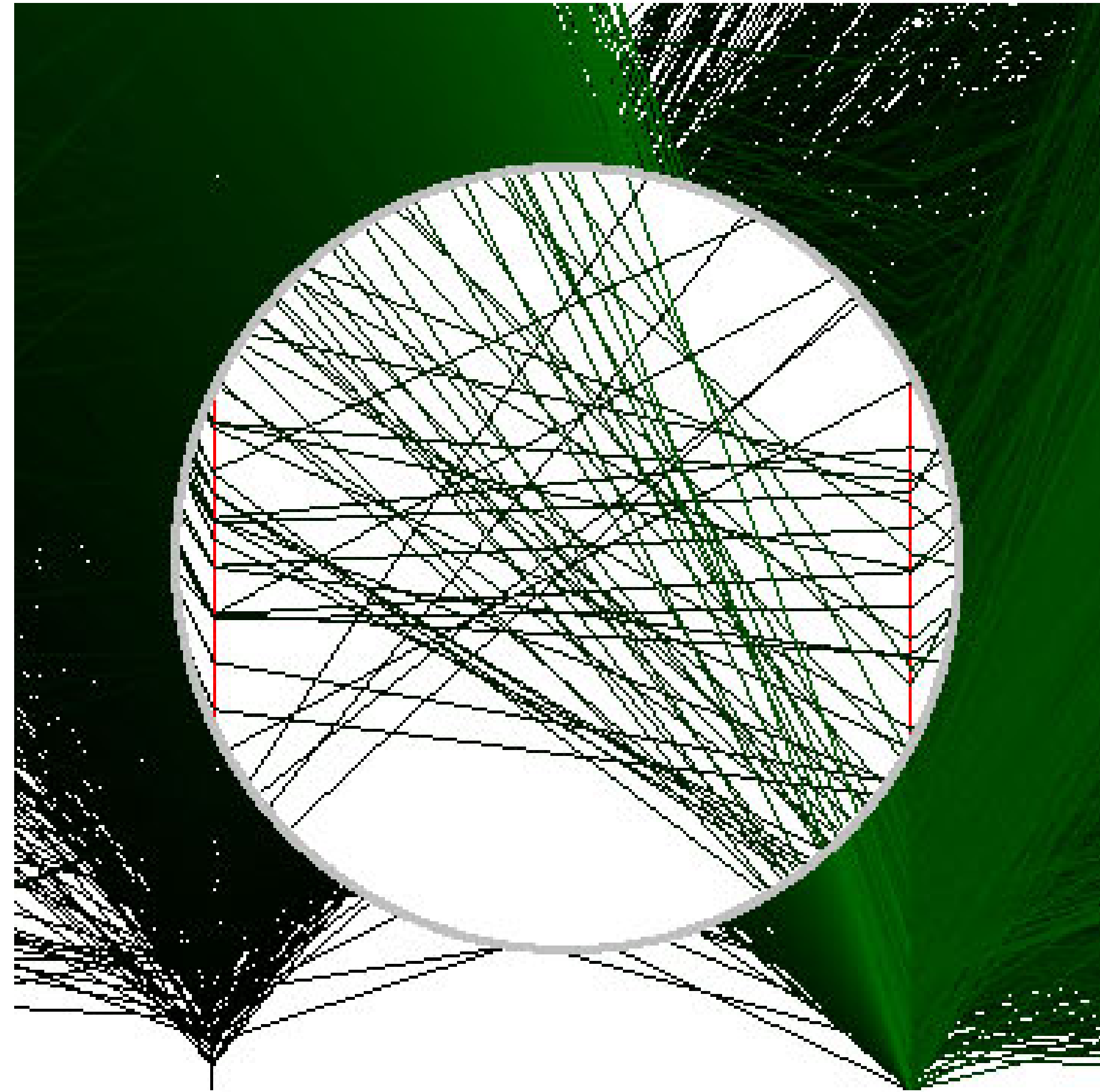
Superimposition

- Different from layers because this is restricted to a particular region
 - For Focus+Context, superimposition is **not global**
 - More like overloading
- Lens may occlude the layer below

Superimposition with Interactive Lenses



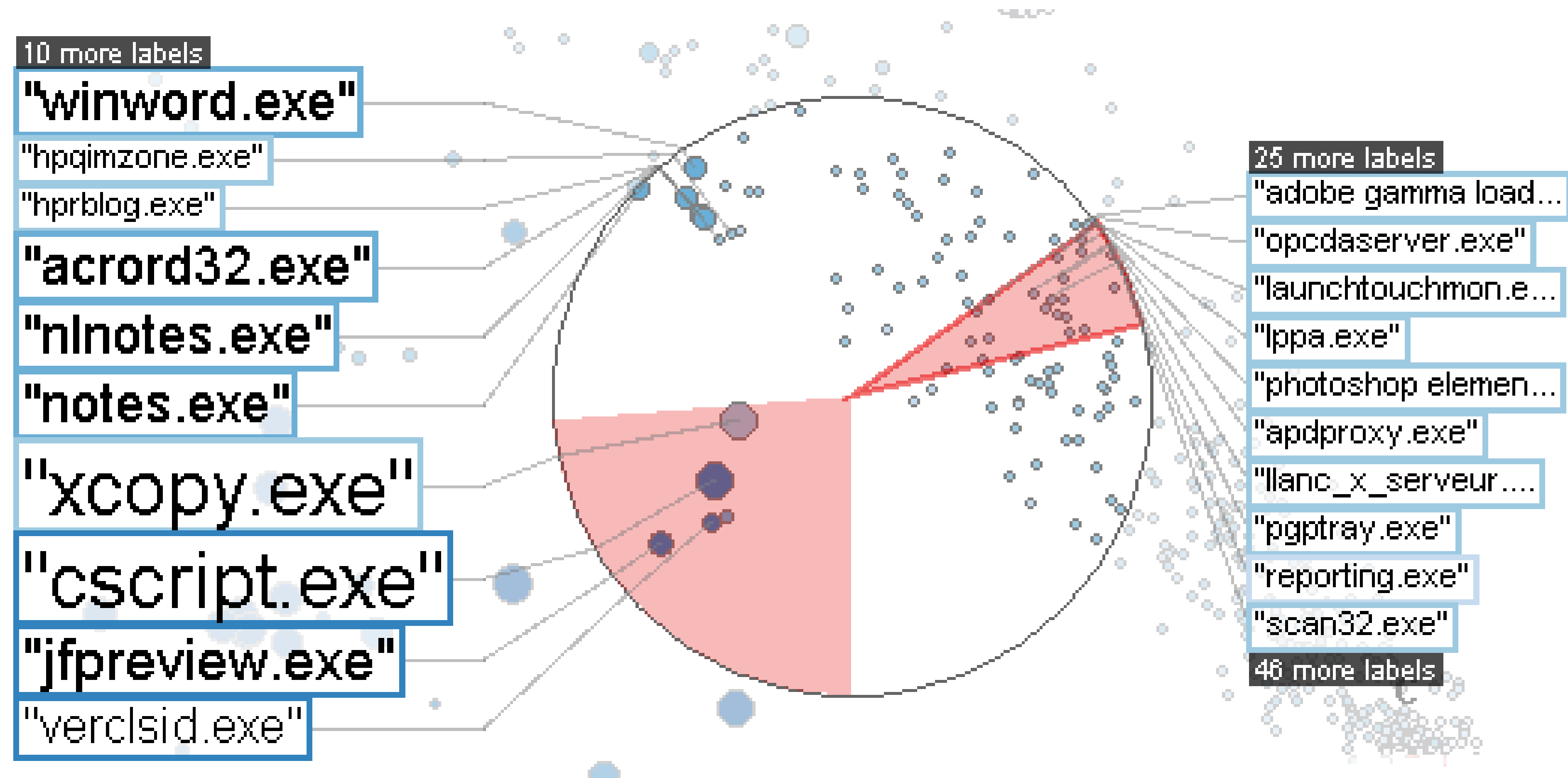
(a) Alteration



(b) Suppression

[ChronoLenses and Sampling Lens in Tominski et al., 2014]

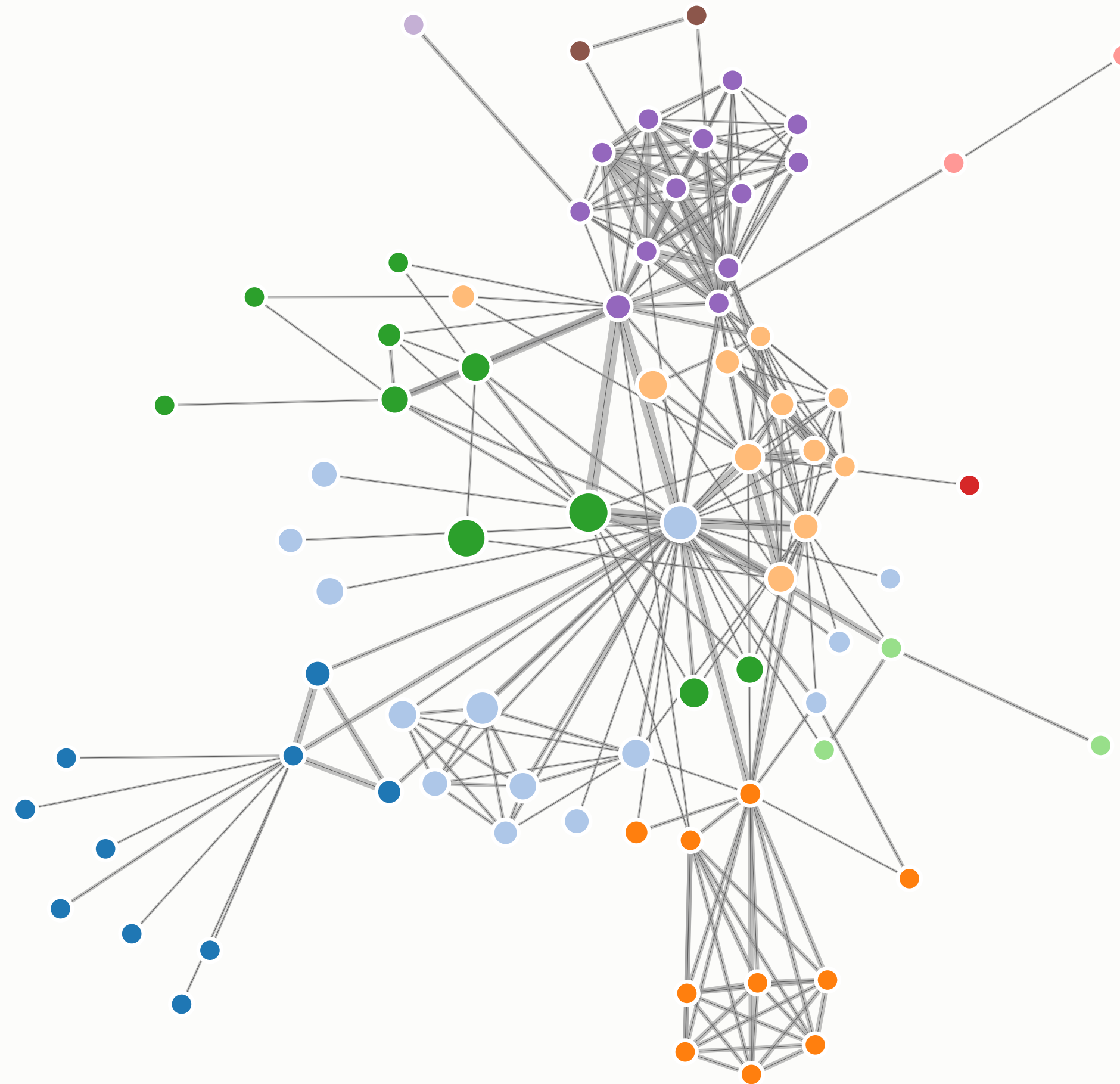
Superimposition with Interactive



(c) Enrichment

[Extended Lens in Tominski et al., 2014]

Distortion

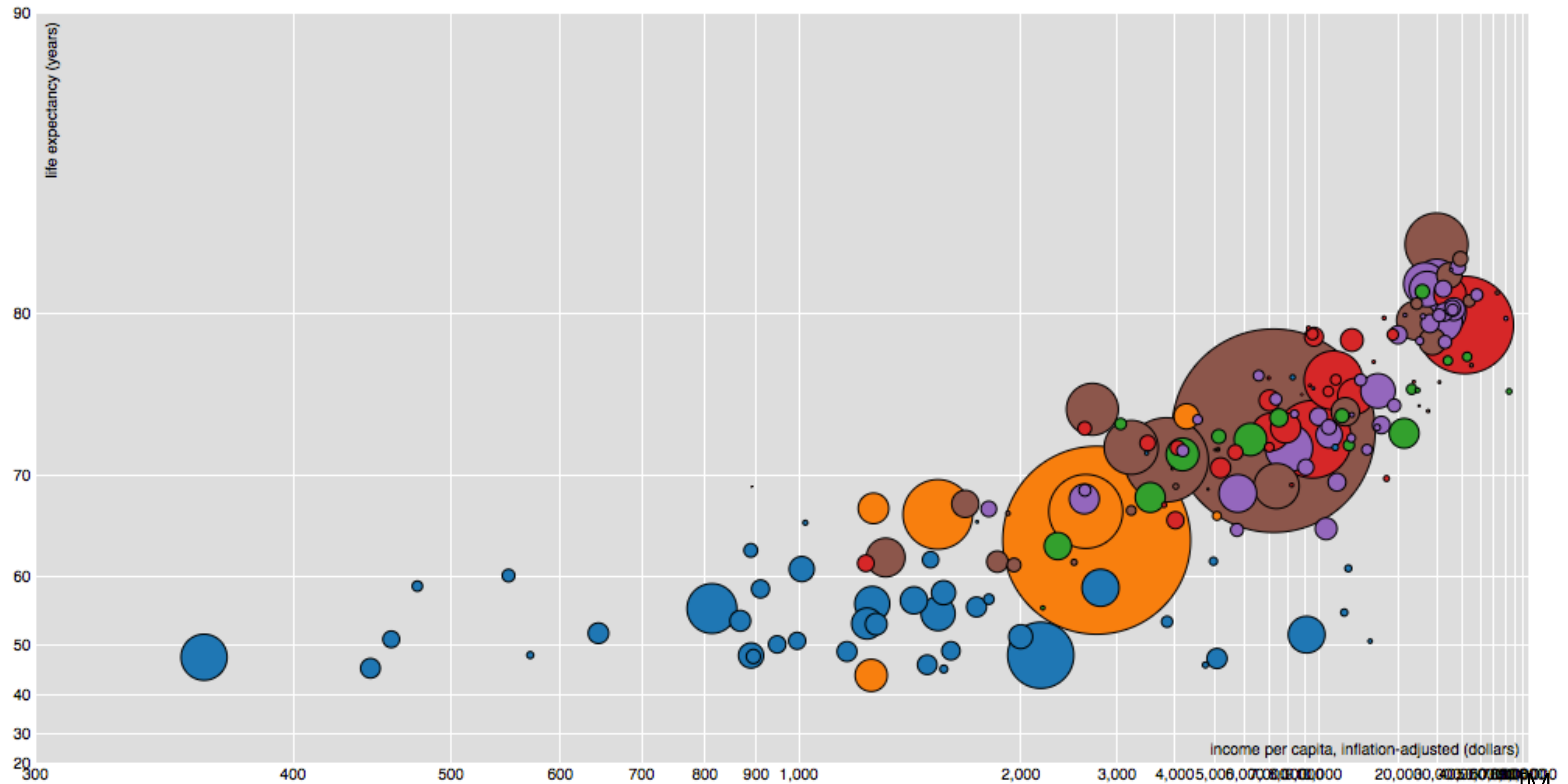


[M. Bostock]

Distortion Choices

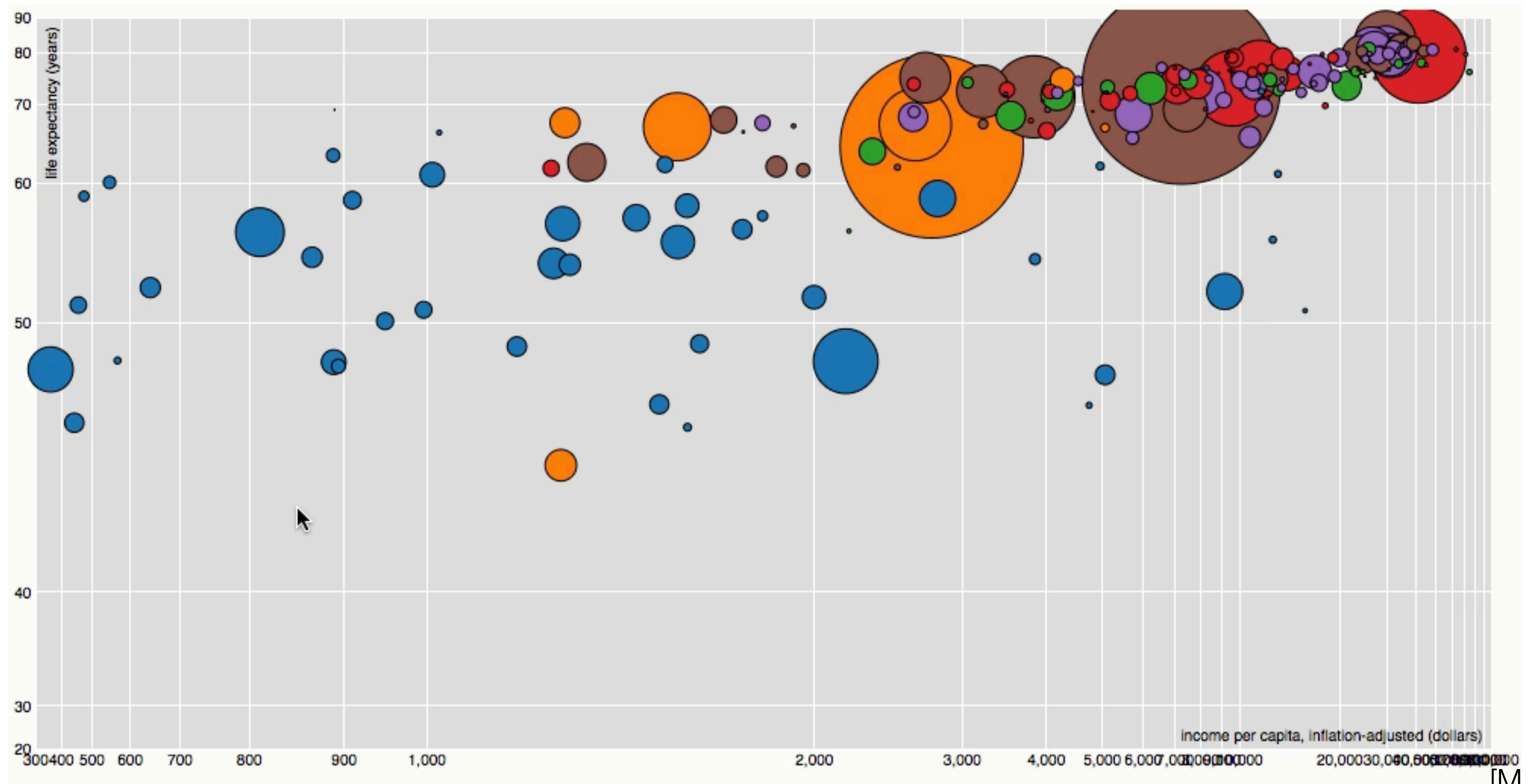
- How many focus regions? One or Multiple
- Shape of the focus?
 - Radial
 - Rectangular
 - Other
- Extent of the focus
 - Constrained similar to magic lenses
 - Entire view changes
- Type of interaction: Geometric, moveable lenses, rubber sheet

Overplotting



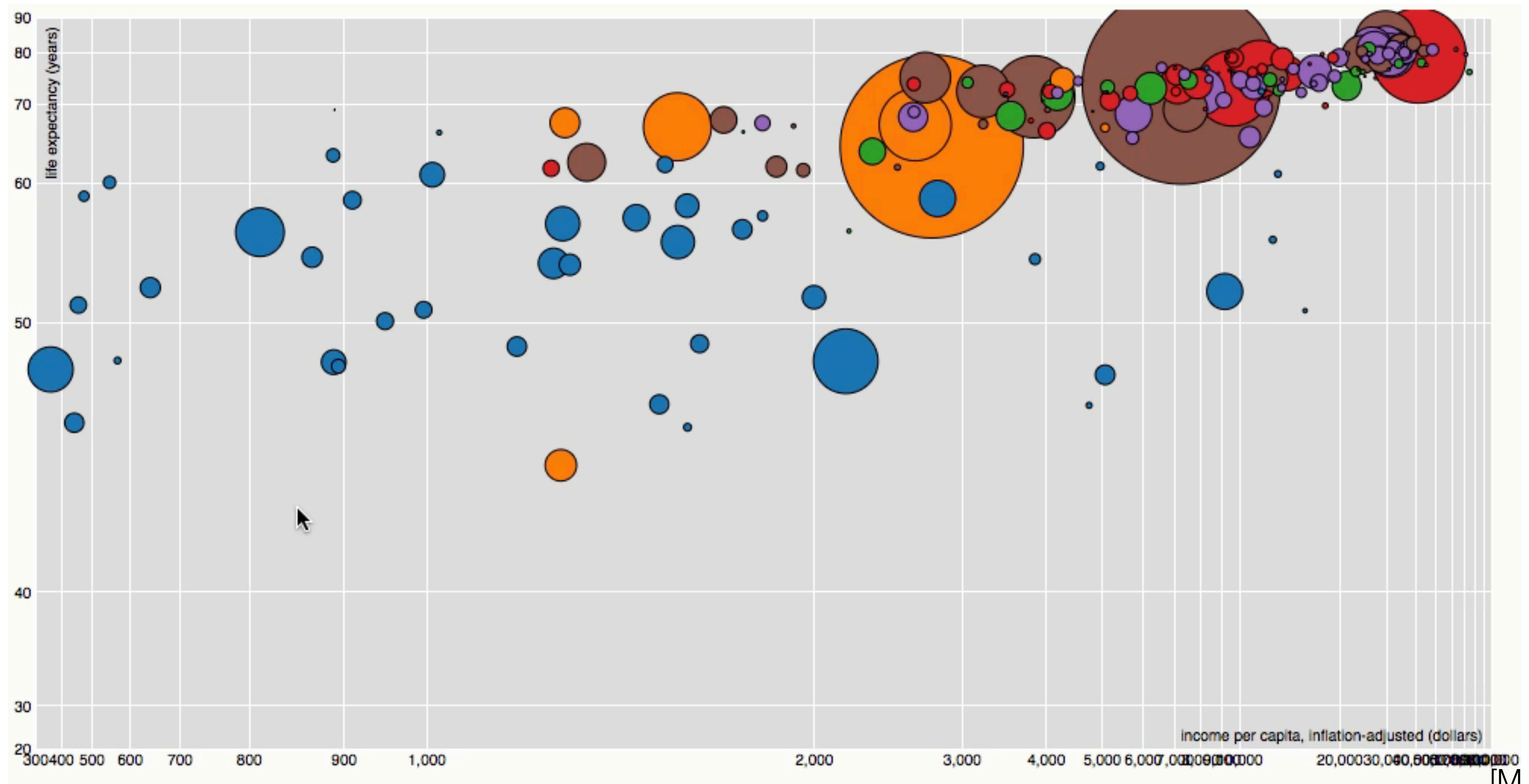
[M. Bostock]

Cartesian Distortion



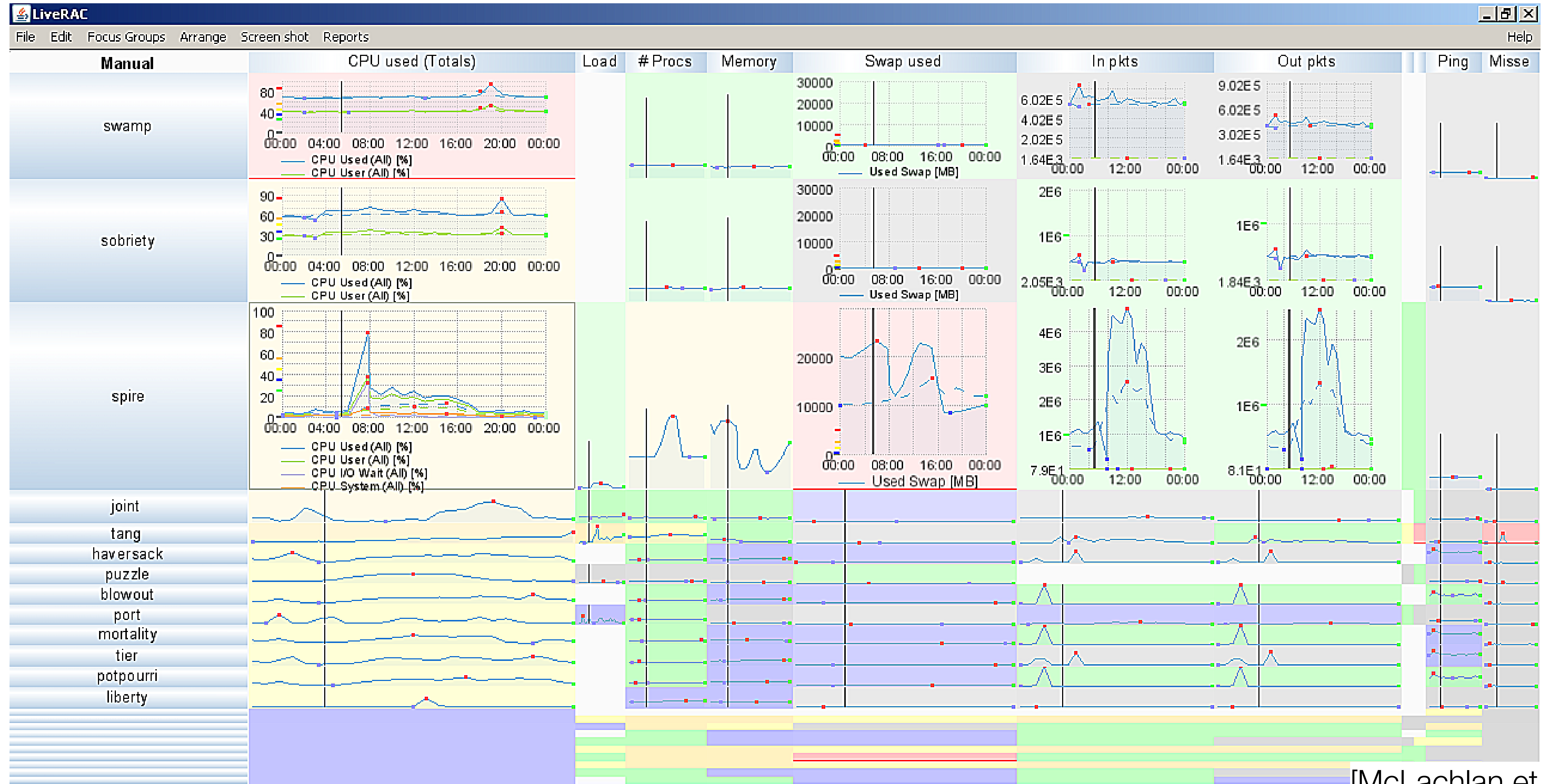
[M. Bostock]

Cartesian Distortion



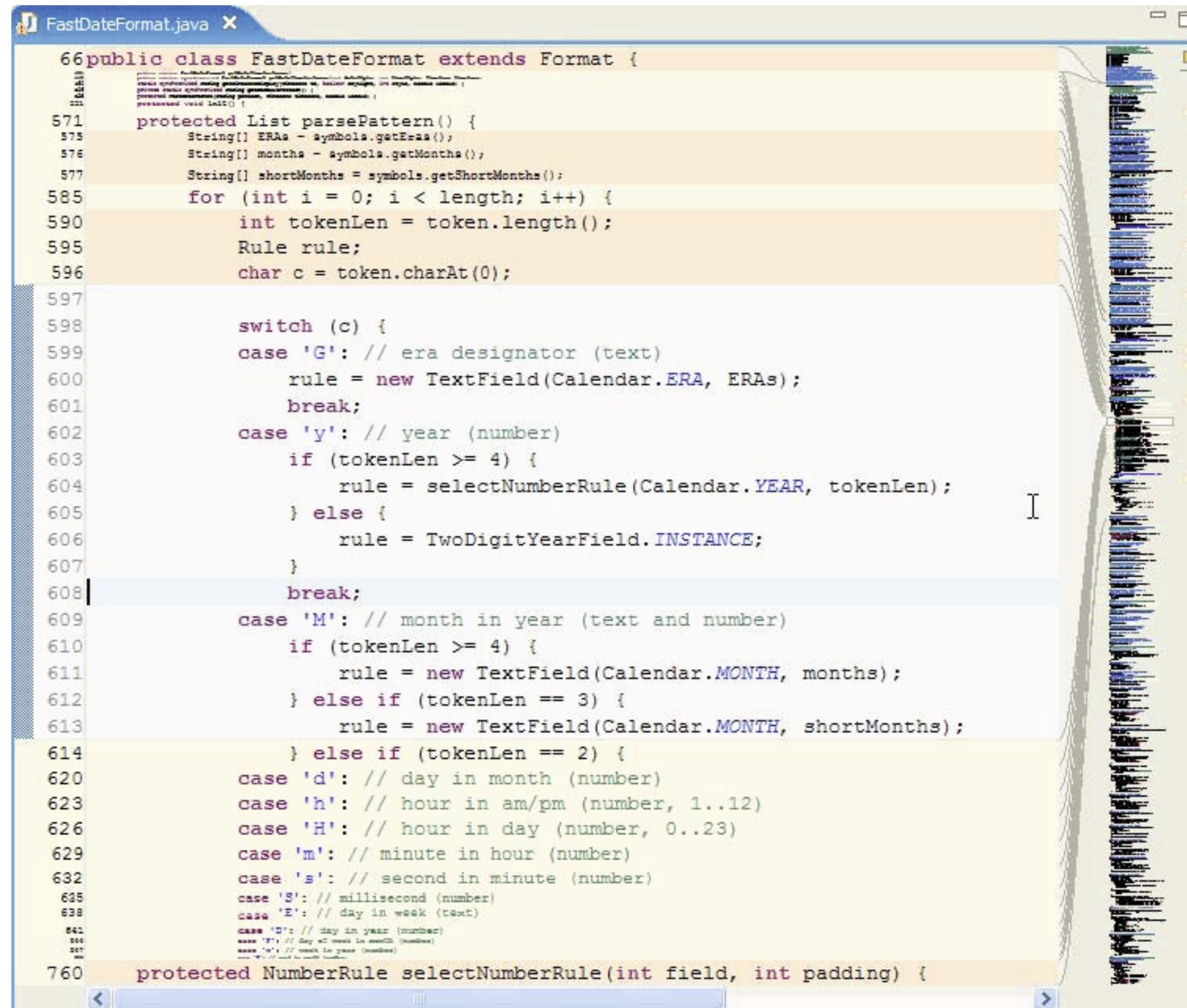
[M. Bostock]

Stretch and Squish Navigation



[McLachlan et al., 2008]

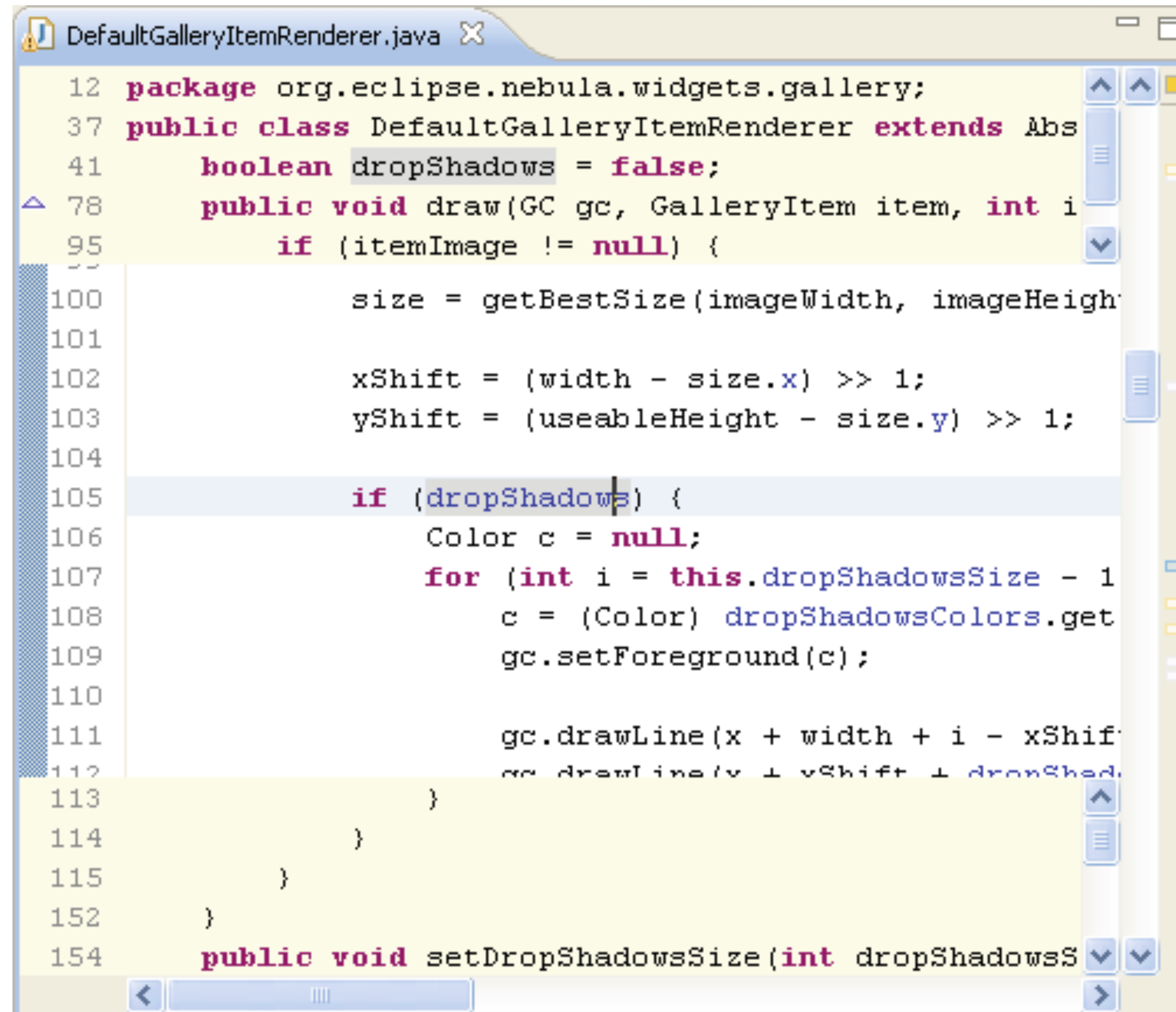
Fisheye Distortion in Programming



```
FastDateFormat.java X
66 public class FastDateFormat extends Format {
    571 protected List parsePattern() {
    575     String[] ERAs = symbols.getEras();
    576     String[] months = symbols.getMonths();
    577     String[] shortMonths = symbols.getShortMonths();
    585     for (int i = 0; i < length; i++) {
    590         int tokenLen = token.length();
    595         Rule rule;
    596         char c = token.charAt(0);
    597
    598         switch (c) {
    599             case 'G': // era designator (text)
    600                 rule = new TextField(Calendar.ERA, ERAs);
    601                 break;
    602             case 'y': // year (number)
    603                 if (tokenLen >= 4) {
    604                     rule = selectNumberRule(Calendar.YEAR, tokenLen);
    605                 } else {
    606                     rule = TwoDigitYearField.INSTANCE;
    607                 }
    608                 break;
    609             case 'M': // month in year (text and number)
    610                 if (tokenLen >= 4) {
    611                     rule = new TextField(Calendar.MONTH, months);
    612                 } else if (tokenLen == 3) {
    613                     rule = new TextField(Calendar.MONTH, shortMonths);
    614                 } else if (tokenLen == 2) {
    620                 case 'd': // day in month (number)
    623                 case 'h': // hour in am/pm (number, 1..12)
    626                 case 'H': // hour in day (number, 0..23)
    629                 case 'm': // minute in hour (number)
    632                 case 's': // second in minute (number)
    635                 case 'S': // millisecond (number)
    638                 case 'E': // day in week (text)
    641                 case 'D': // day in year (number)
    642                 case 'F': // day of week in month (number)
    643                 case 'w': // week in year (number)
    644                 case 'W': // week in month (number)
    760 protected NumberRule selectNumberRule(int field, int padding) {
```

[Jakobsen and Hornbaek, 2011]

Distortion vs. Hide



```
12 package org.eclipse.nebula.widgets.gallery;
37 public class DefaultGalleryItemRenderer extends AbstractItemRenderer {
41     boolean dropShadows = false;
78     public void draw(GC gc, GalleryItem item, int index) {
95         if (item.getImage() != null) {
100             size = getBestSize(item.getImage().getWidth(), item.getImage().getHeight());
101
102             xShift = (width - size.x) >> 1;
103             yShift = (useableHeight - size.y) >> 1;
104
105             if (dropShadows) {
106                 Color c = null;
107                 for (int i = this.dropShadowsSize - 1; i > 0; i--) {
108                     c = (Color) dropShadowsColors.get(i);
109                     gc.setForeground(c);
110
111                     gc.drawLine(x + width + i - xShift, y + height + i - yShift,
112                                x + width + i - xShift, y + height + i - yShift + dropShadowsSize);
113                 }
114             }
115             gc.drawImage(item.getImage(), x + width, y + height, size.x, size.y);
152     }
154     public void setDropShadowsSize(int dropShadowsSize) {

```

[Jakobsen and Hornbaek, 2011]

Research Questions

- Is a priori importance useful (and for what)?
- What does the user focus on?
 - predictability of view changes when focus changes
 - how direct user control is
 - task & context
- What interesting information should be displayed
 - degree of interest function may produce varied result sizes
- Do fisheye views integrate or disintegrate?
 - interference with other interactions; allow on-demand use?
- Are fisheye views suitable for large displays?

[Jakobsen and Hornbaek, 2011]

Distortion Concerns

- Distance and length judgments are **harder**
 - Example: Mac OS X Dock with Magnification
 - Spatial position of items changes as the focus changes
- Node-link diagrams not an issue... why?
- Users have to be made aware of distortion
 - Back to scatterplot with distortion example
 - Lenses or shading give clues to users
- **Object constancy**: understanding when two views show the same object
 - What happens under distortion?
 - 3D Perspective is distortion... but we are well-trained for that
- Think about **what** is being shown (filtering) and method (fisheye)

H3 Layout

**Large Graph Exploration
with H3Viewer and
Site Manager
(Demo)**

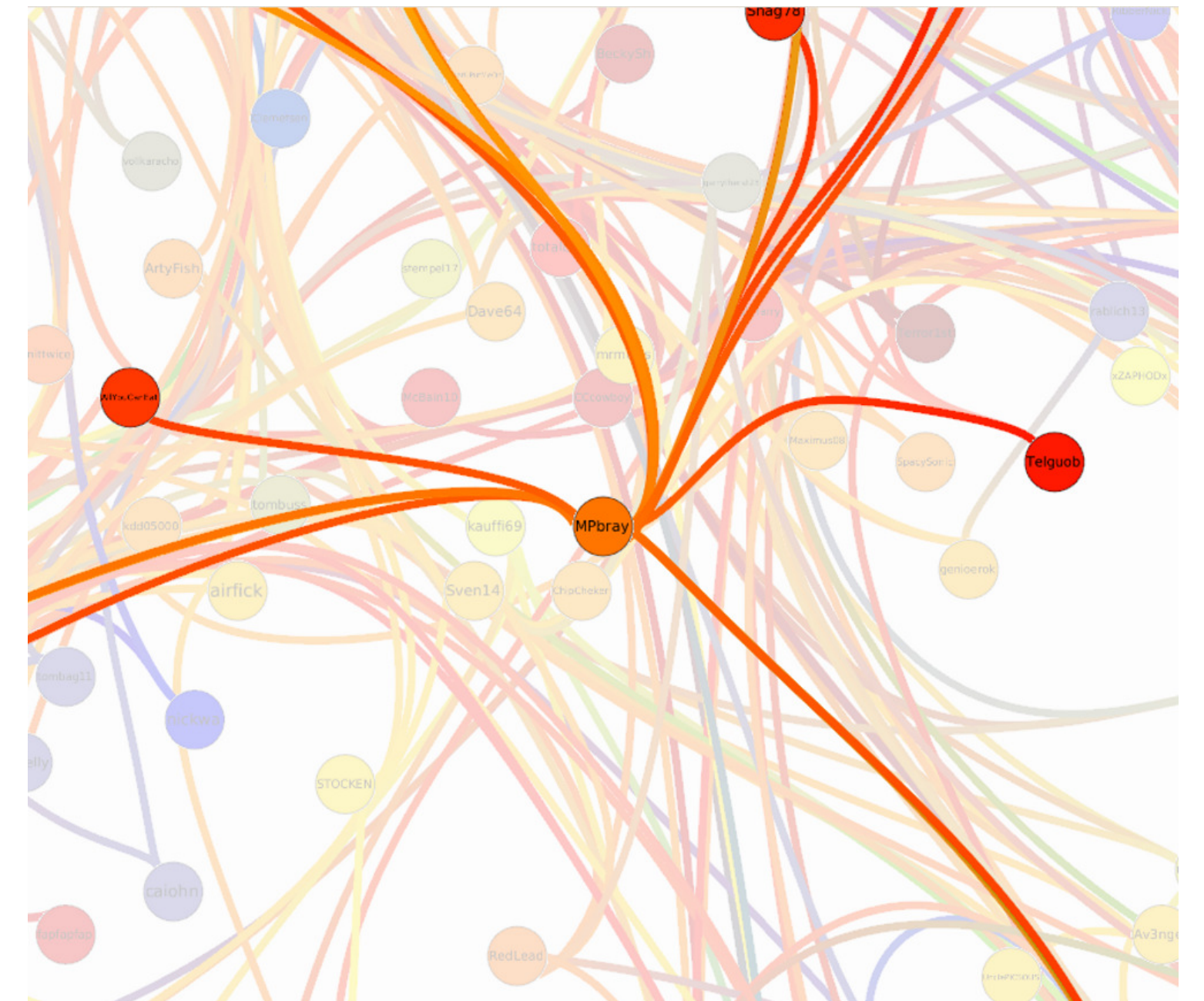
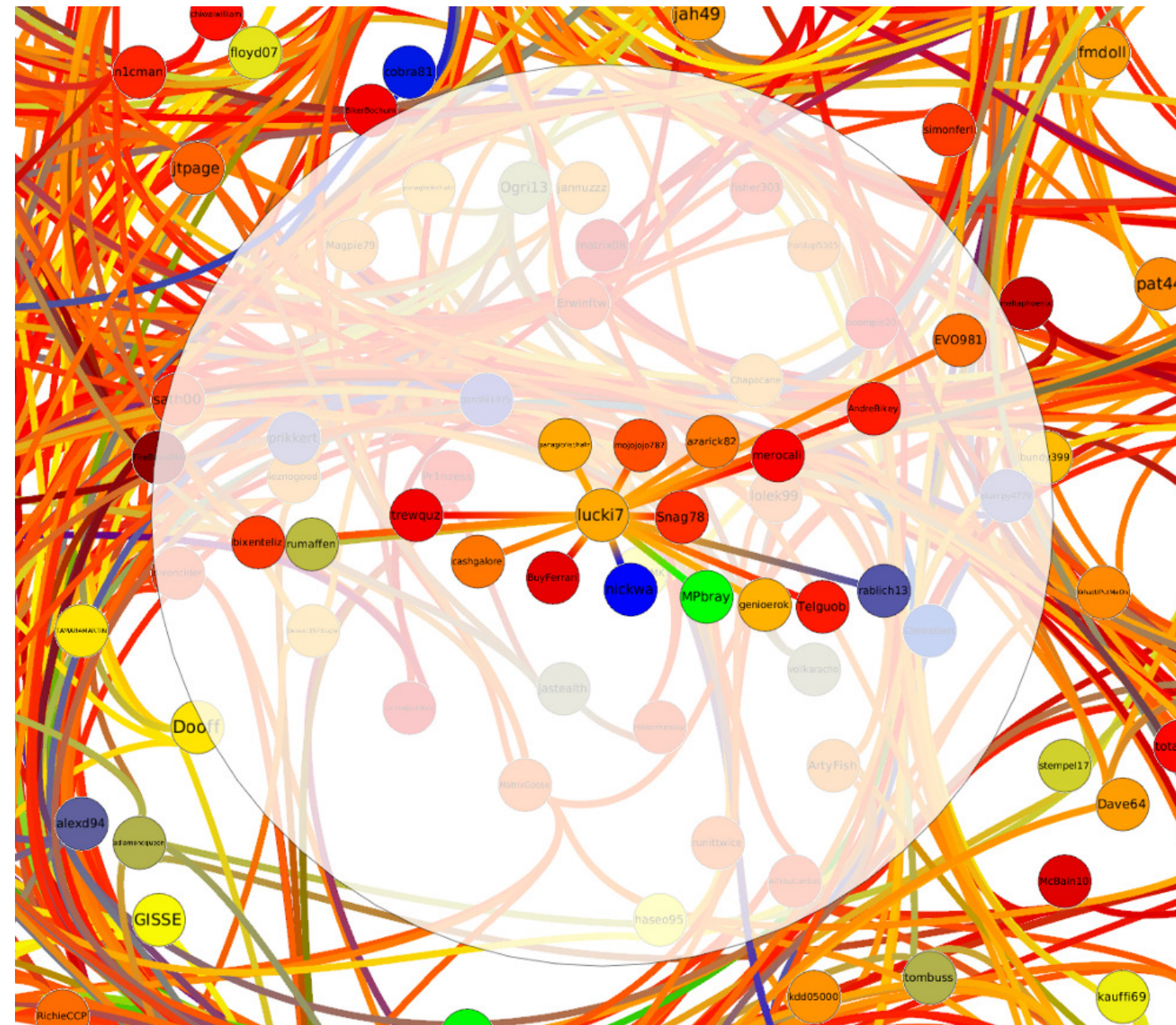
[T. Munzner, 1998]

H3 Layout

**Large Graph Exploration
with H3Viewer and
Site Manager
(Demo)**

[T. Munzner, 1998]

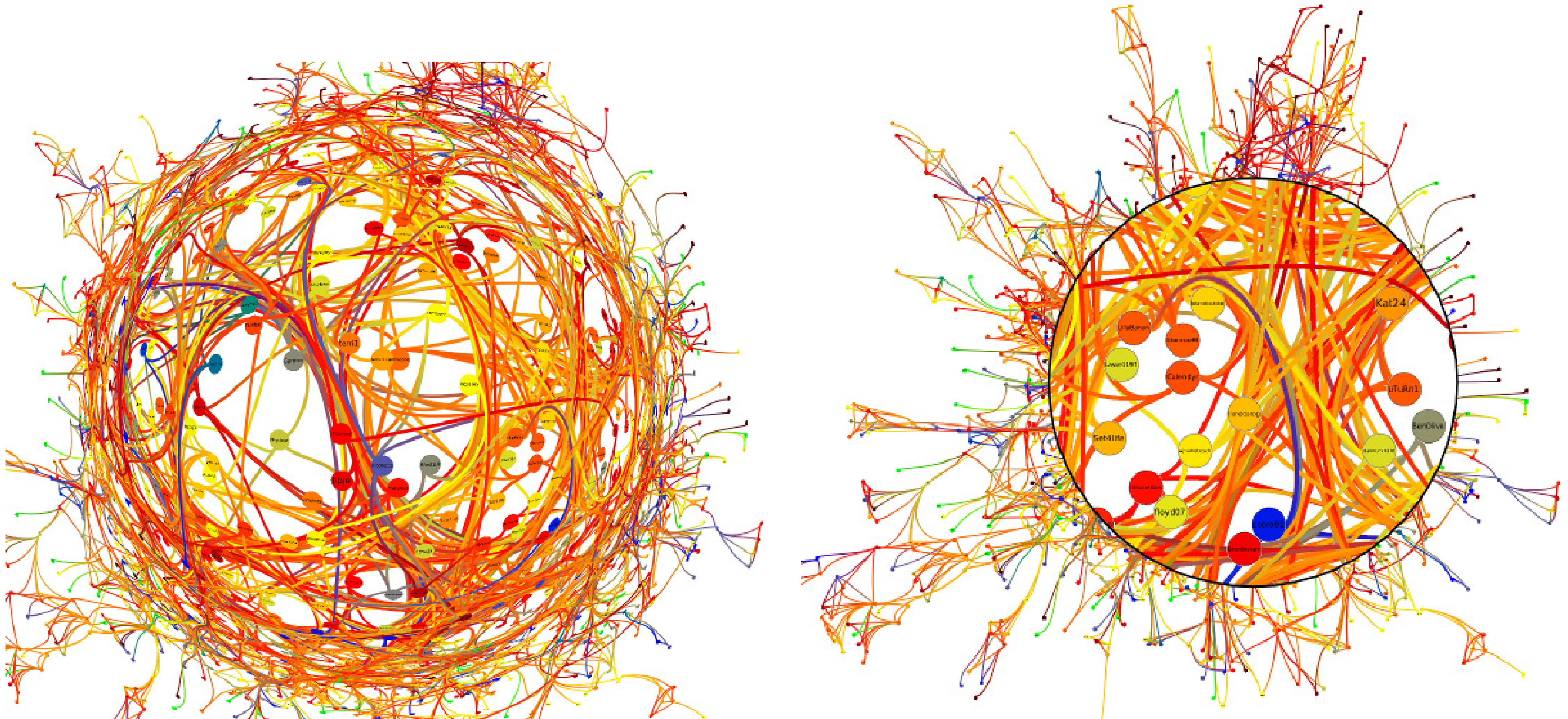
Focus+Context in Network Exploration



(a) Bring (step 1) – Selecting a node fades out all graph elements but the node neighborhood. (b) Bring (step 2) – Neighbor nodes are pulled close to the selected node. (c) Go – After selecting a neighbor (the green node in Fig. 4(b)), a short animation brings the focus towards a new neighborhood.

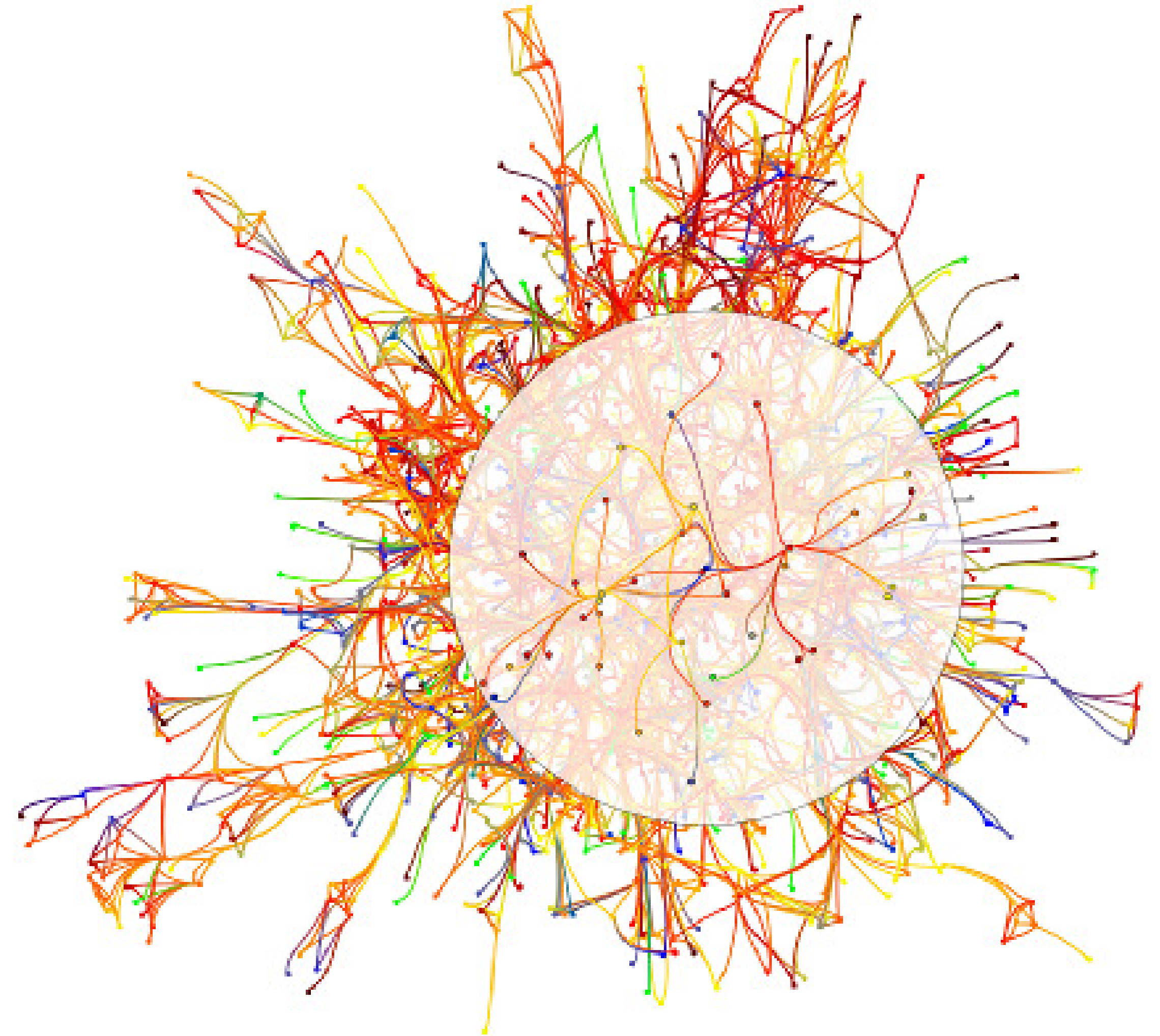
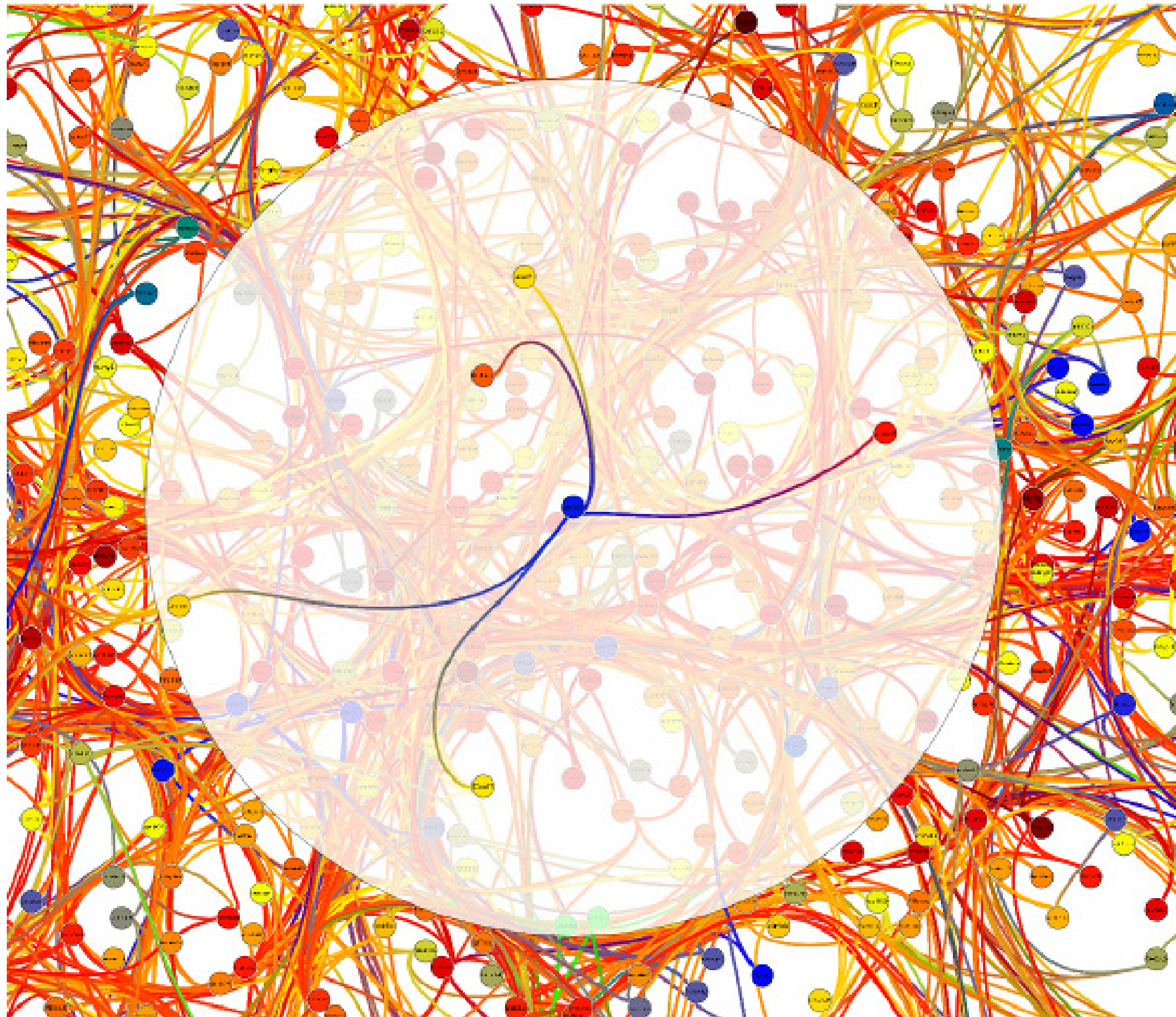
[Lambert et al., 2010]

Focus+Context in Network Exploration



[Lambert et al., 2010]

Focus+Context in Network Exploration



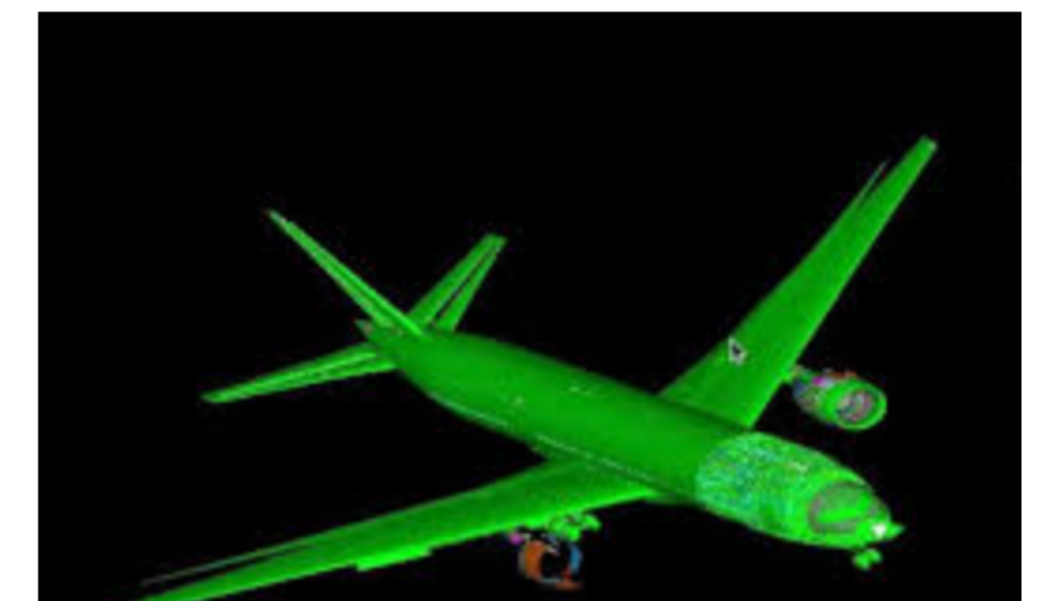
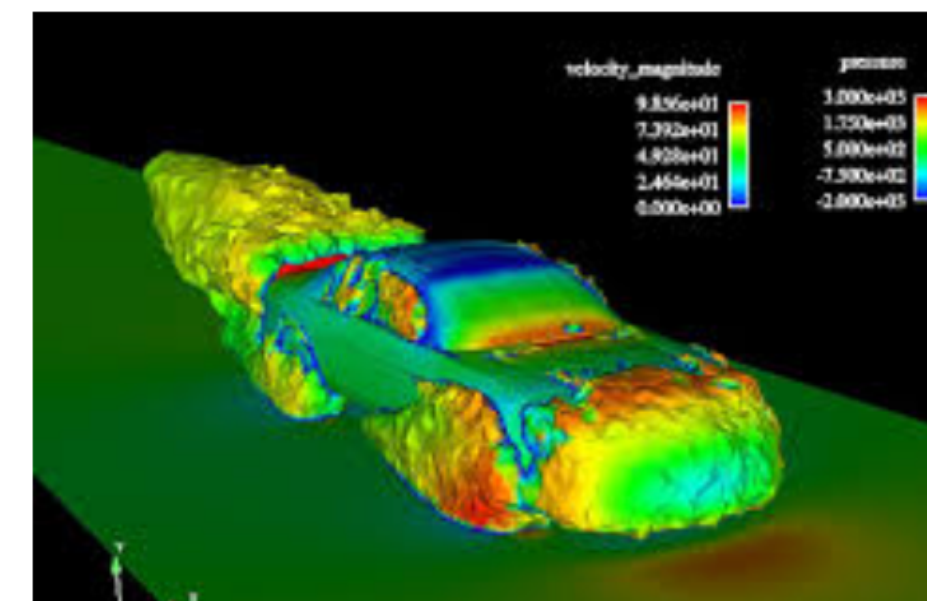
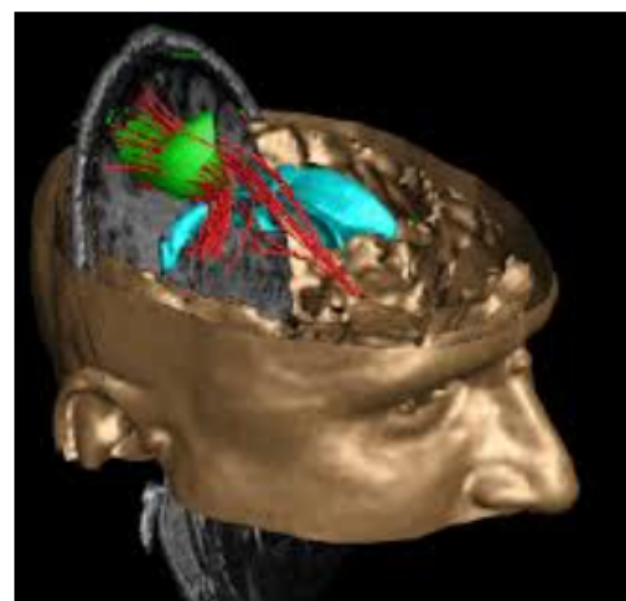
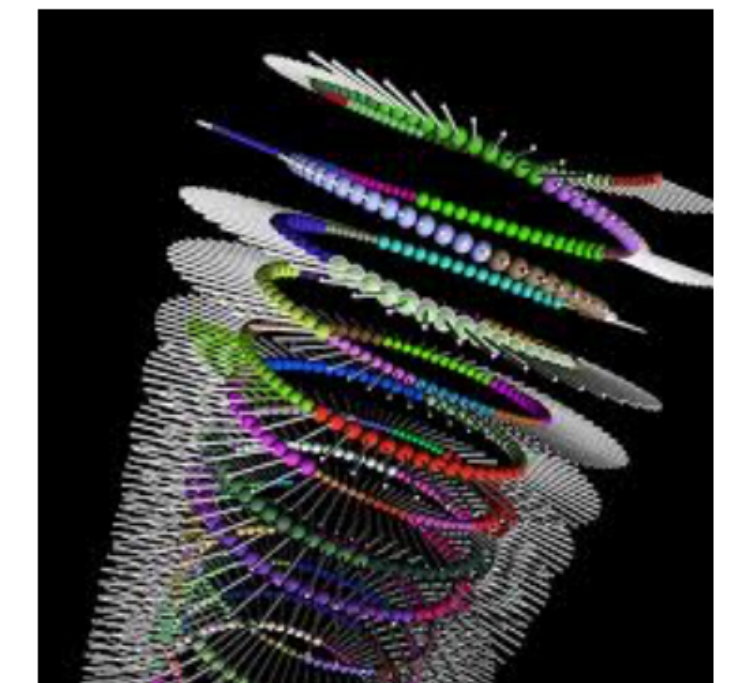
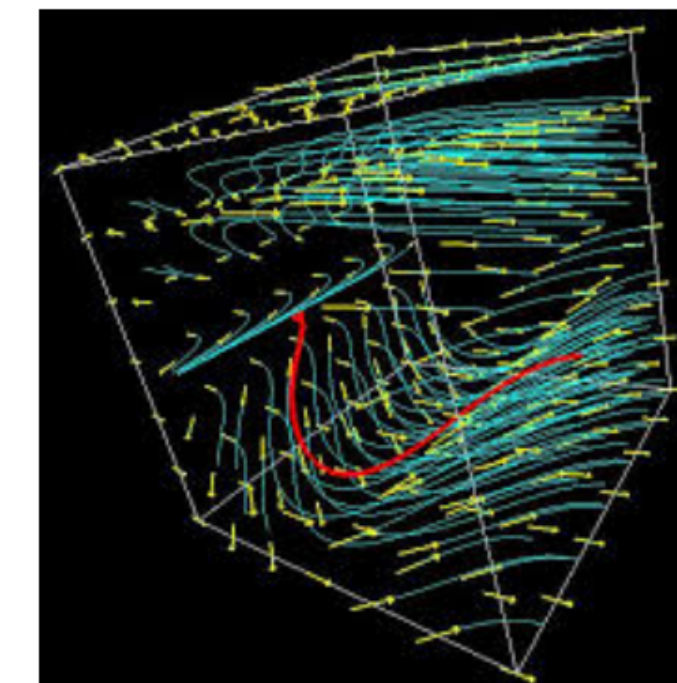
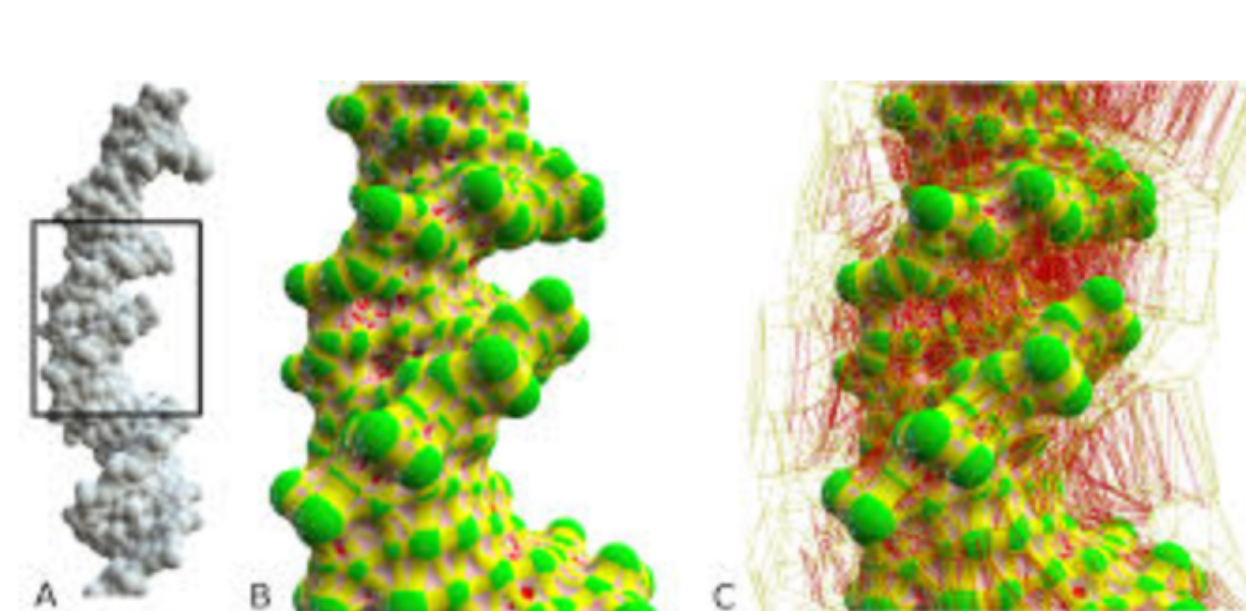
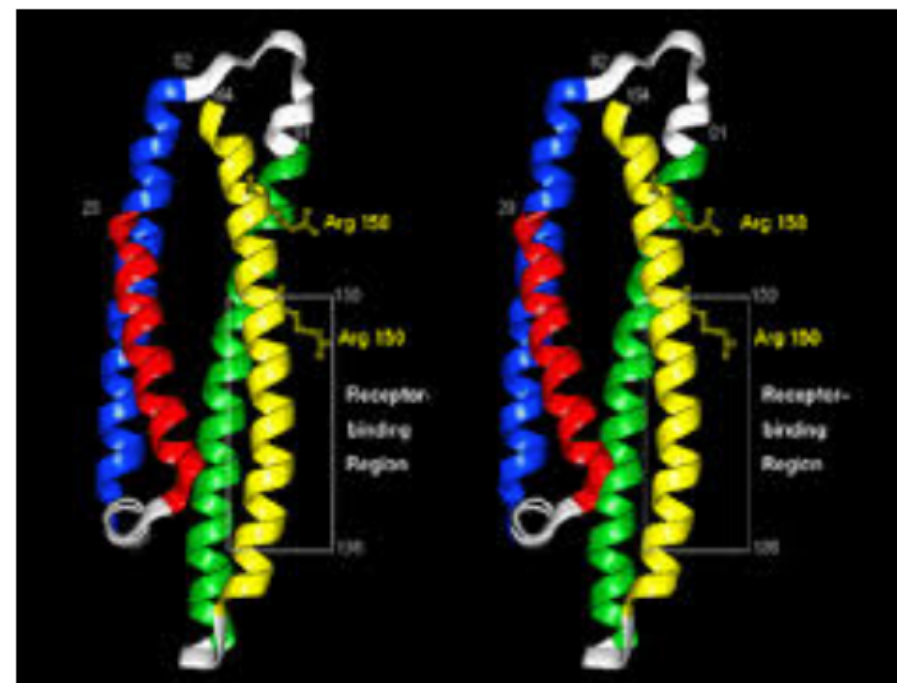
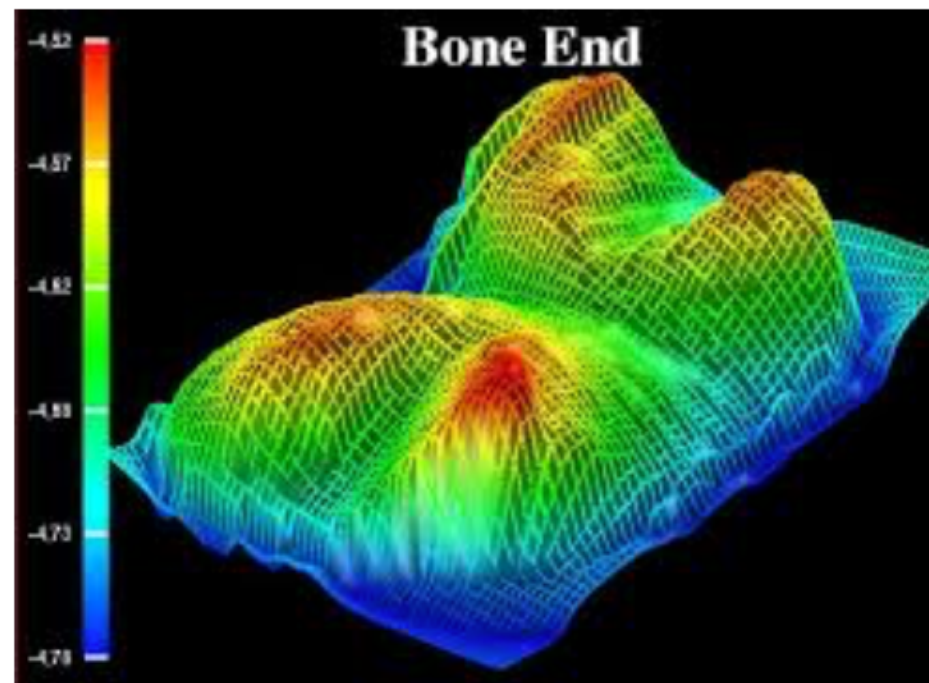
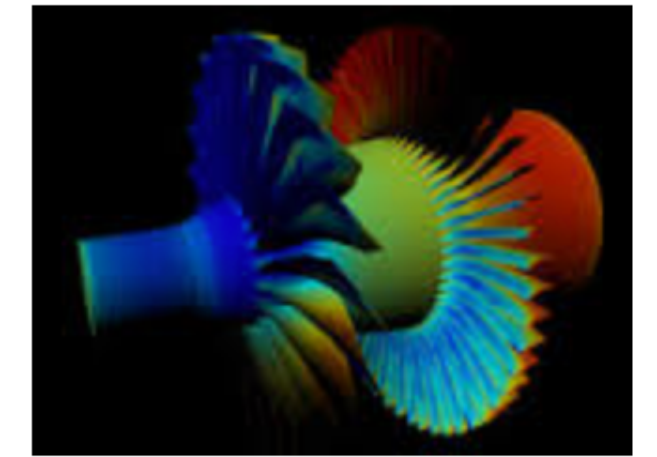
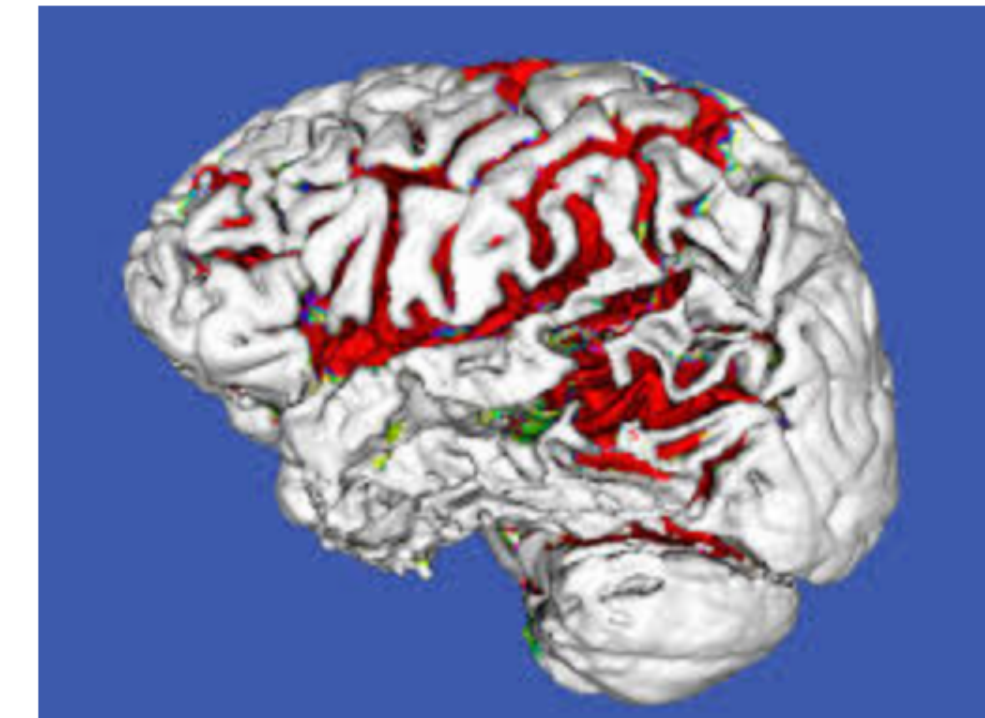
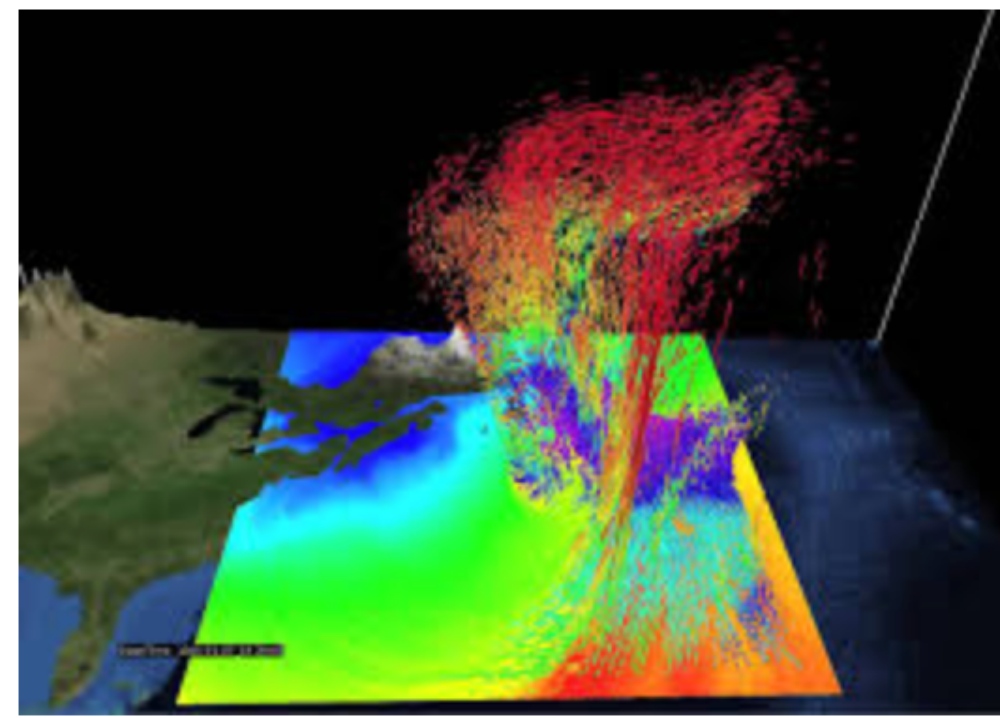
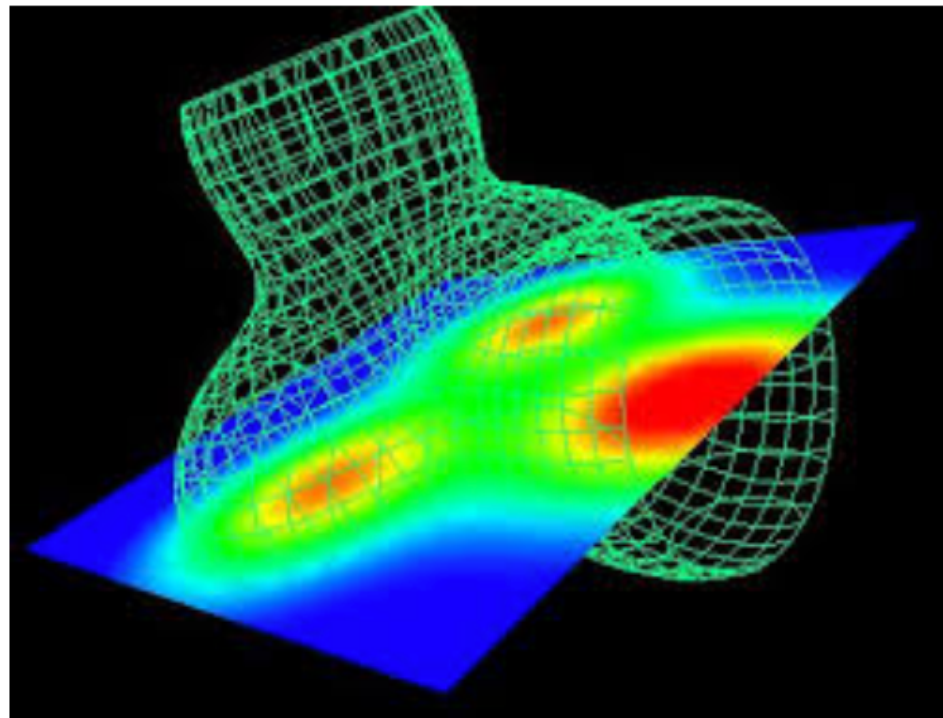
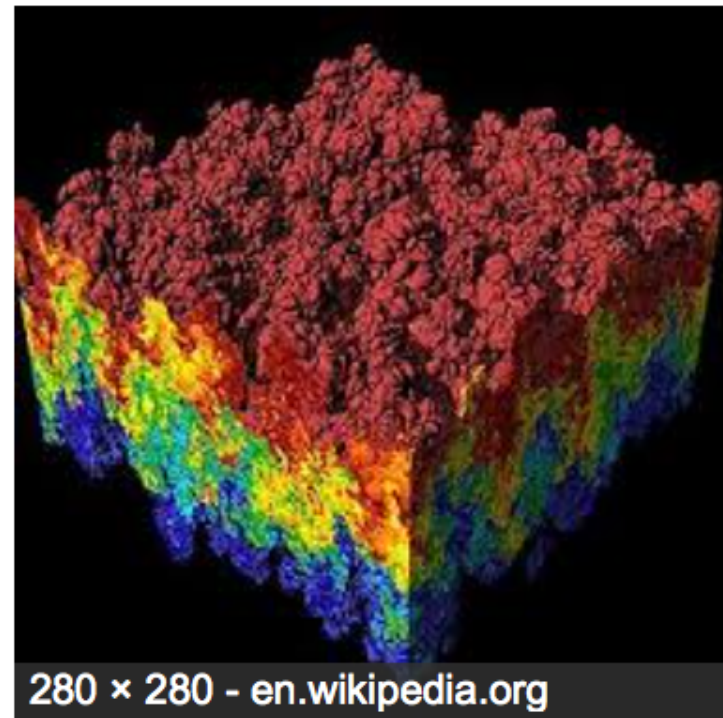
[Lambert et al., 2010]

Scientific Visualization

Scivis and Infovis

- Two subfields of visualization
- **Scivis** deals with data where the spatial position is given with data
 - Usually continuous data
 - Often displaying physical phenomena
 - Techniques like isosurfacing, volume rendering, vector field vis
- In **Infovis**, the data has no set spatial representation, designer chooses how to visually represent data

SciVis



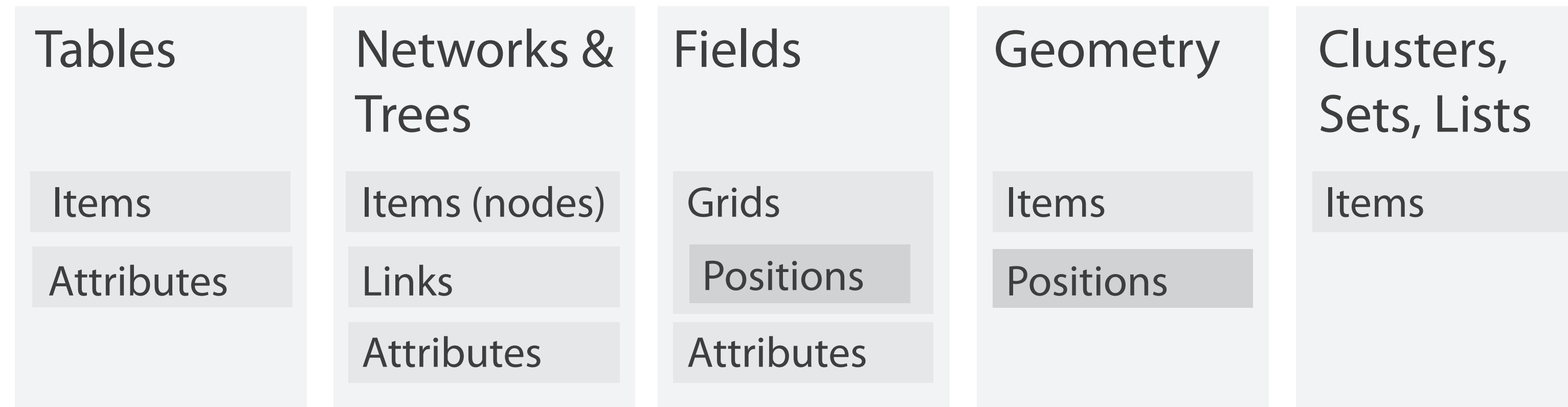
[Google Image Search for "scientific visualization", 2017]

InfoVis



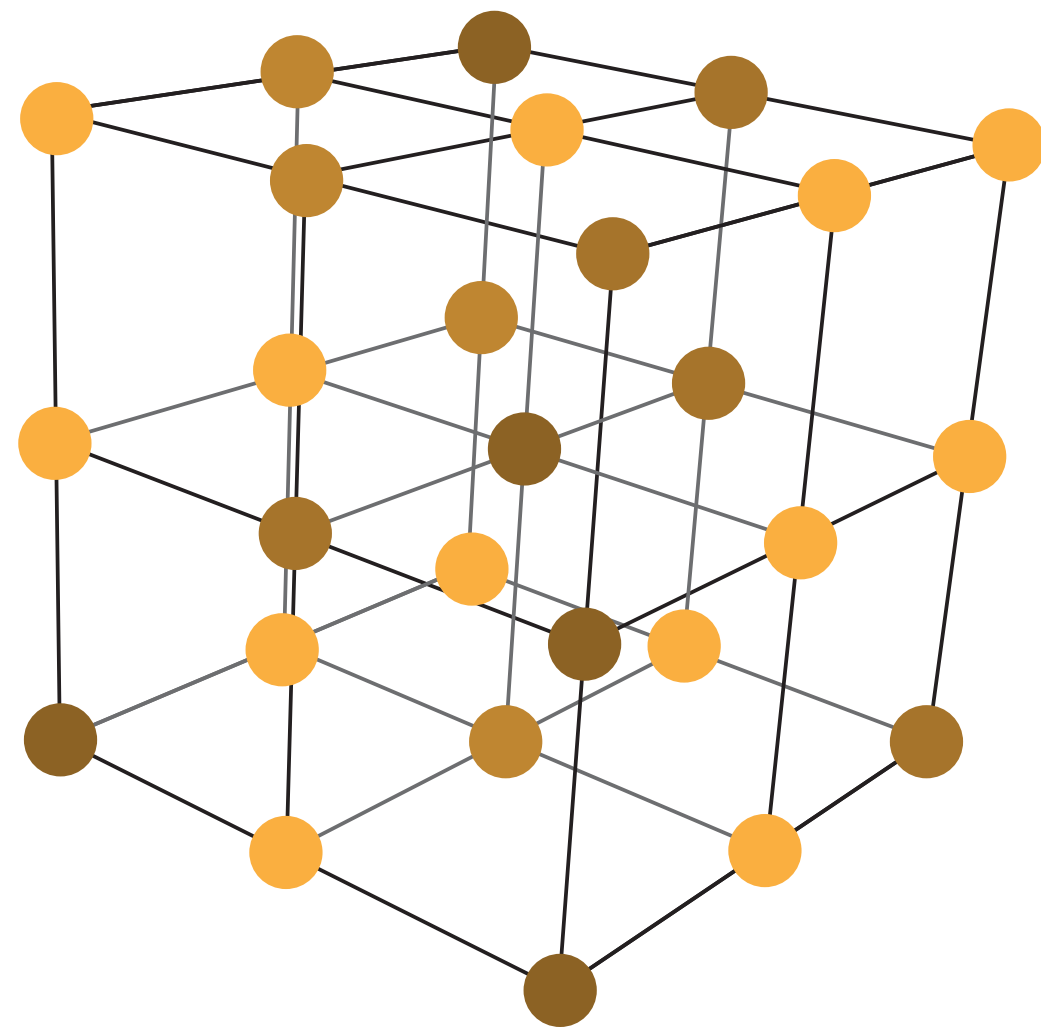
[Google Image Search for "information visualization", 2017]

Fields



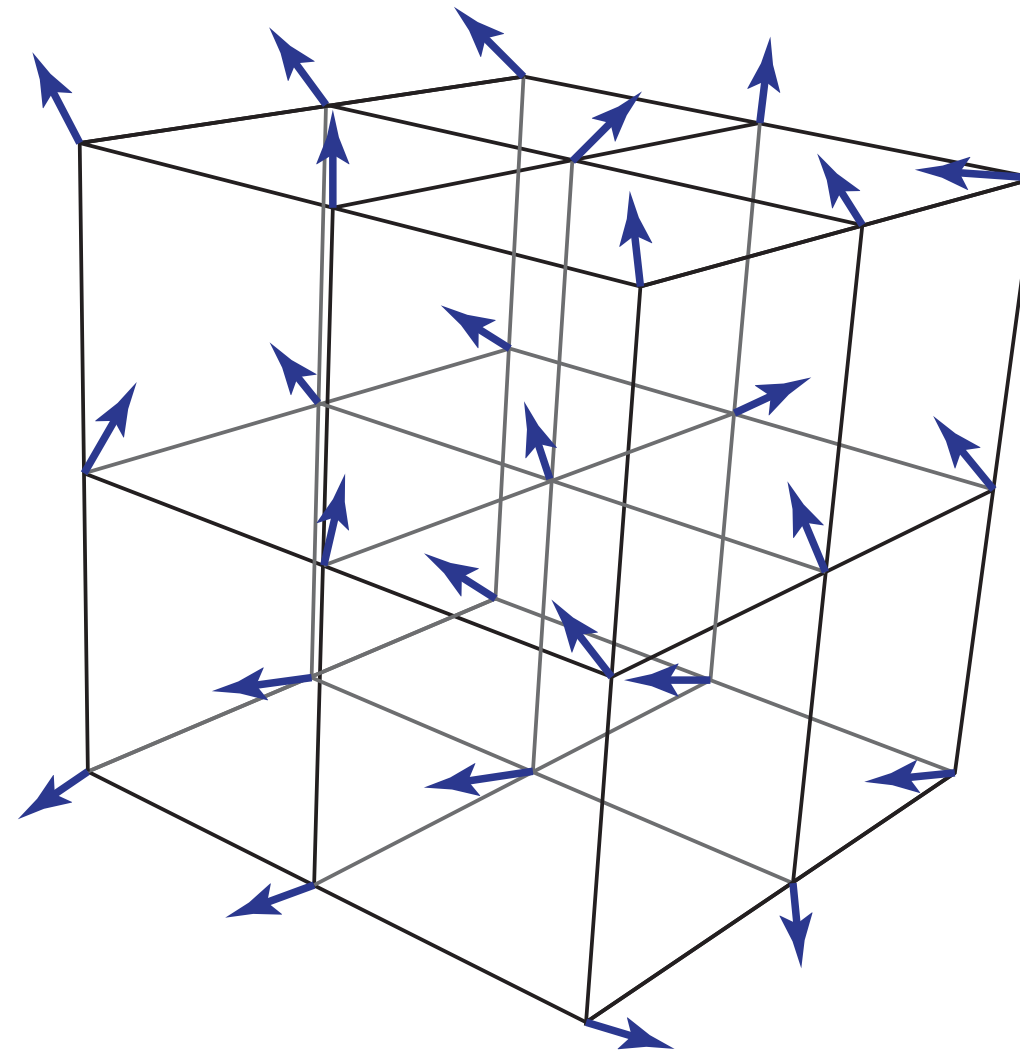
- Values come from a **continuous** domain, infinitely many values
- **Sampled** at certain positions to approximate the entire domain
- Positions are often aligned in **grids**
- Often measurements of natural or simulated phenomena
- Examples: temperature, wind speed, tissue density, pressure, speed, electrical conductance

Fields in Visualization



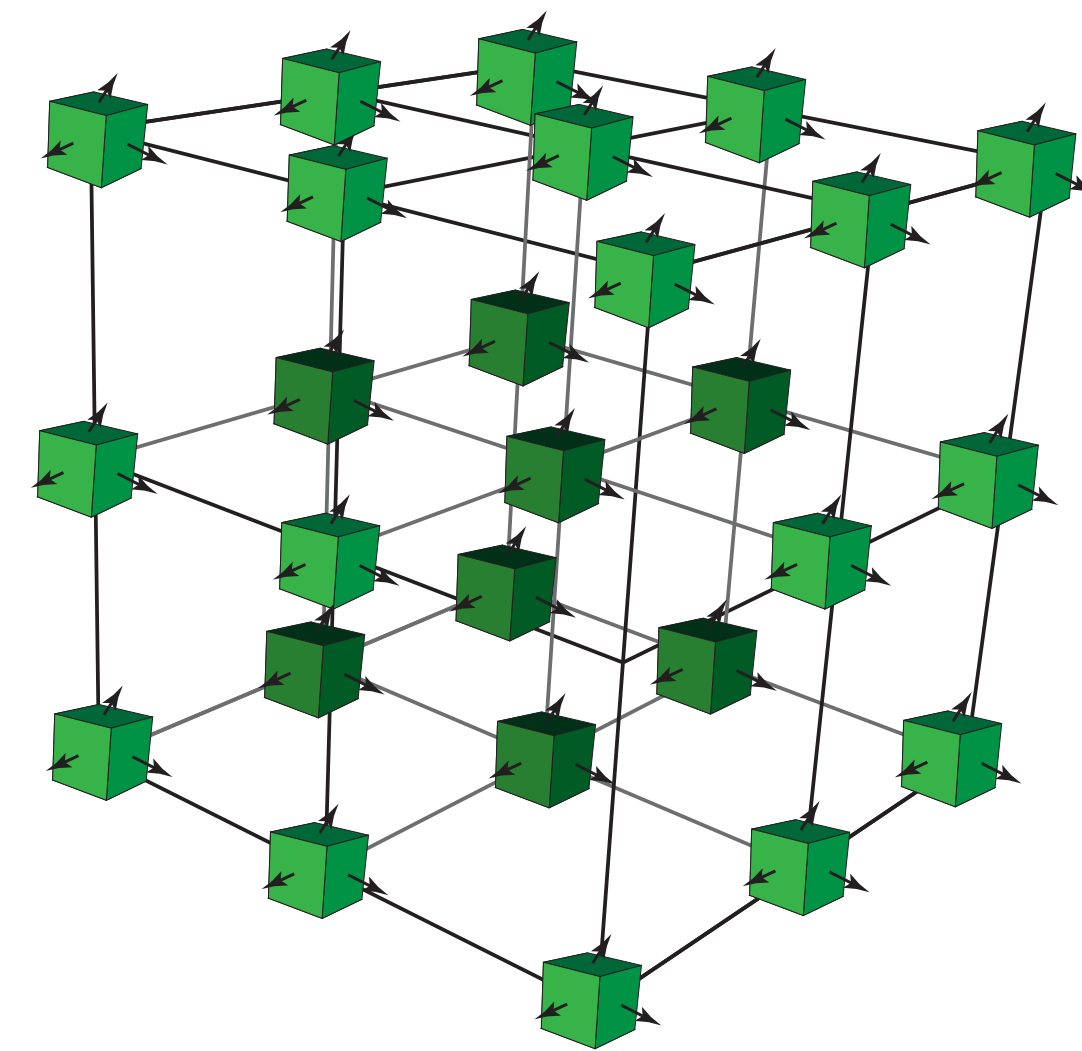
Scalar Fields

(Order-0 Tensor Fields)



Vector Fields

(Order-1 Tensor Fields)



Tensor Fields

(Order-2+)

Each point in space has an associated...

s_0

Scalar

$$\begin{bmatrix} v_0 \\ v_1 \\ v_2 \end{bmatrix}$$

Vector

$$\begin{bmatrix} \sigma_{00} & \sigma_{01} & \sigma_{02} \\ \sigma_{10} & \sigma_{11} & \sigma_{12} \\ \sigma_{20} & \sigma_{21} & \sigma_{22} \end{bmatrix}$$

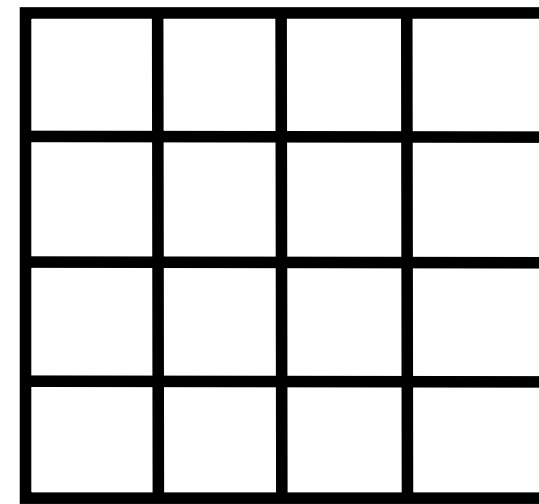
Tensor

Grids

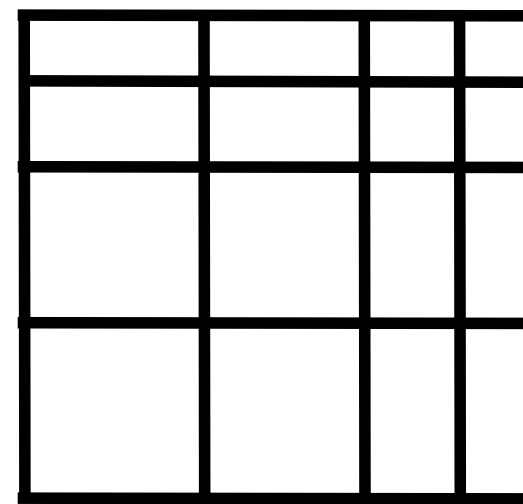
- [illegible]

Grids

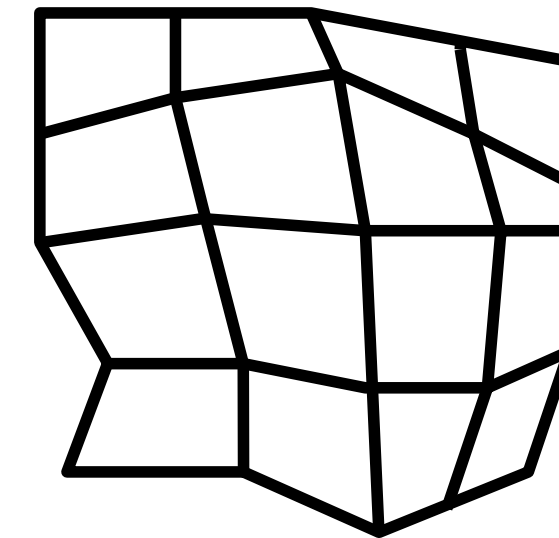
- Remember we have continuous data and want to sample it in order to understand the **entire** domain
- Possible schemes?



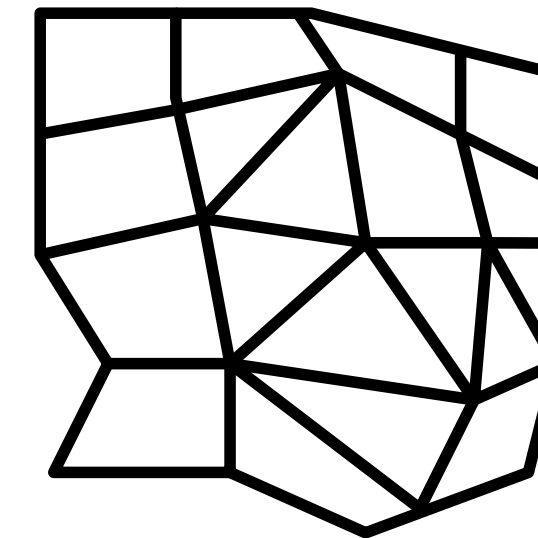
uniform



rectilinear



structured

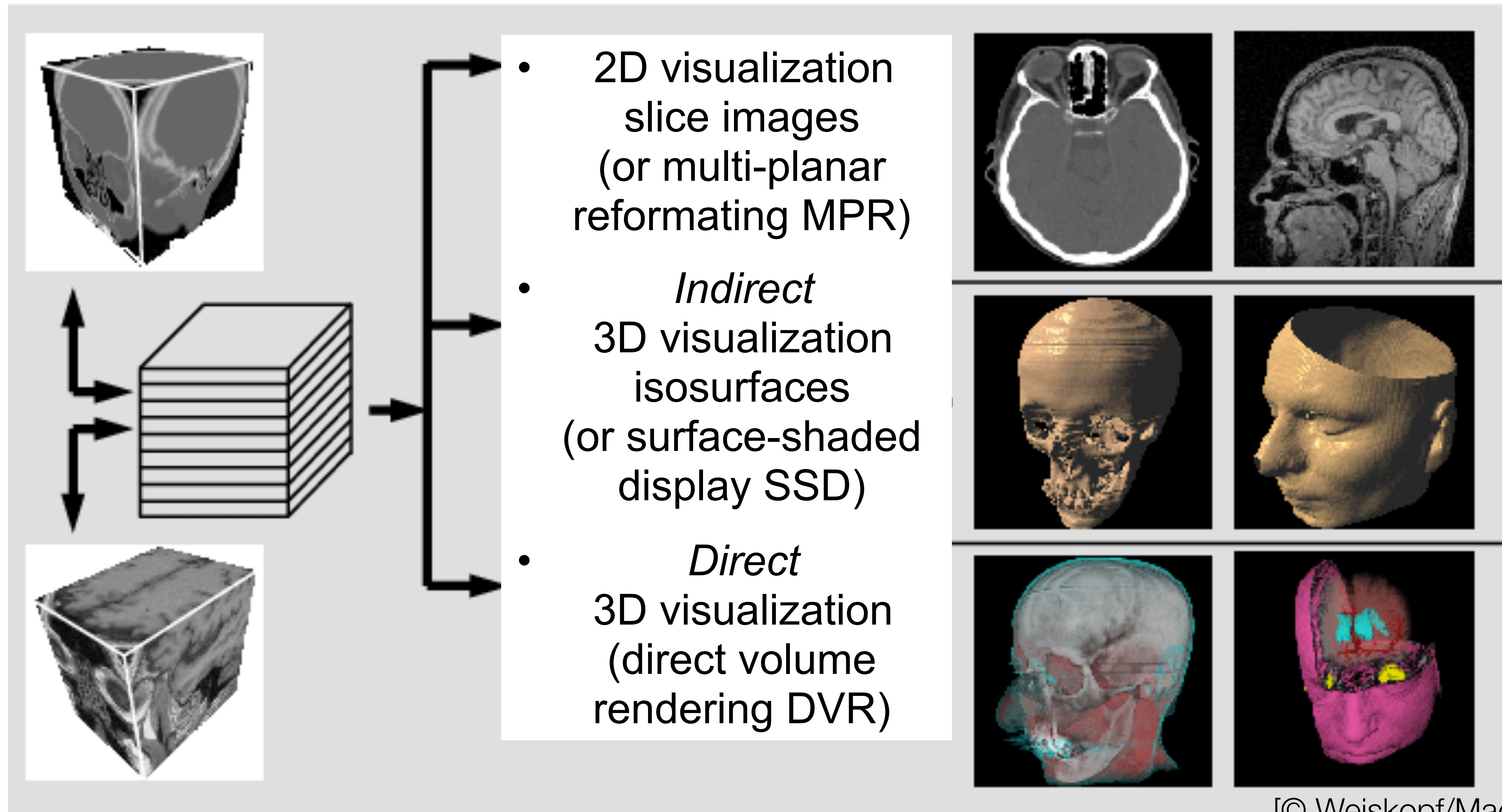


unstructured

[© Weiskopf/Machiraju/Möller]

- Geometry: the spatial positions of the data (points)
- Topology: how the points are connected (cells)
- Type of grid determines how much data needs to be stored for both geometry and topology

Visualizing Volume (3D) Data

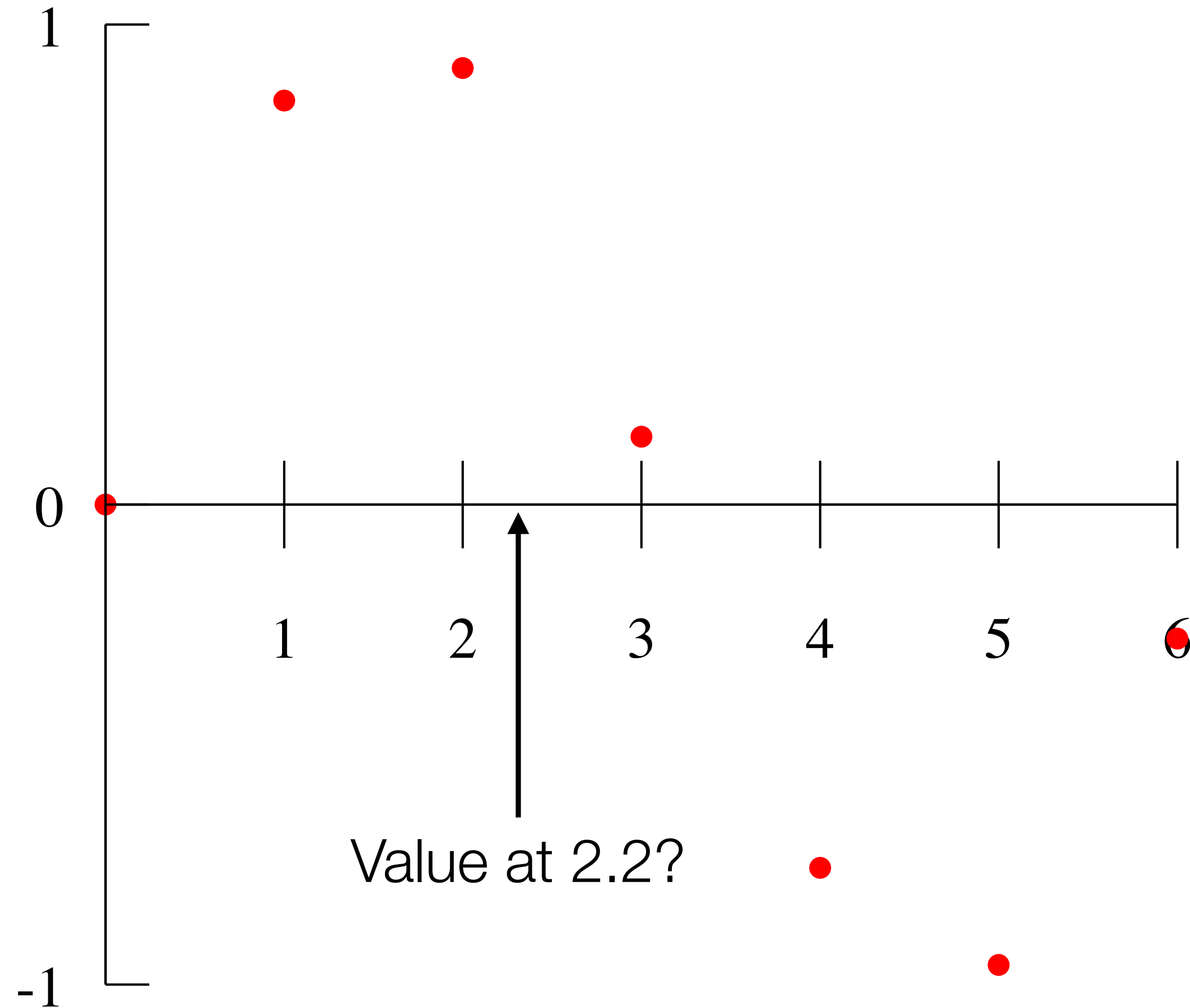


[© Weiskopf/Machiraju/Möller]

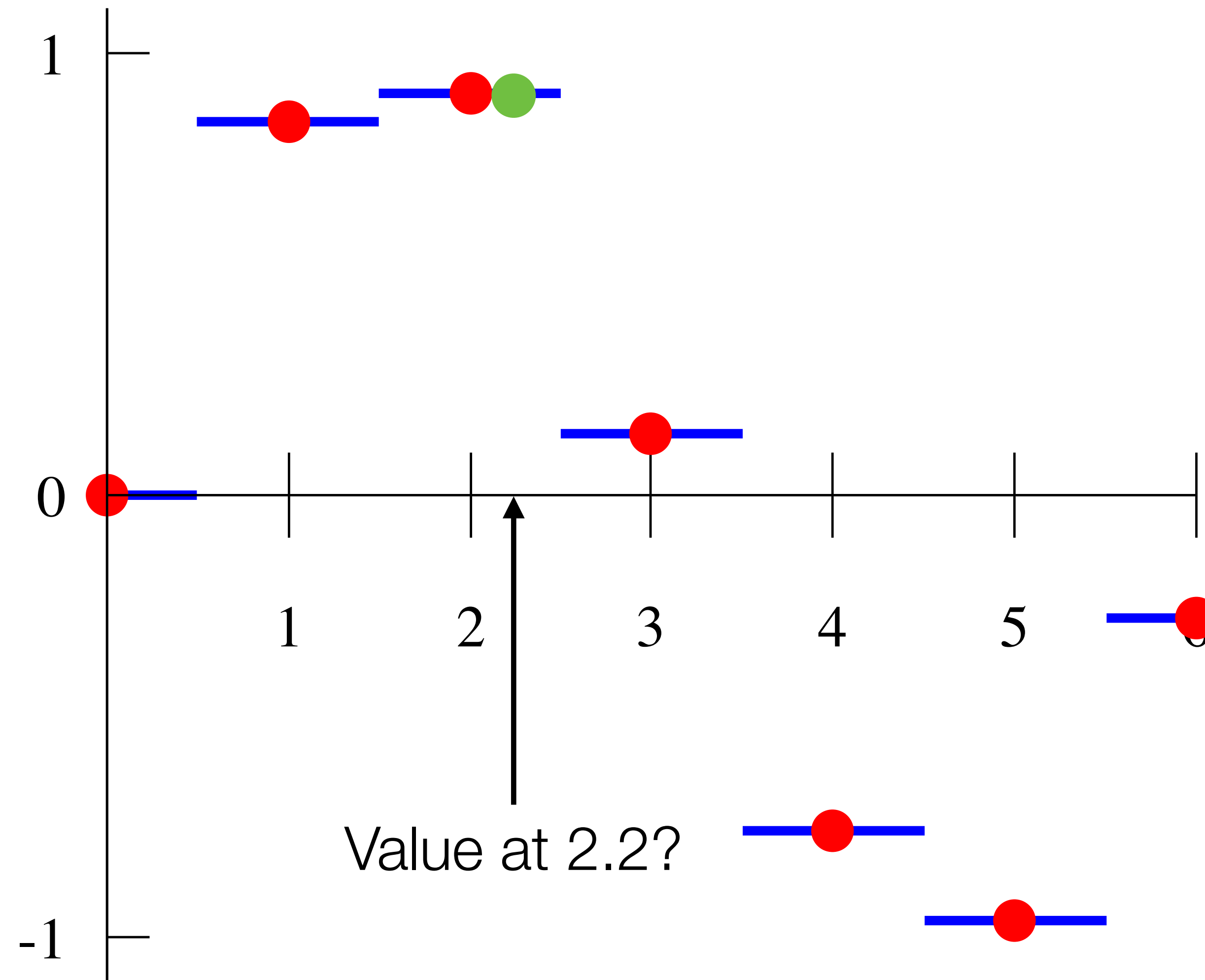
Data

- In this lecture, we will be considering **scalar** data: a single value at each point
- Our data is always discrete, what is the value of a point not exactly on our grid?
- Need a method to determine what these values are...

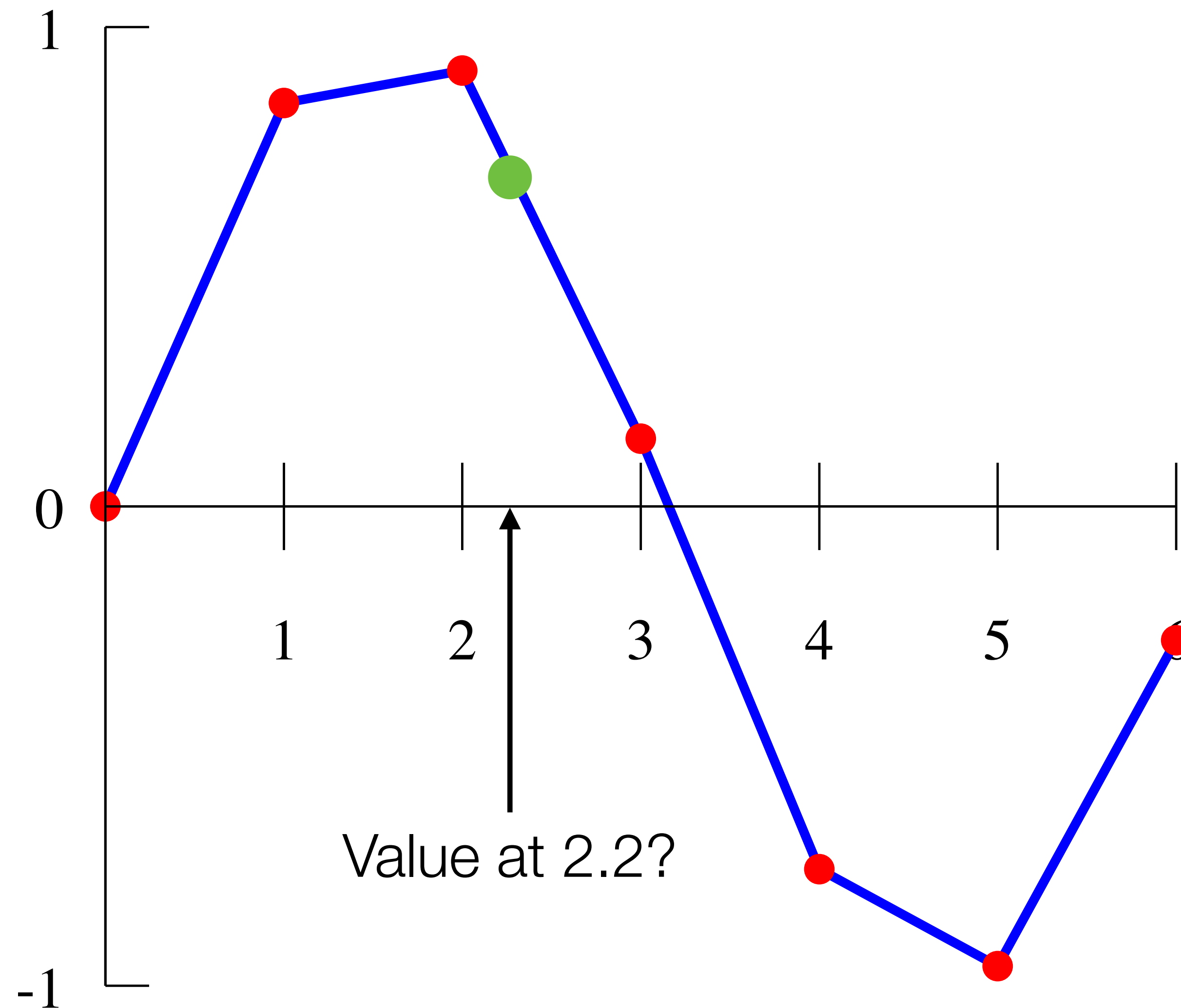
Interpolation



Nearest Neighbor Interpolation



Linear Interpolation



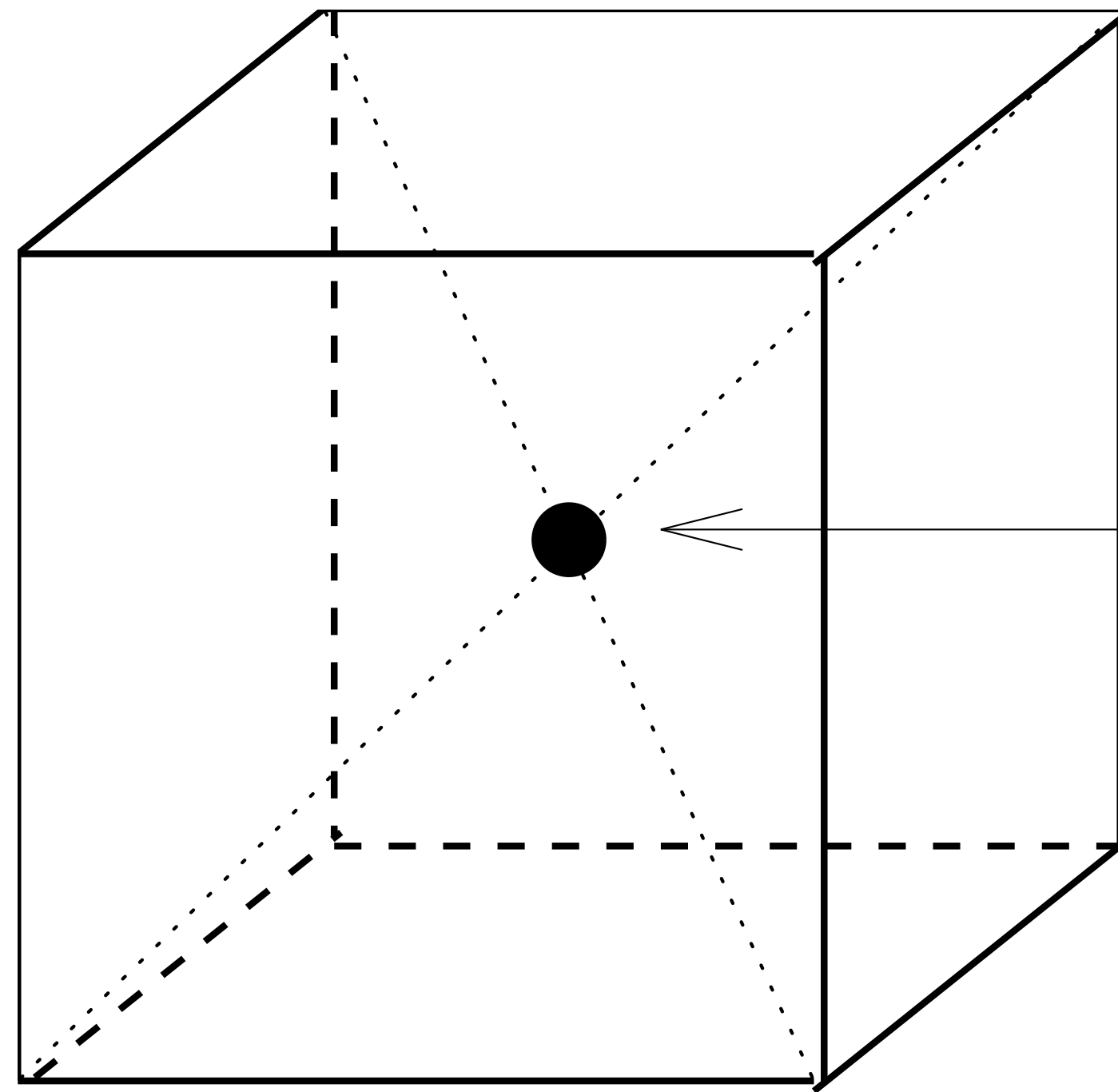
Interpolation

- Other schemes:
 - polynomial interpolation
 - splines
 - more...

Dimensions of Data

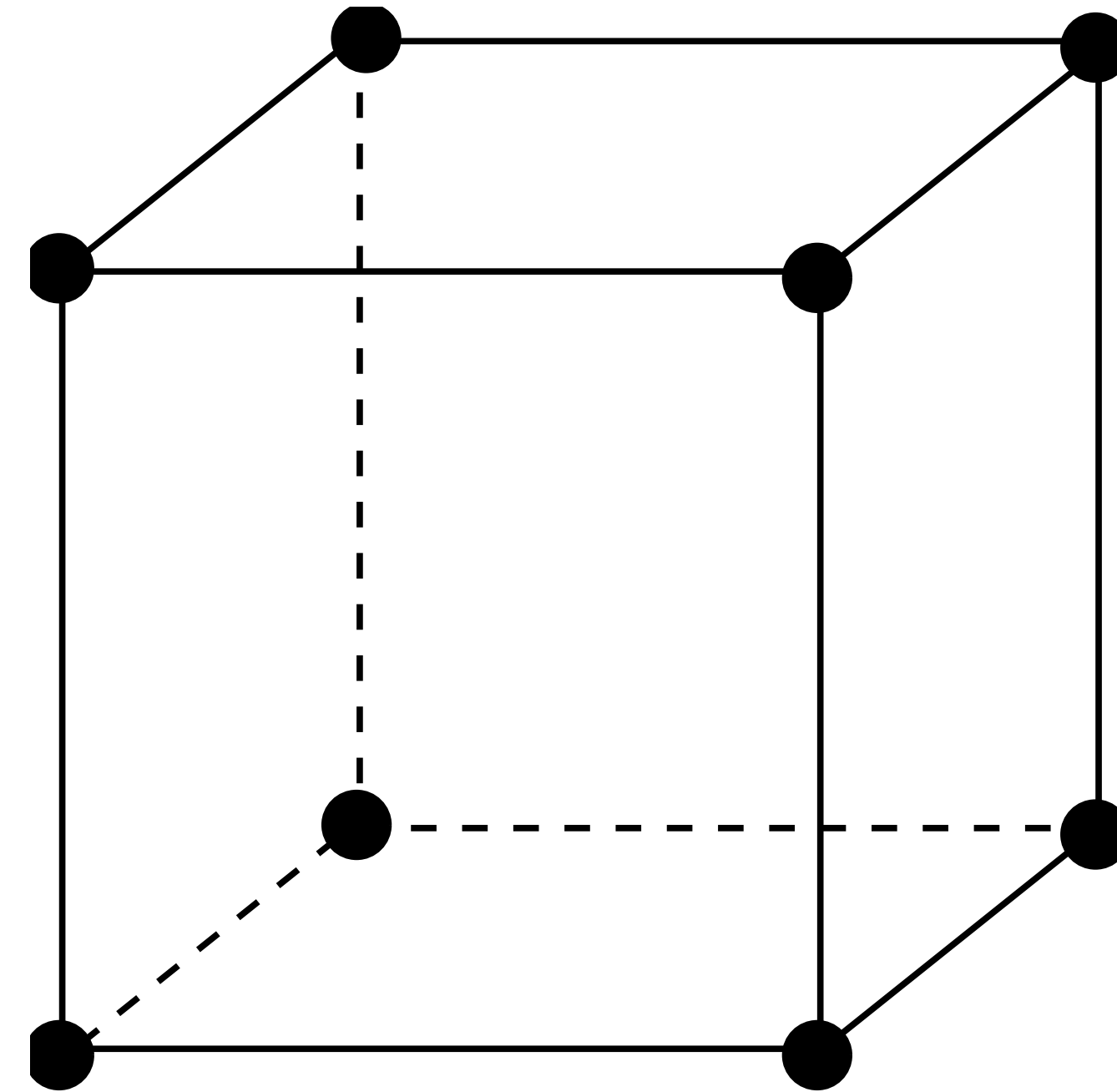
- 1-Dimension: data along a line
 - Example: temperature along my drive from Massachusetts to Illinois
- 2-Dimensional: data on a plane
 - Example: temperature on the surface of a pond
- 3-Dimensional: data in our normal world (data in a **volume**)
 - Example: temperature at every point in the room
- Complexity increases as we add dimensions
- Visualization complexity also increases
- Often, want to be able to see phenomena as we see them in real life settings

3D: Voxels and Cells



VOXEL

gridpoint

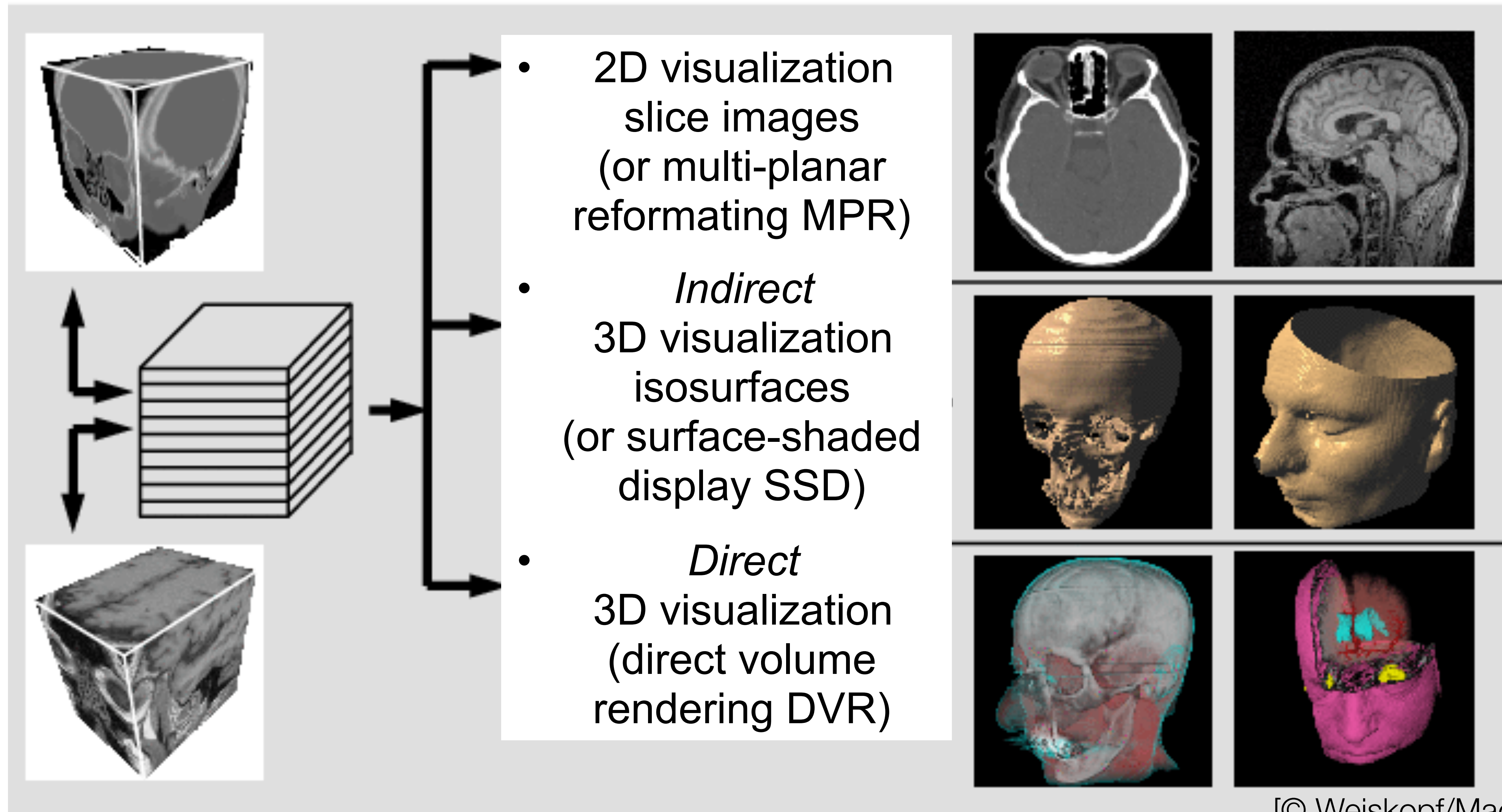


gridpoint

CELL

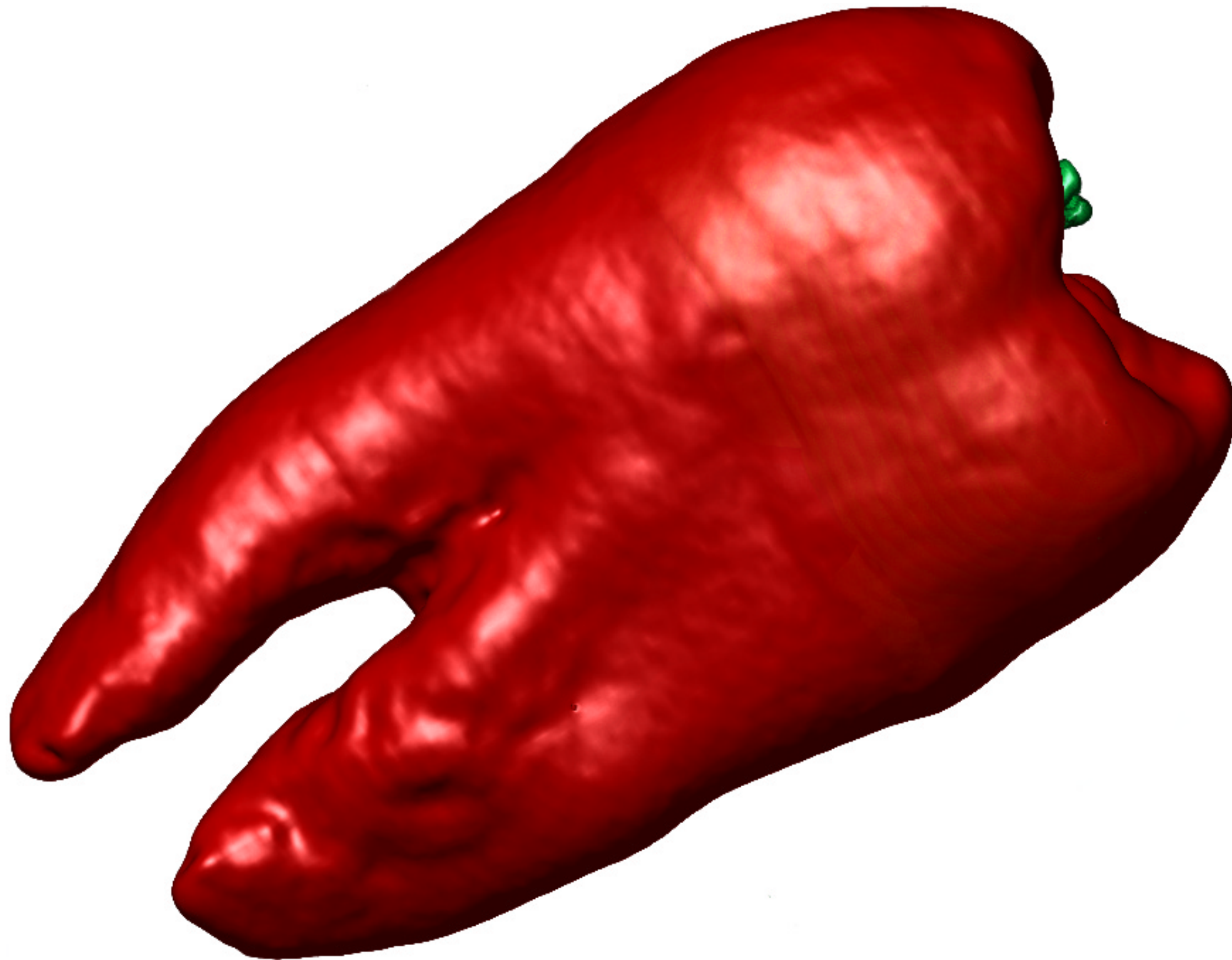
[from <http://www.cs.rug.nl/~michael/FANTOM/FANTOM1a.pdf>]

Visualizing Volume (3D) Data

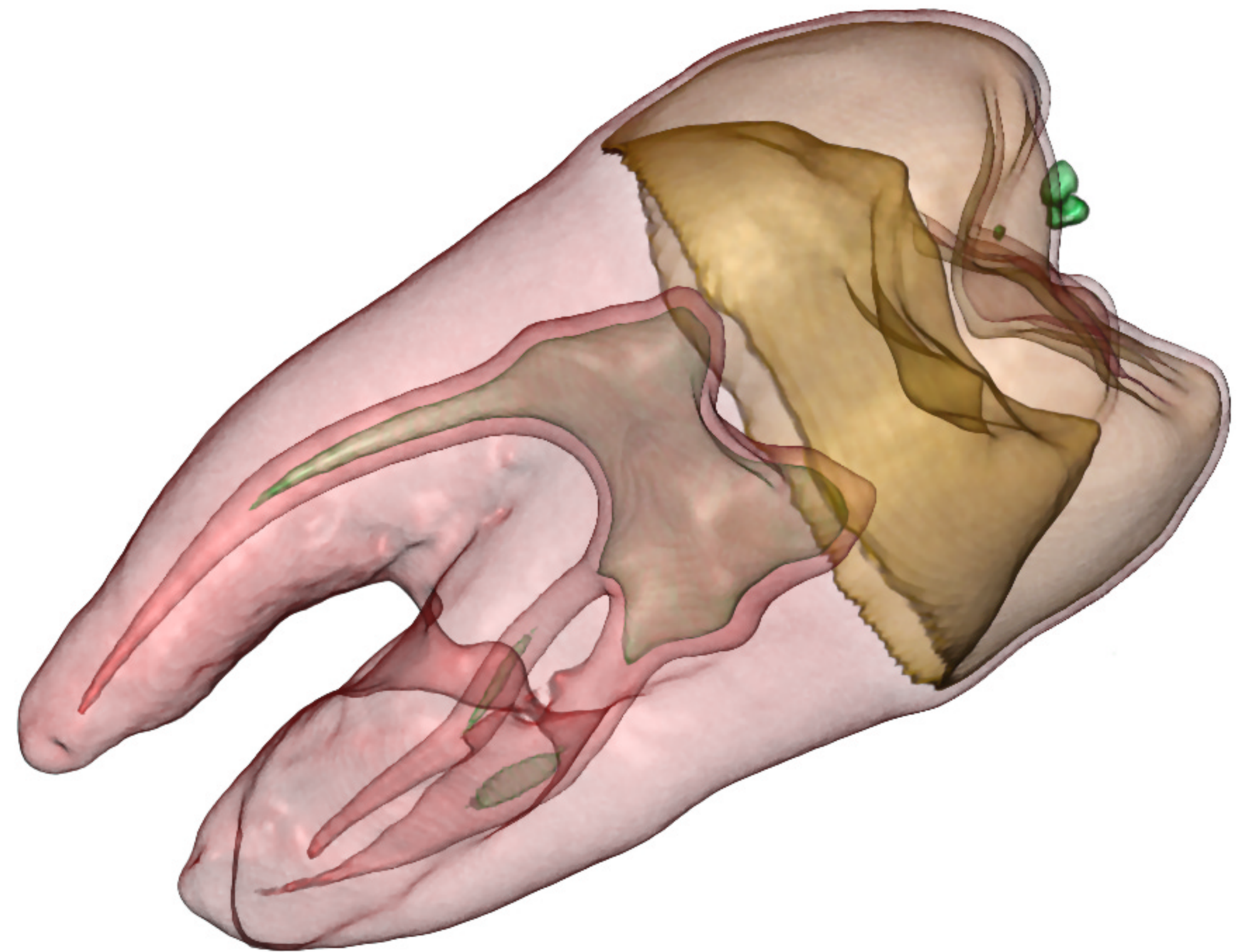


[© Weiskopf/Machiraju/Möller]

Visualizing Volume (3D) Data



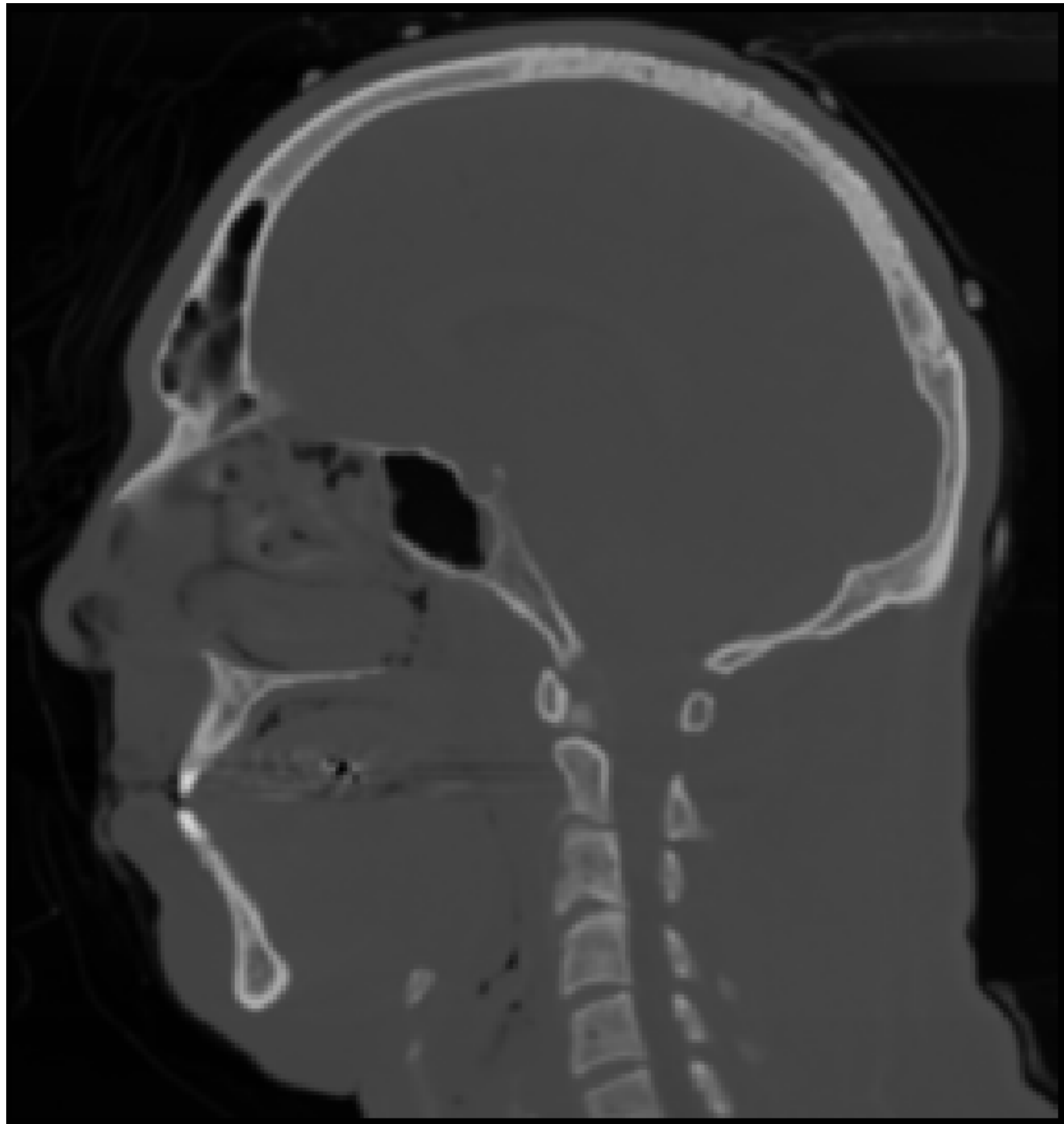
(a) An isosurfaced tooth.



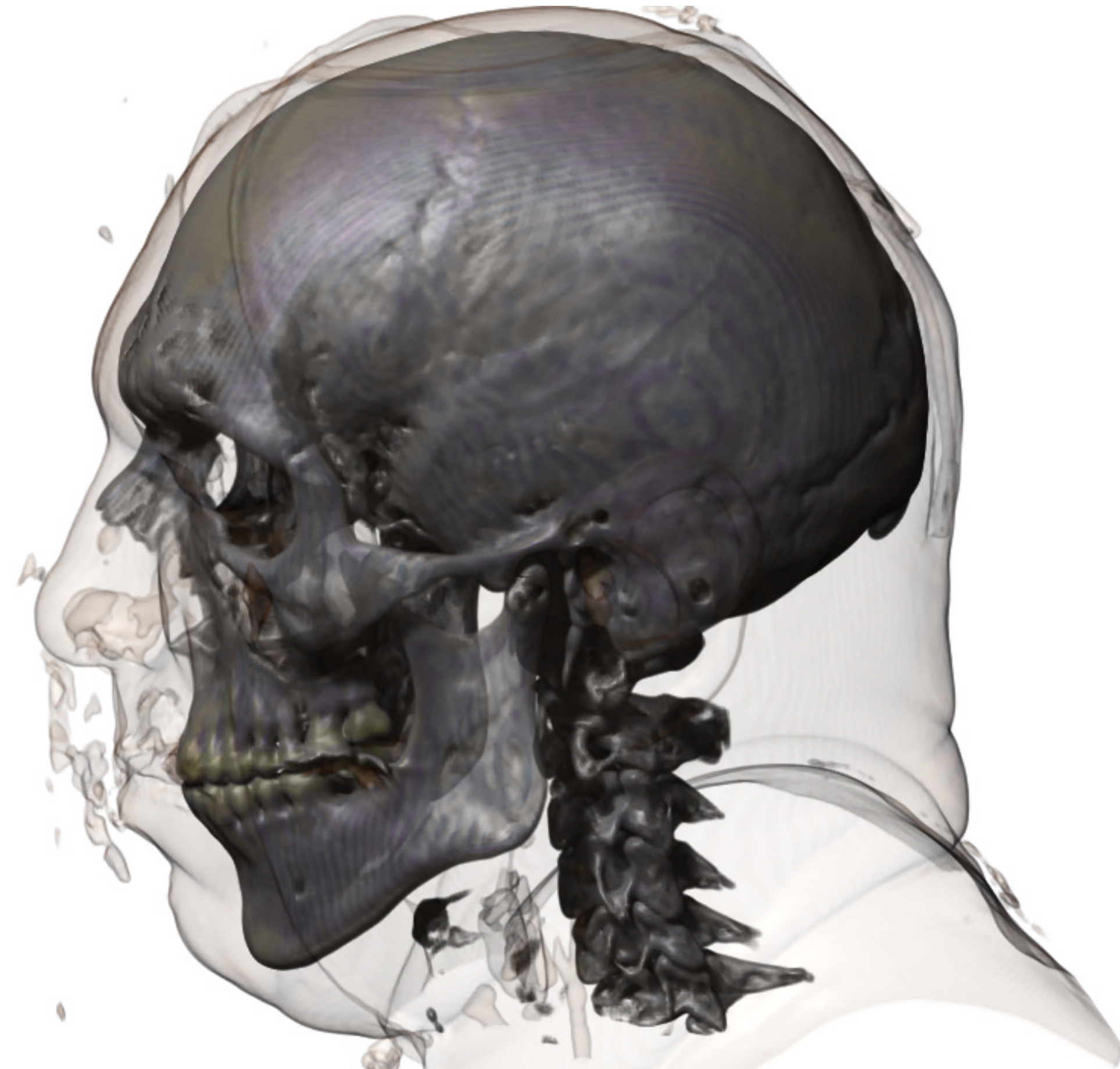
(b) Multiple isosurfaces.

[J. Kniss, 2002]

Visualizing Volume (3D) Data



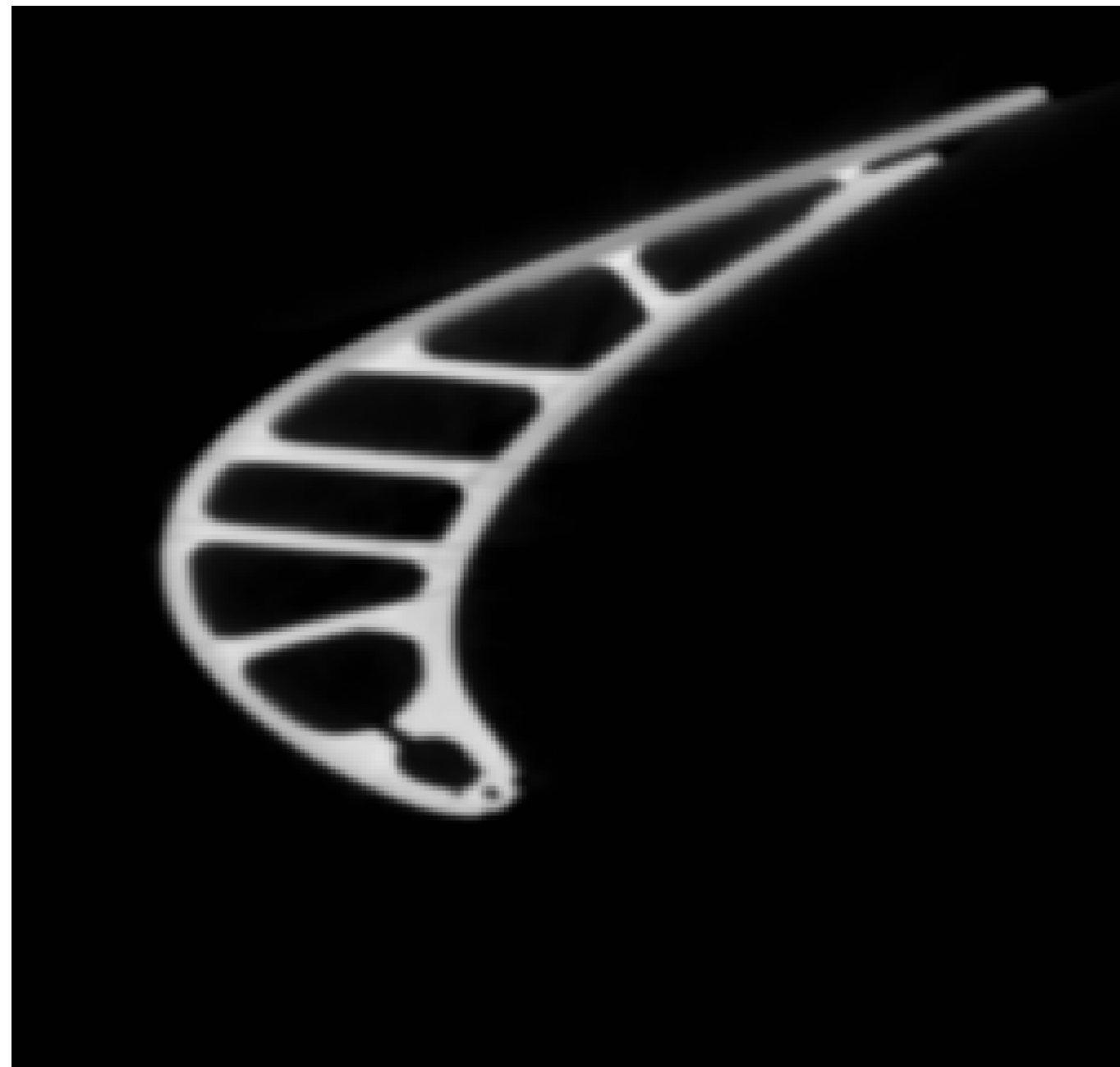
(a) 2D slice



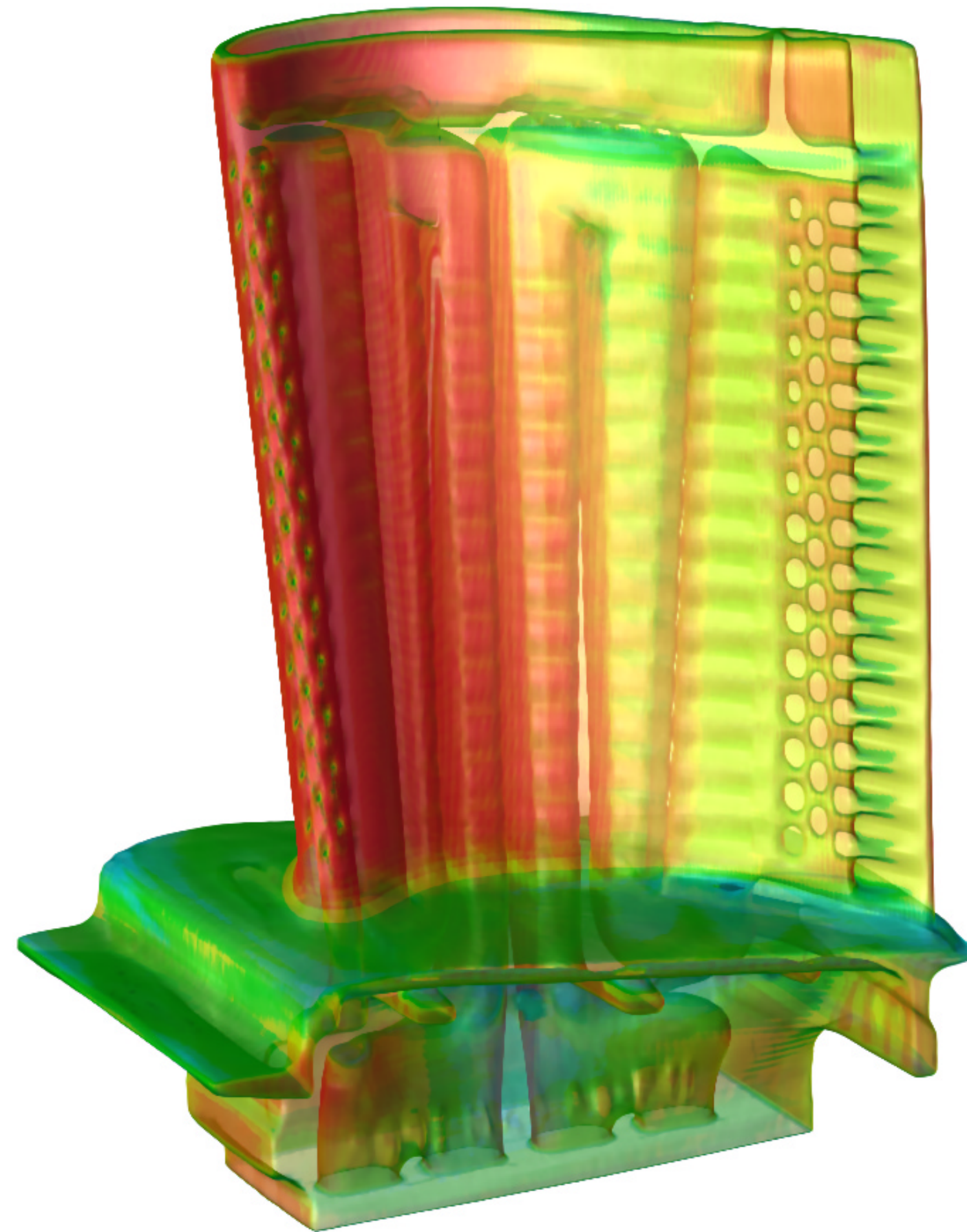
(b) Volume Rendering

[J. Kniss, 2002]

Visualizing Volume (3D) Data



(a) 2D slice



(b) Volume Rendering

[J. Kniss, 2002]

How have we encoded 3D scalar data before?
Hint: Think about elevation maps