Data Visualization (CSCI 627/490)

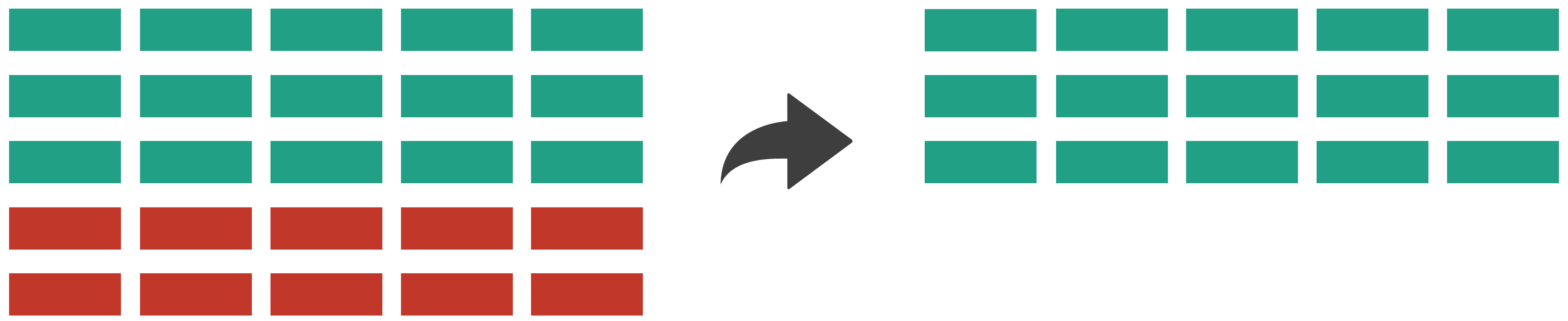
Isosurfacing

Dr. David Koop

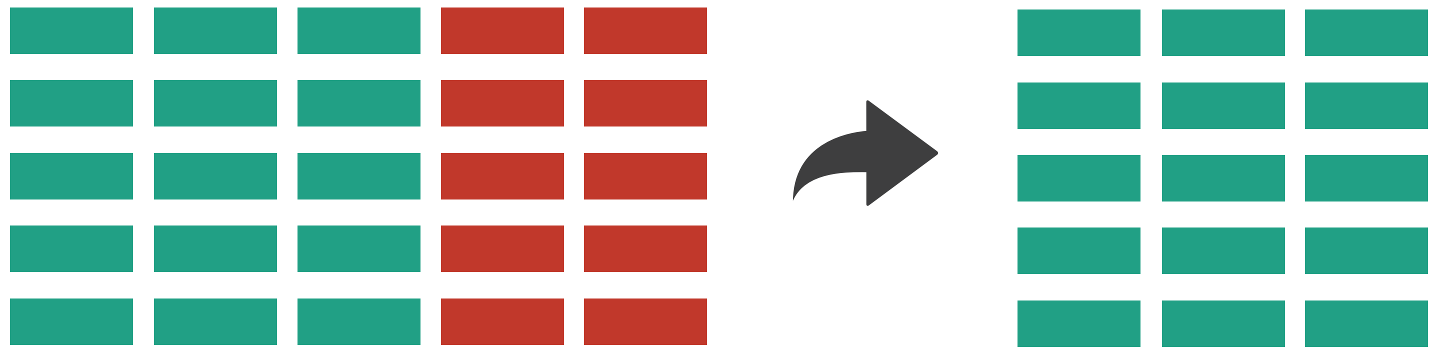
Overview: Reducing Items & Attributes

Filter

→ Items

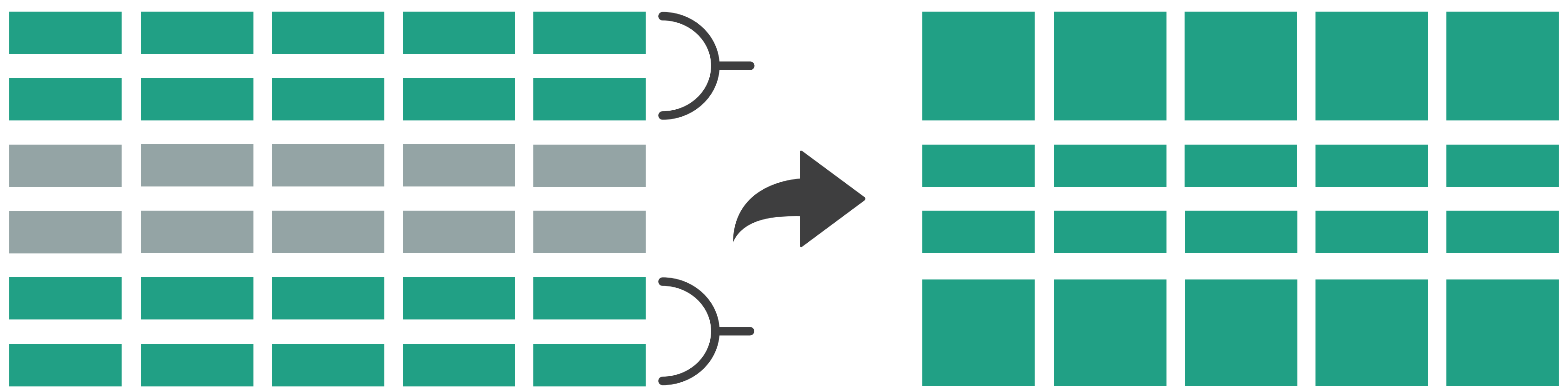


→ Attributes

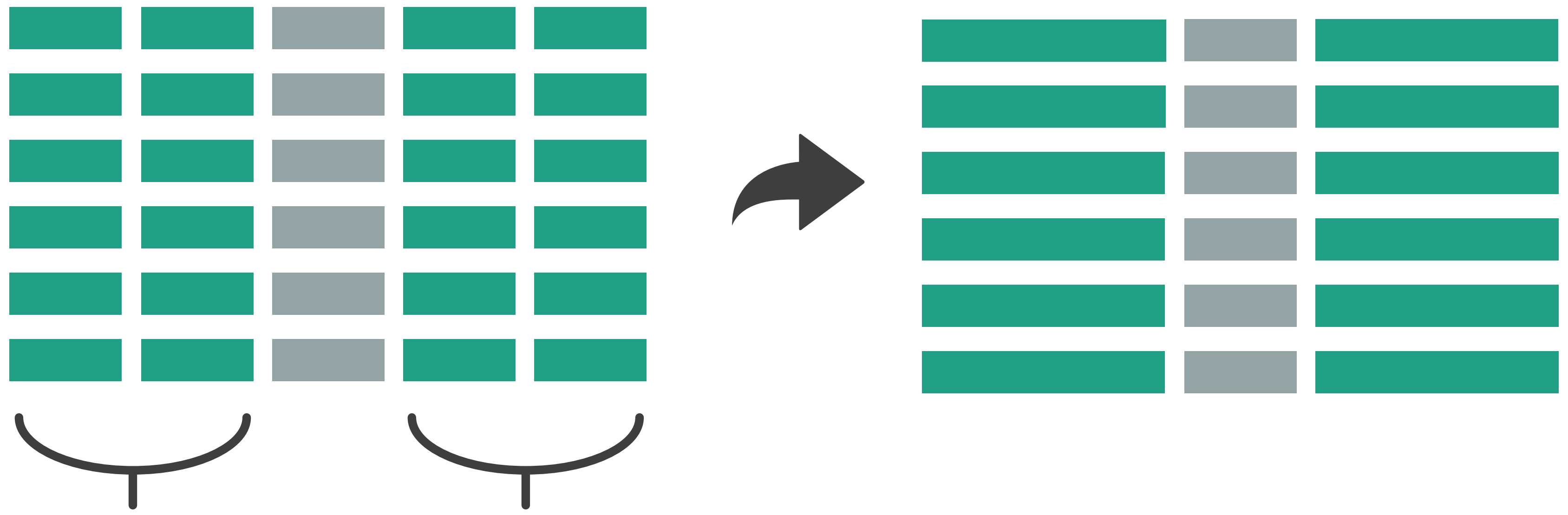


Aggregate

→ Items

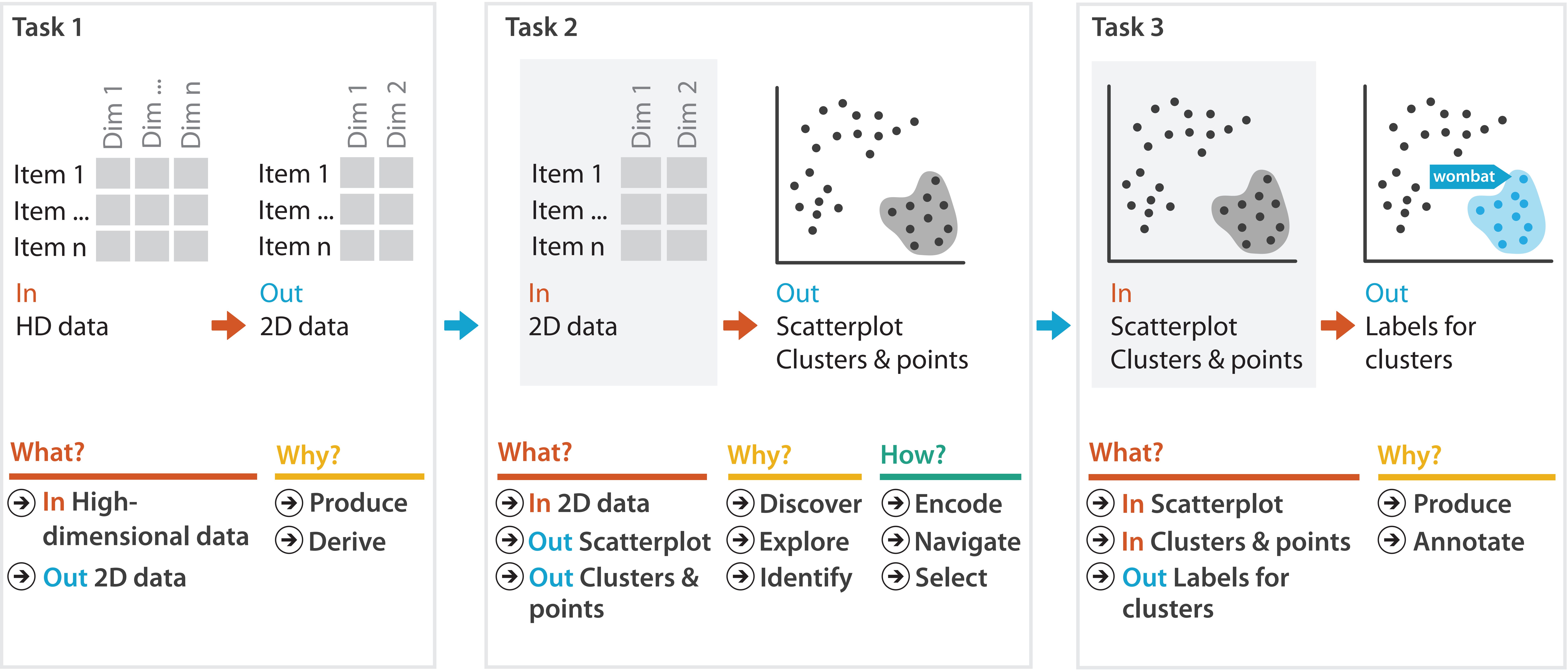


→ Attributes



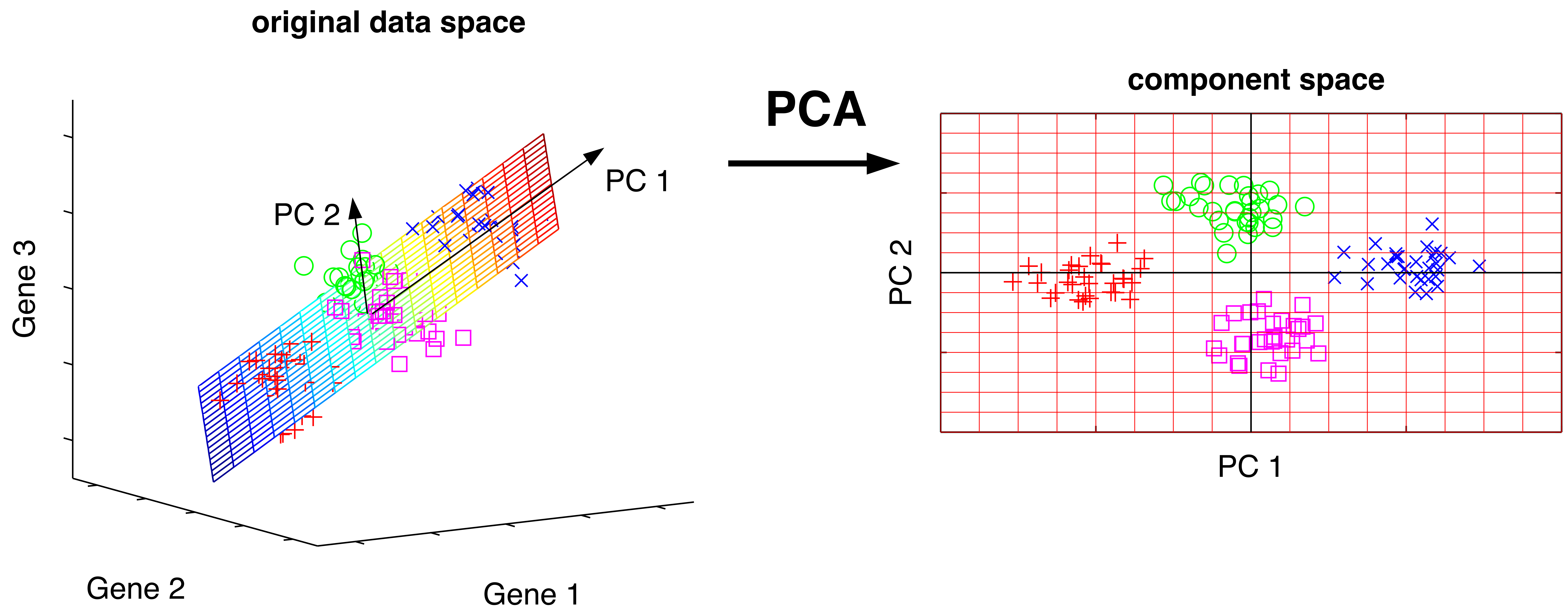
[Munzner (ill. Maguire), 2014]

Tasks in Understanding High-Dim. Data

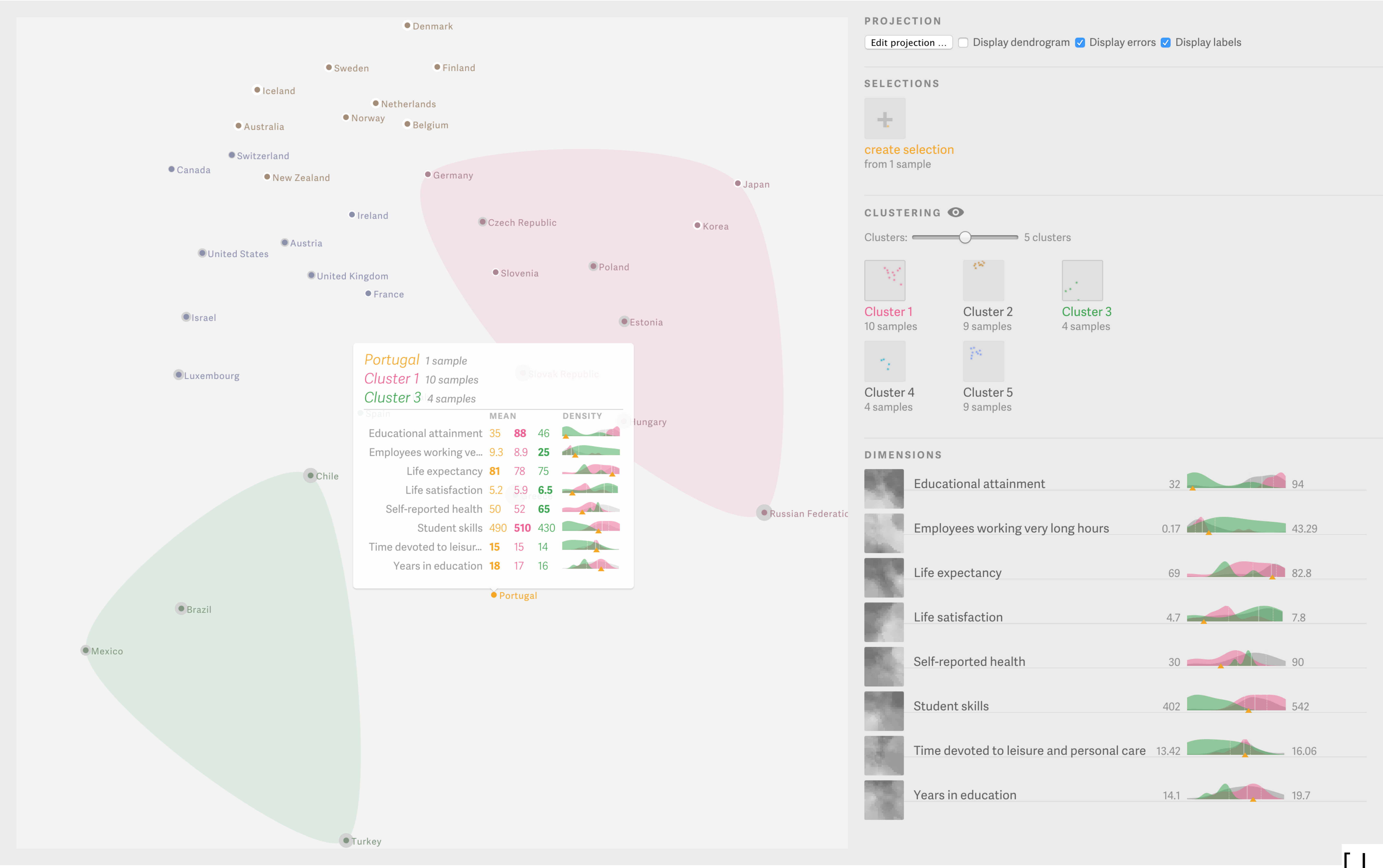


[Munzner (ill. Maguire), 2014]

Principle Component Analysis (PCA)



Probing Projections



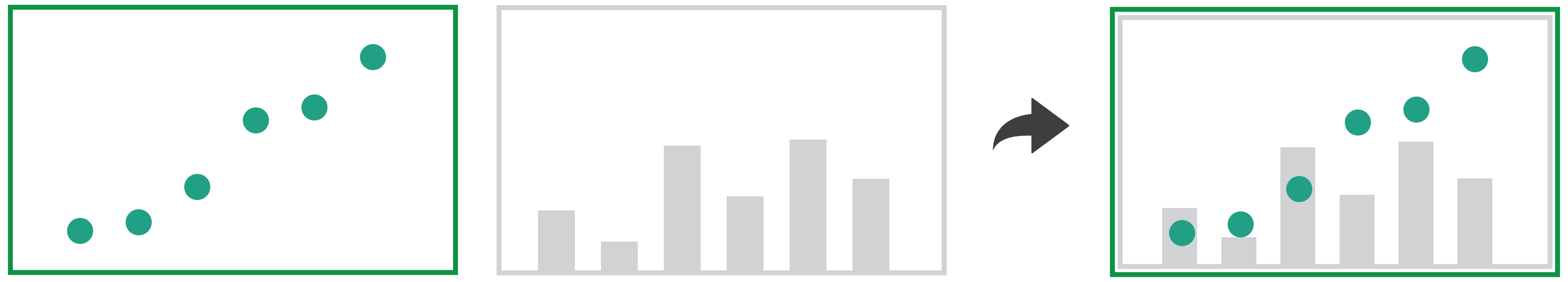
[J. Stahnke et al., 2015]

Focus+Context Overview

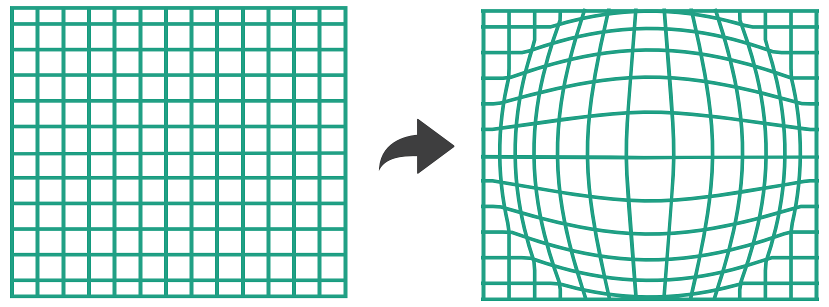
Embed

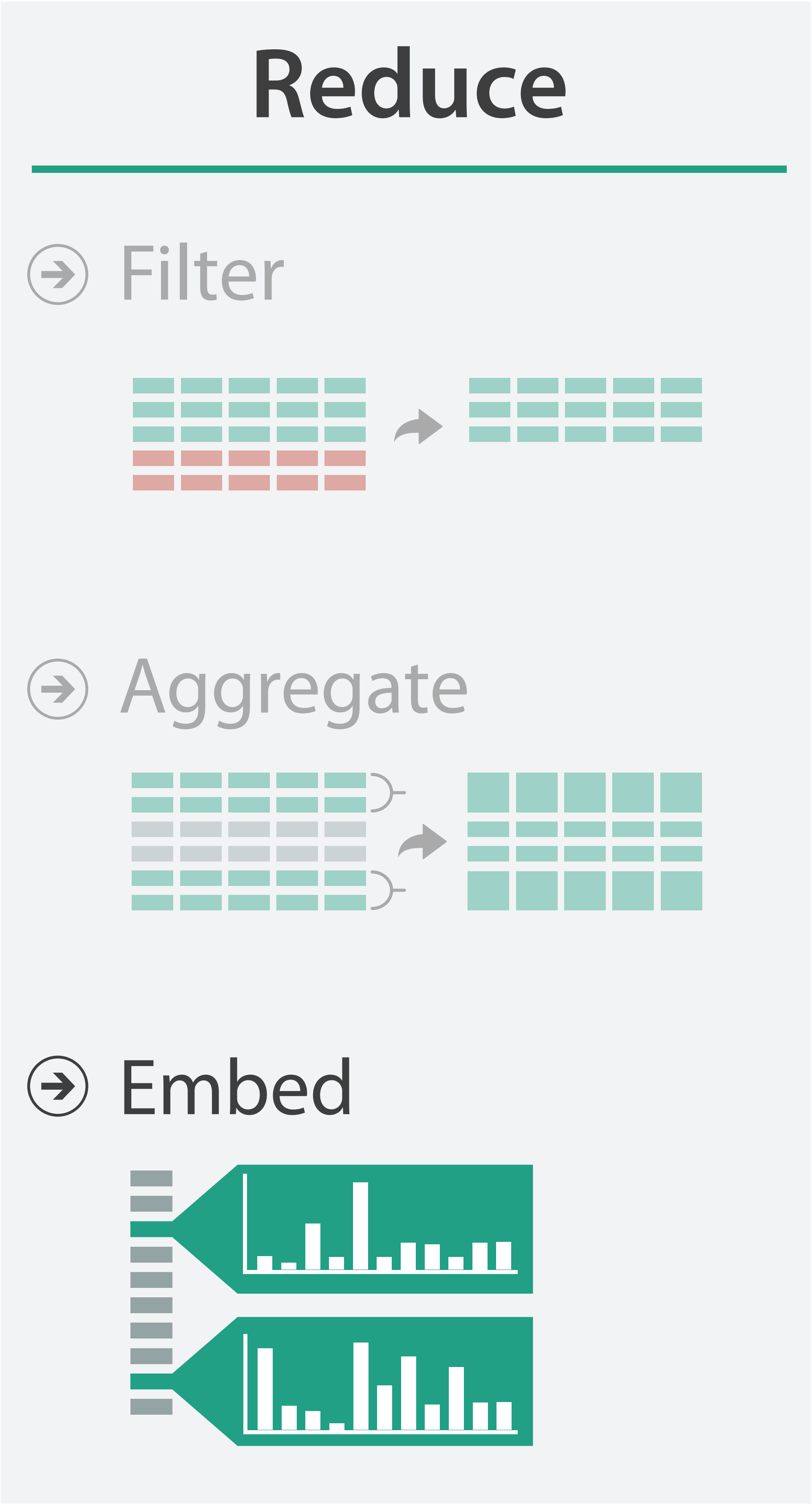
- Elide Data

- Superimpose Layer



- Distort Geometry

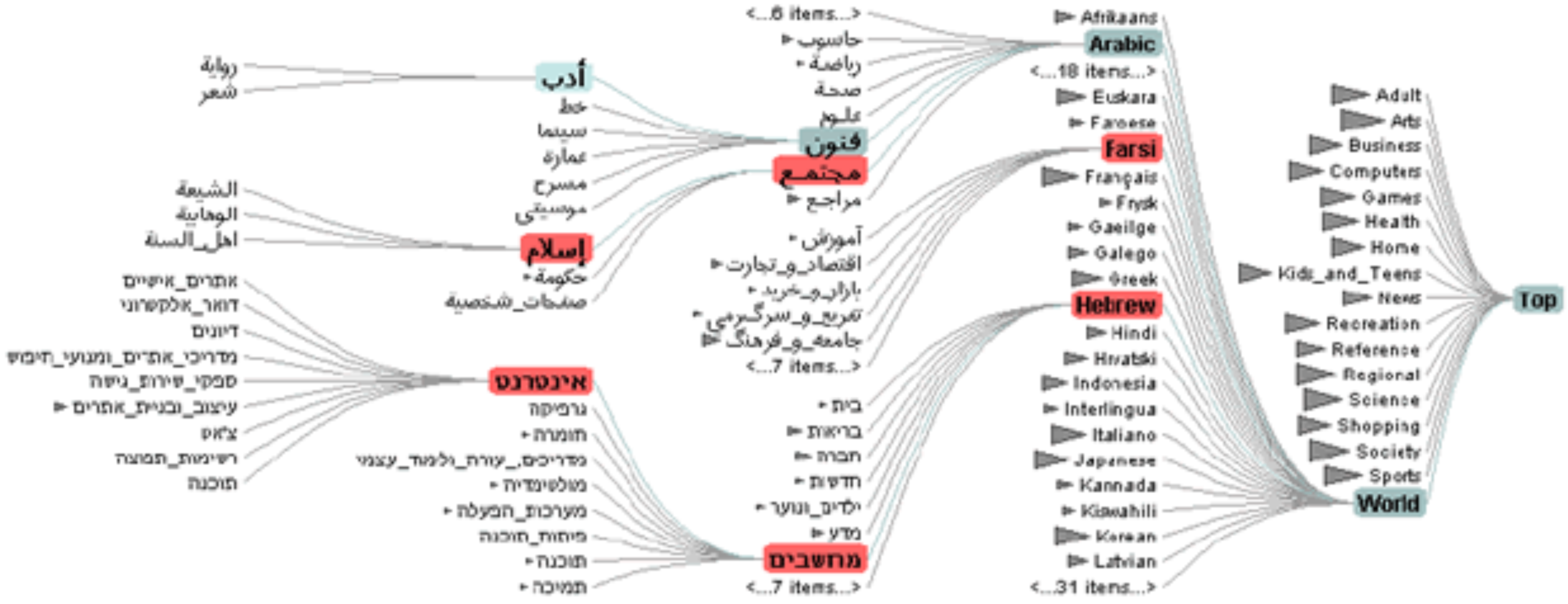




[Munzner (ill. Maguire), 2014]

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

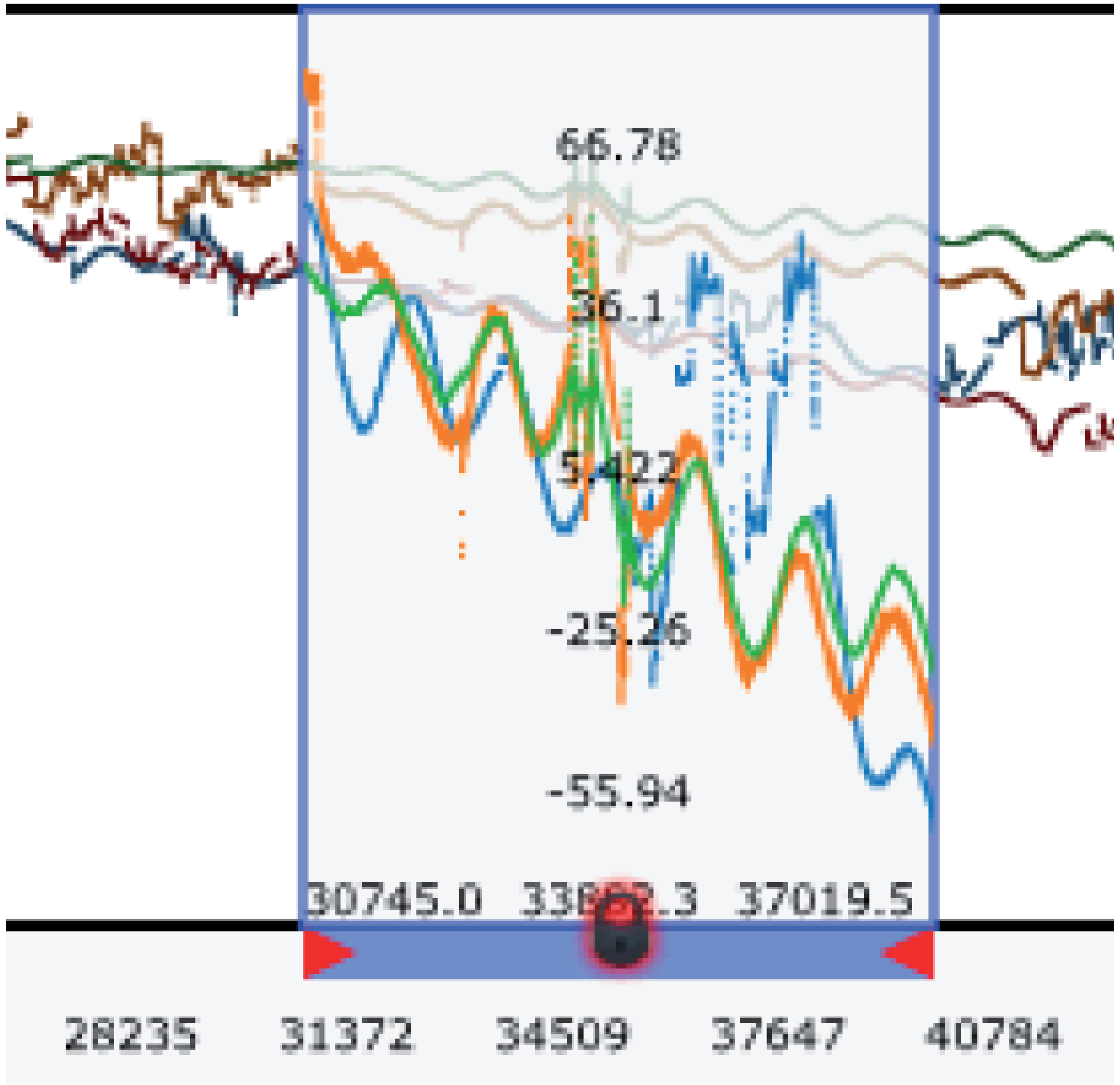


[Heer and Card, 2004]

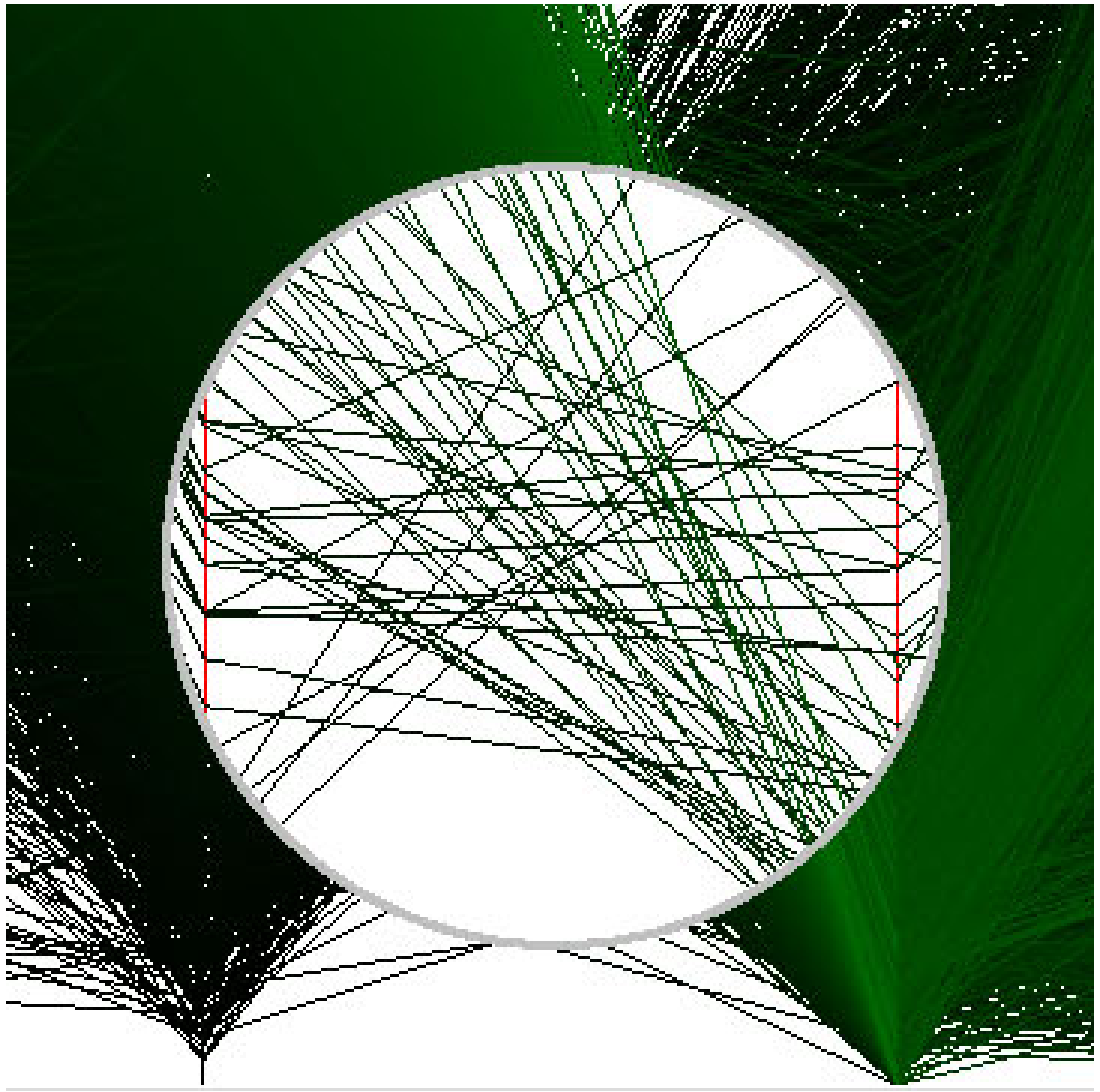
Superimposition

- 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



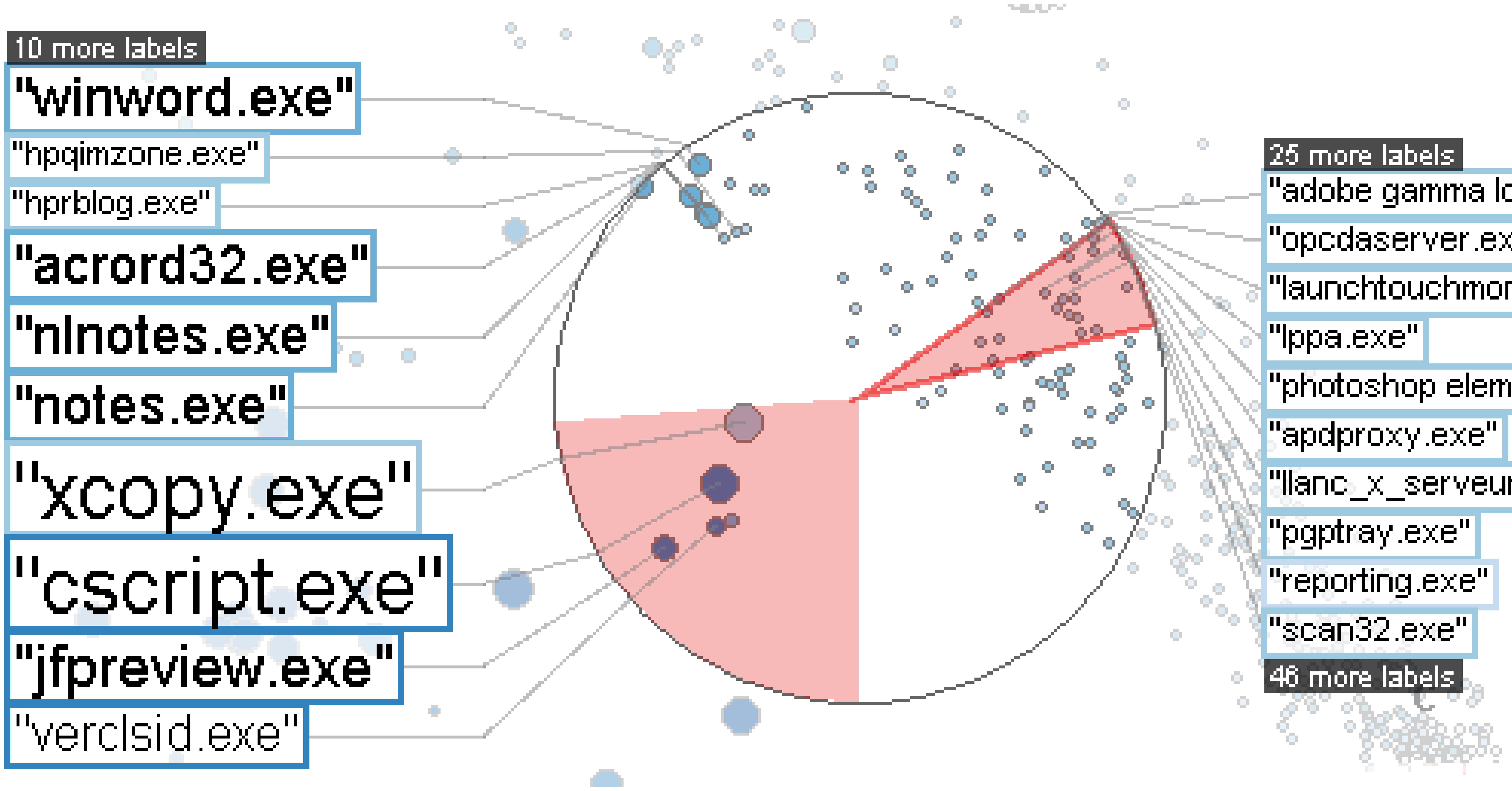
(a) Alteration



(b) Suppression

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

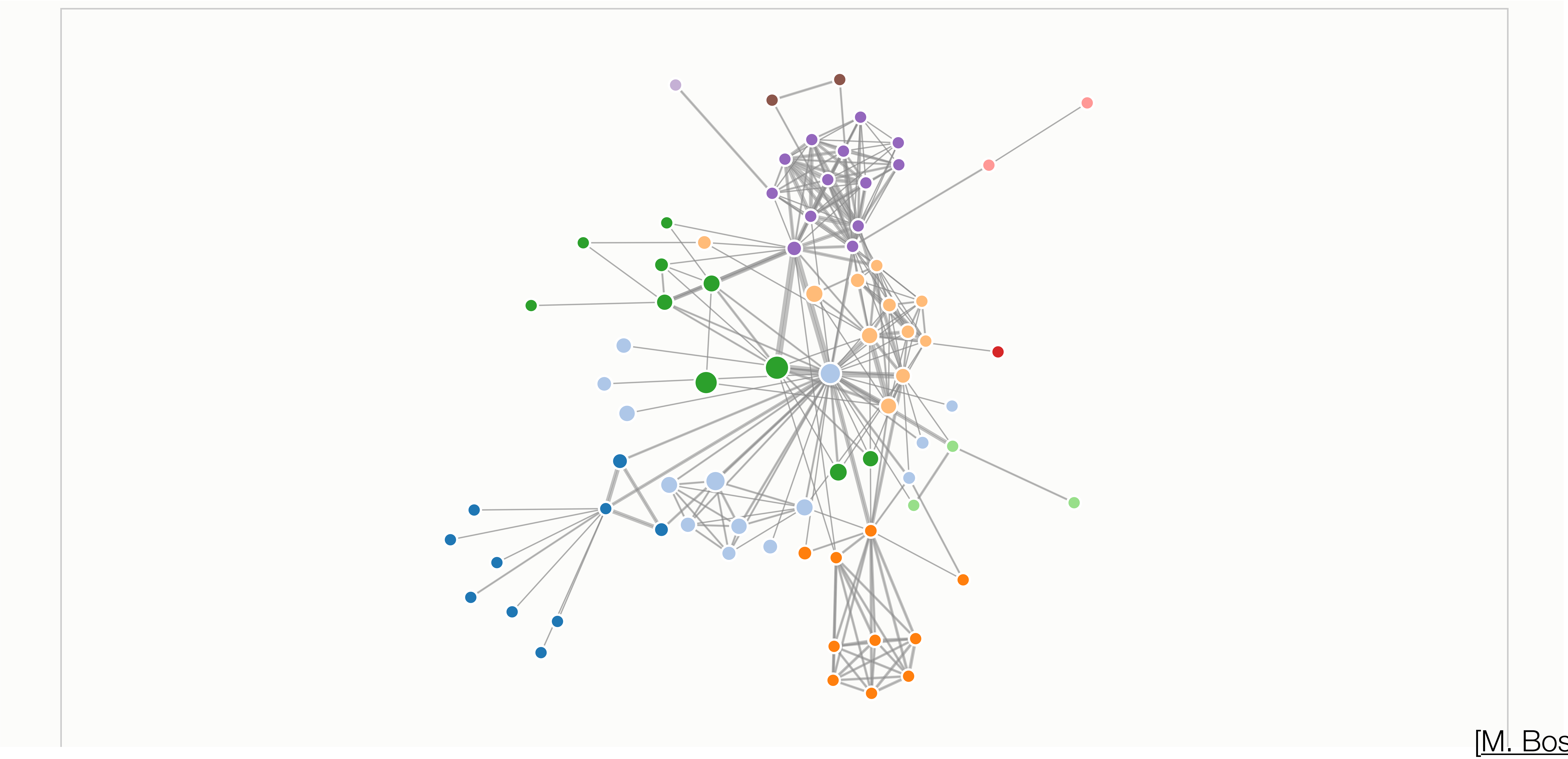
Superimposition with Interactive



(c) Enrichment

[Extended Lens in Tominski et al., 2014]

Distortion

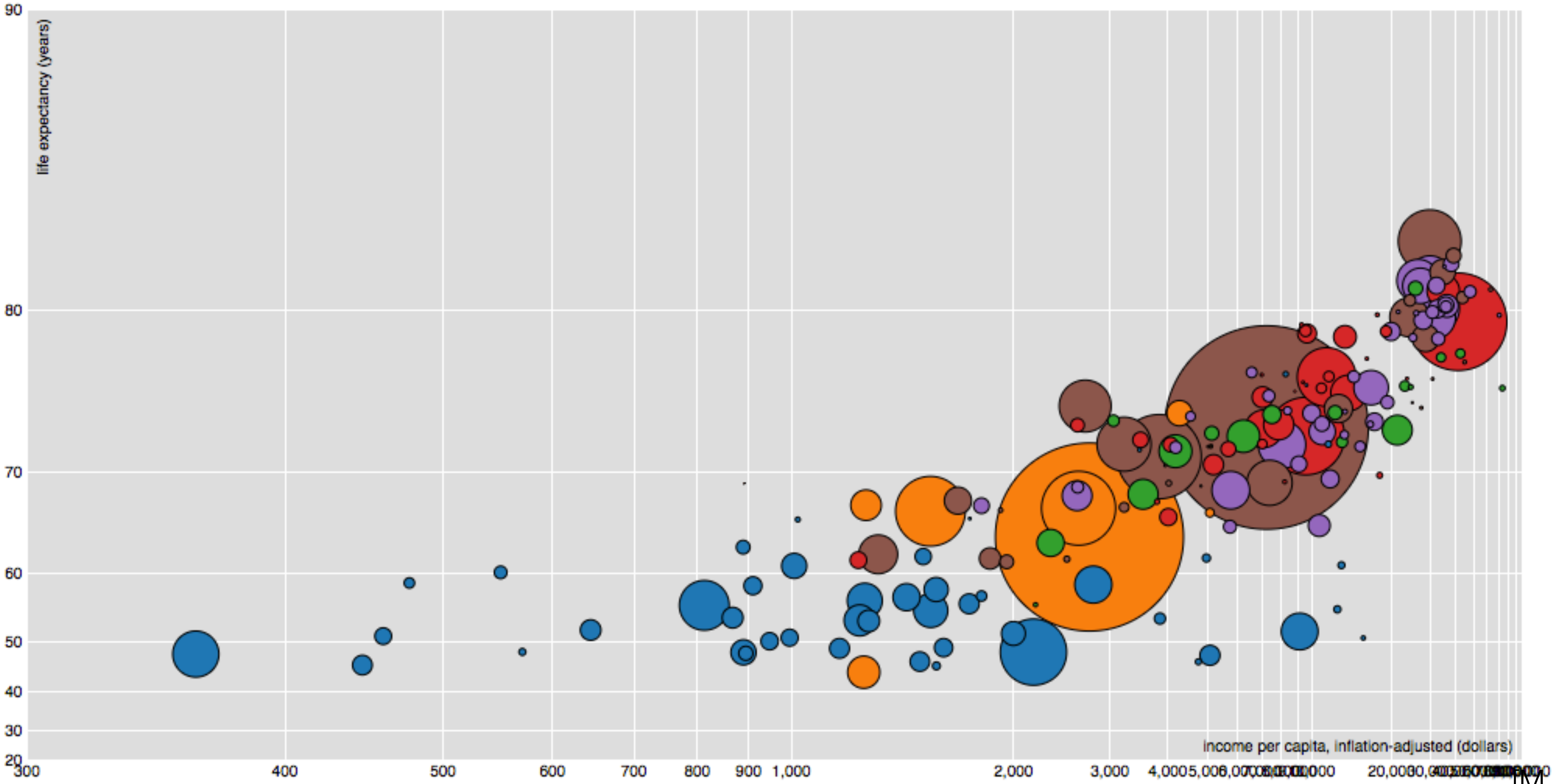


[M. Bostock]

Distortion Choices

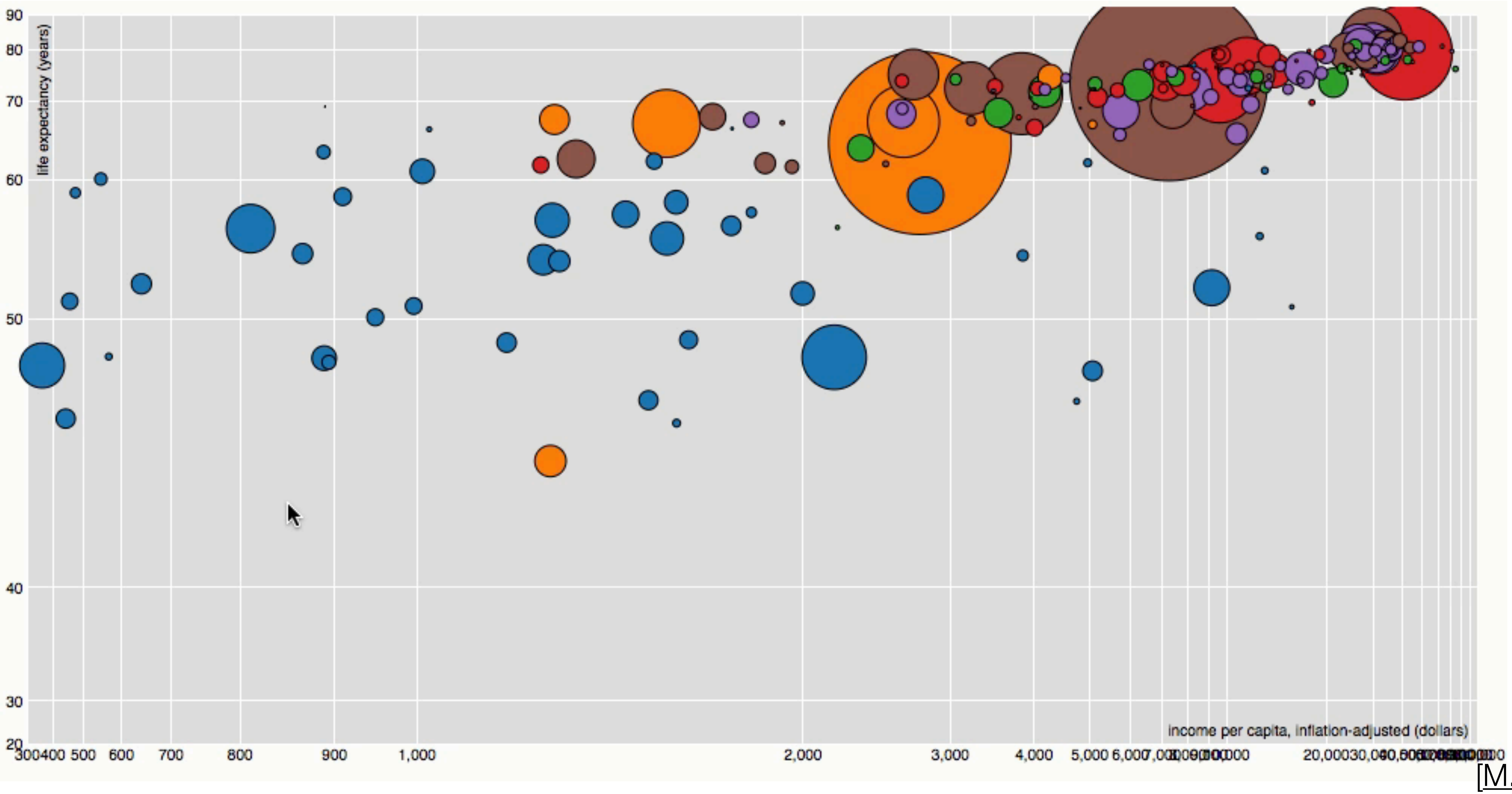
- How many focus regions? One or Multiple
- Shape of the focus?
  - Radial
  - Rectangular
  - Other
- Extent of the focus
  - Constrained similar to magic lenses
  - Entire view changes
- Type of interaction: Geometric, moveable lenses, rubber sheet

Overplotting



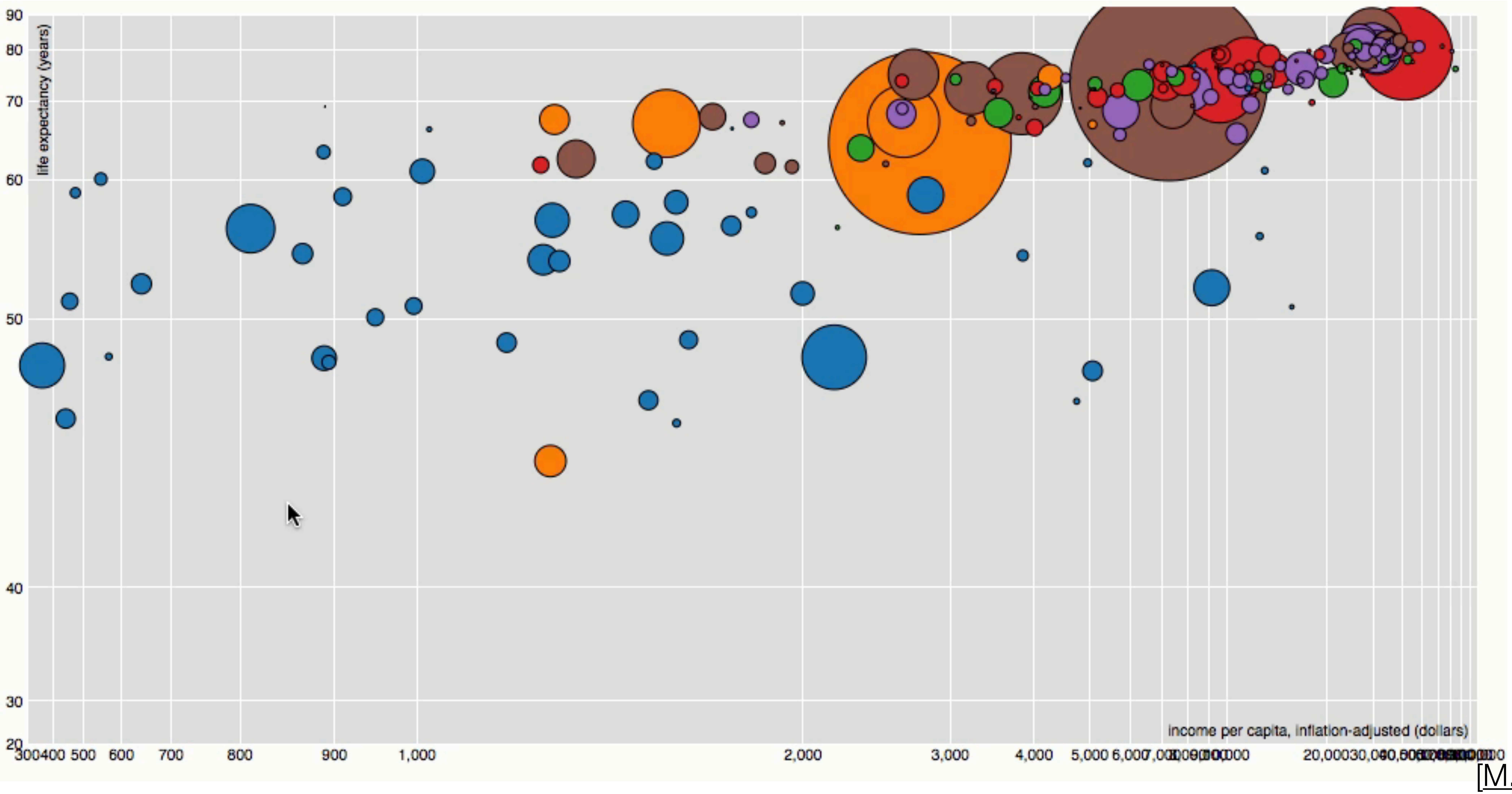
[M. Bostock]

Cartesian Distortion



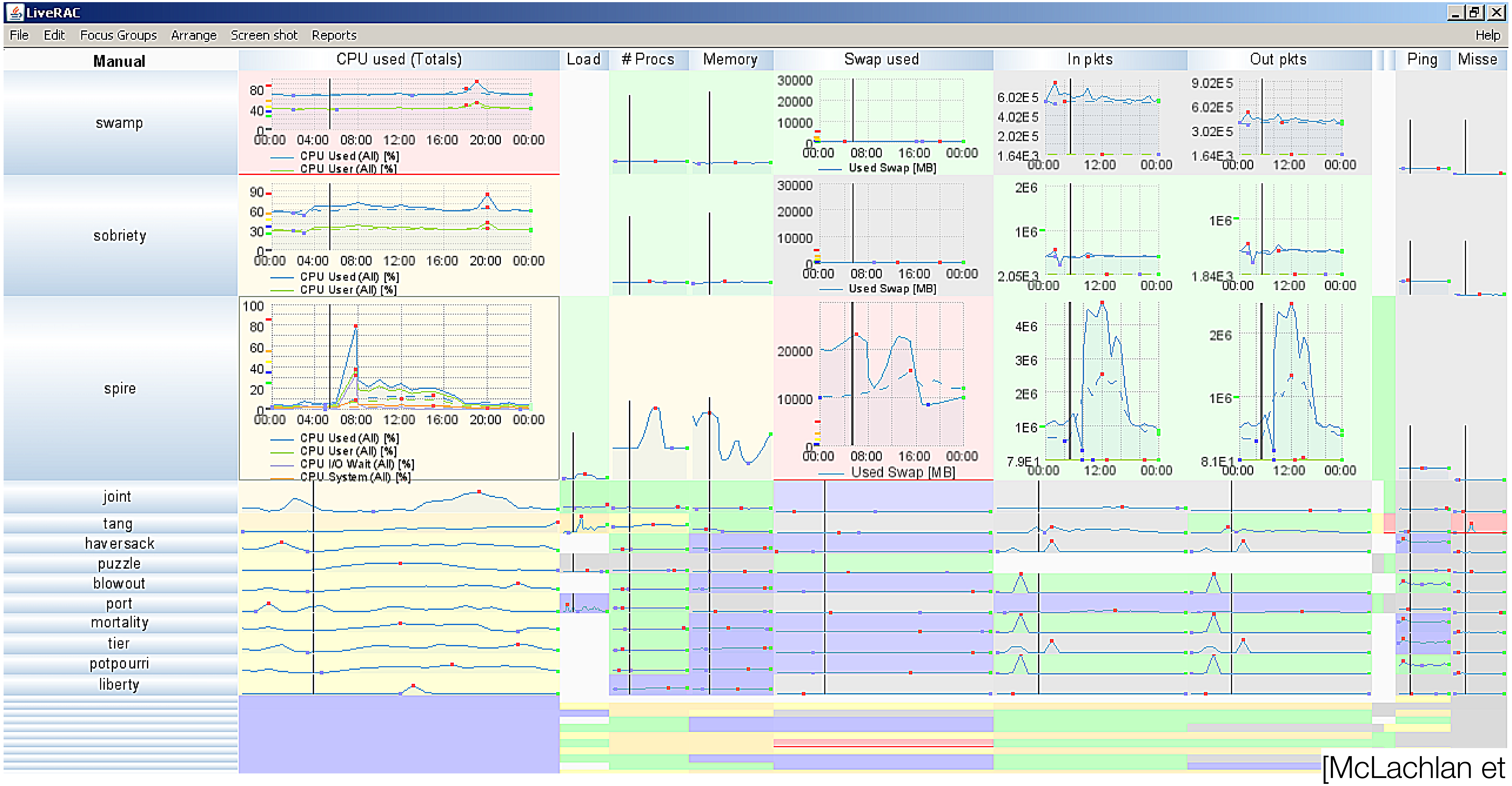
[M. Bostock]

Cartesian Distortion



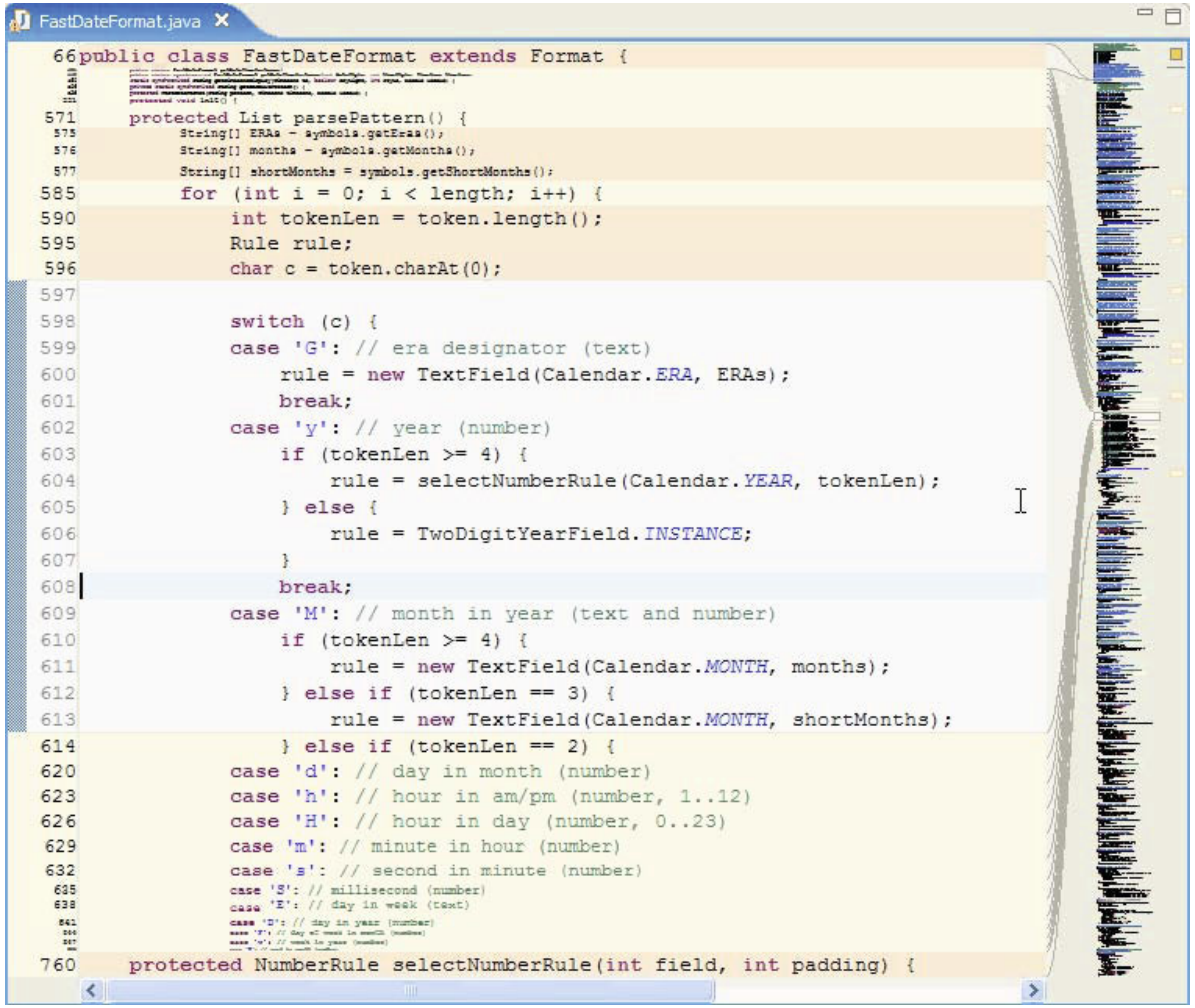
[M. Bostock]

Stretch and Squish Navigation



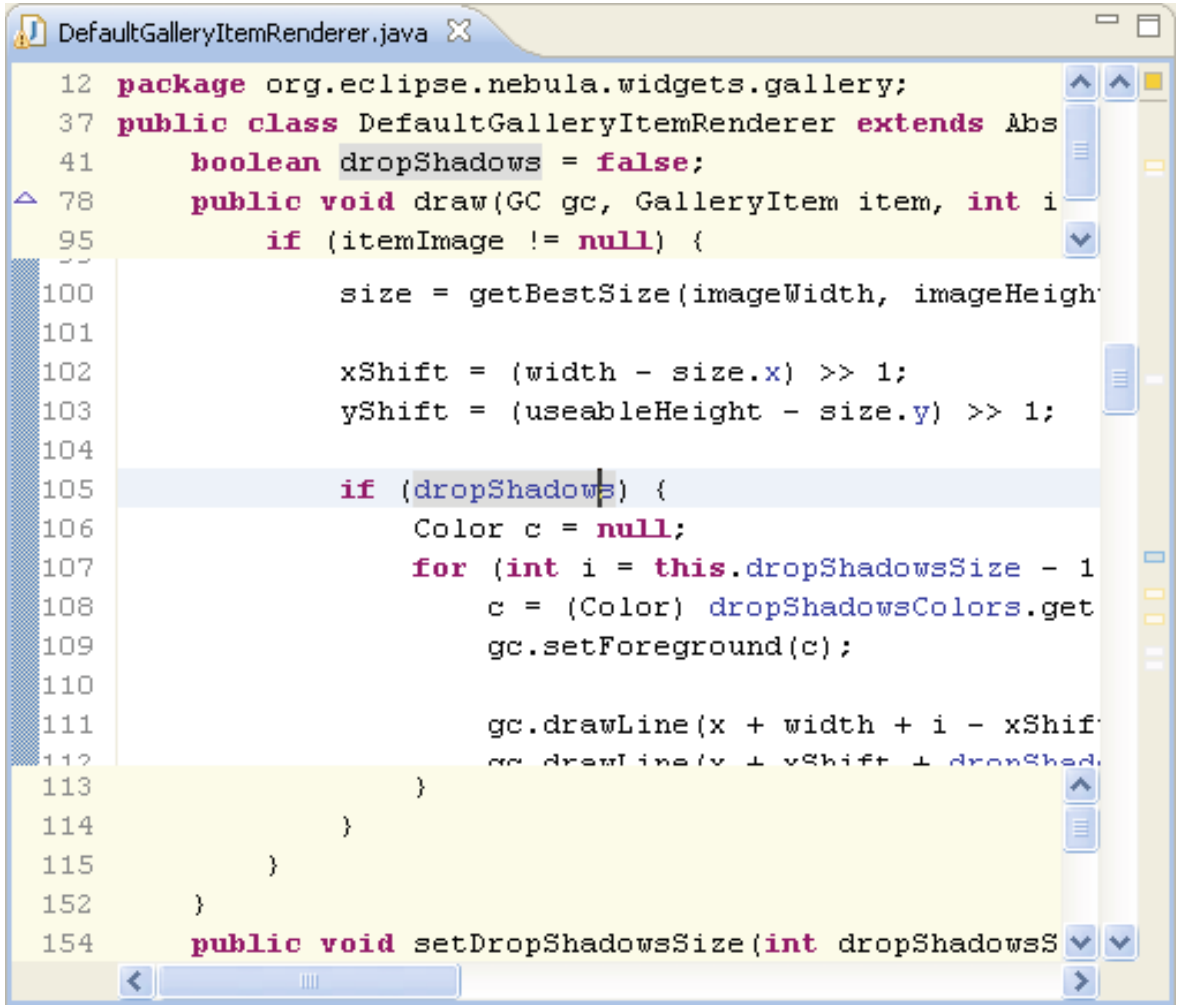
[McLachlan et al., 2008]

Fisheye Distortion in Programming



[Jakobsen and Hornbaek, 2011]

Distortion vs. Hide



[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)

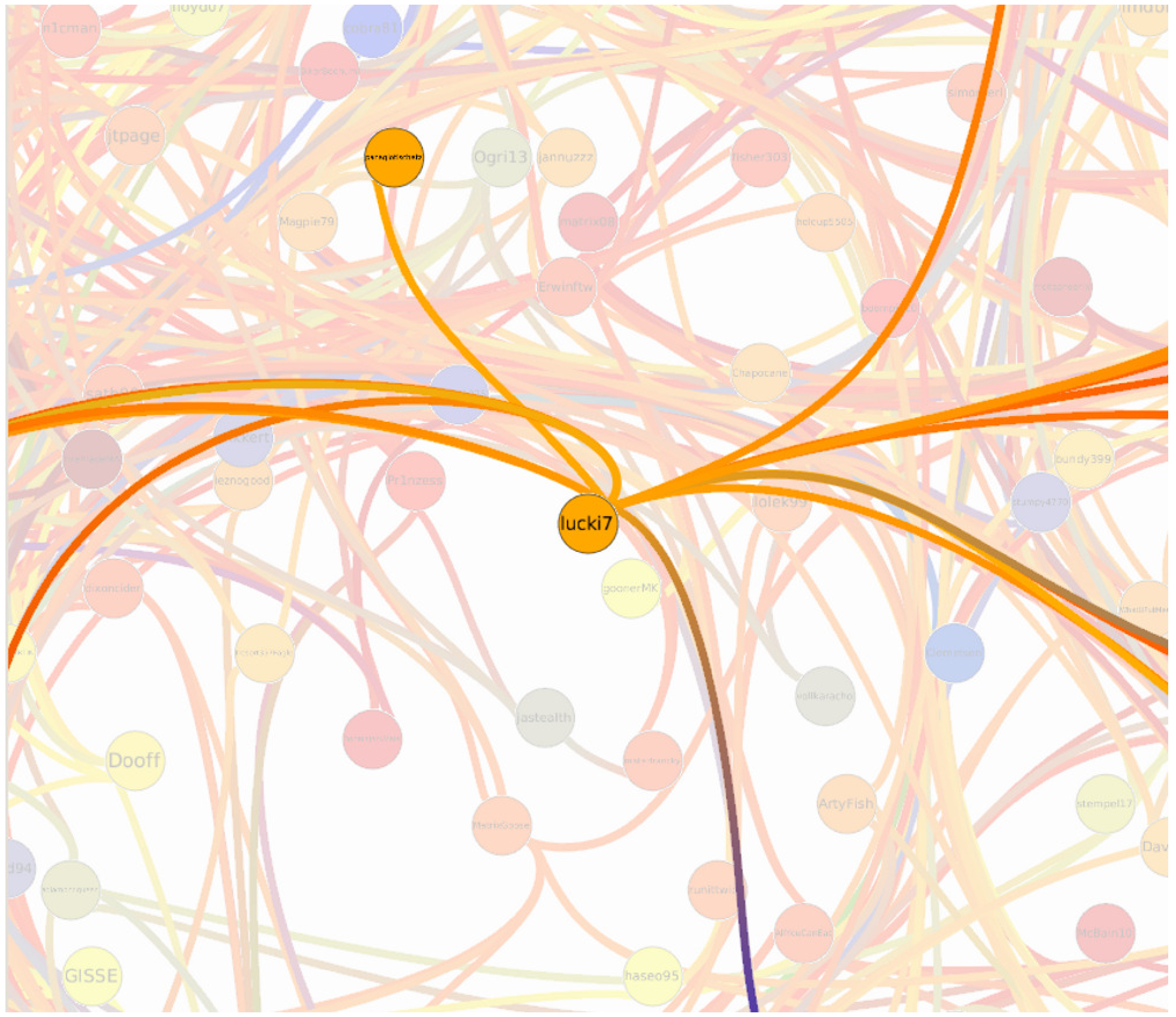
H3 Layout

[T. Munzner, 1998]

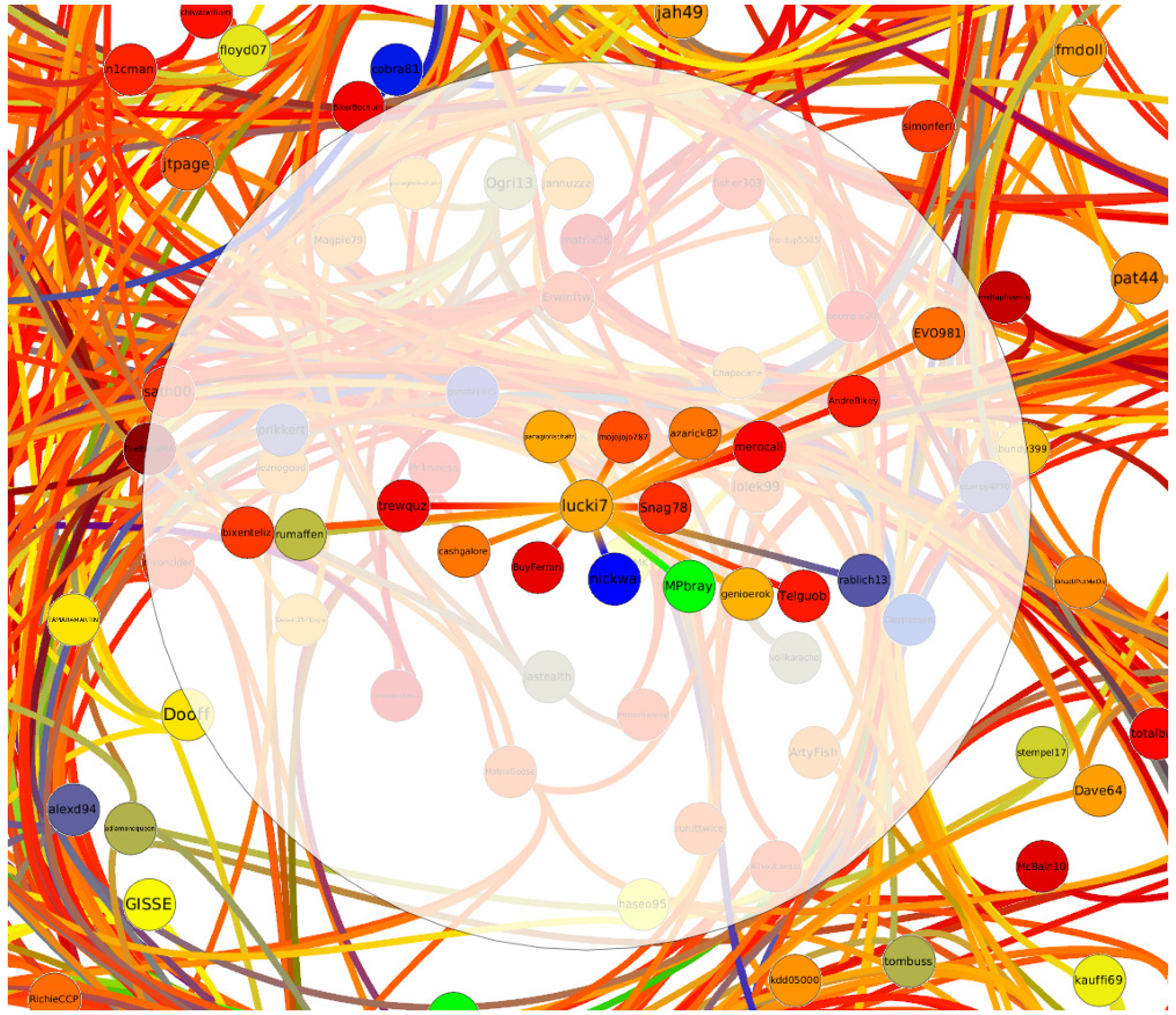
H3 Layout

[T. Munzner, 1998]

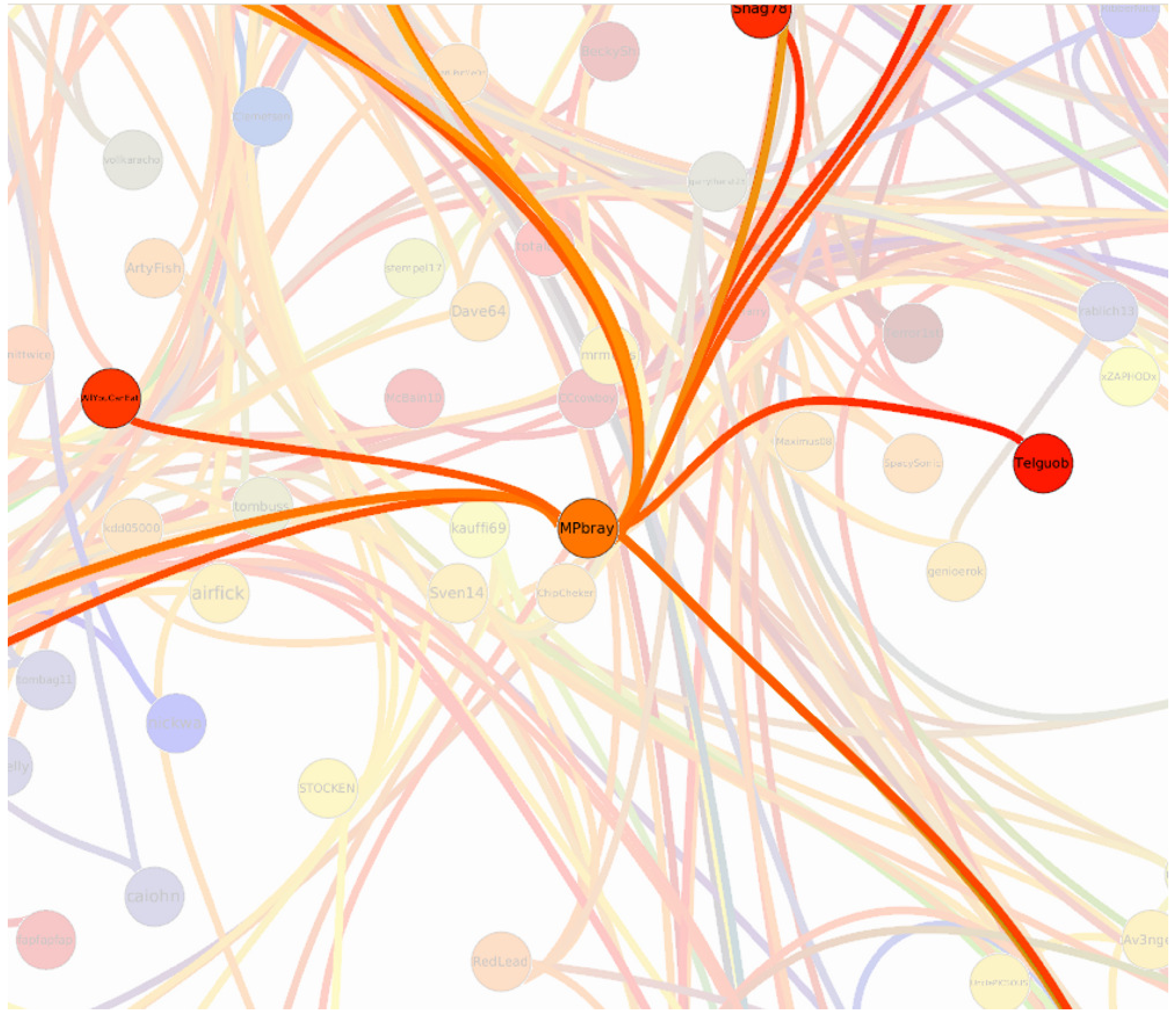
Focus+Context in Network Exploration



(a) Bring (step 1) – Selecting a node fades out all graph elements but the node neighborhood.



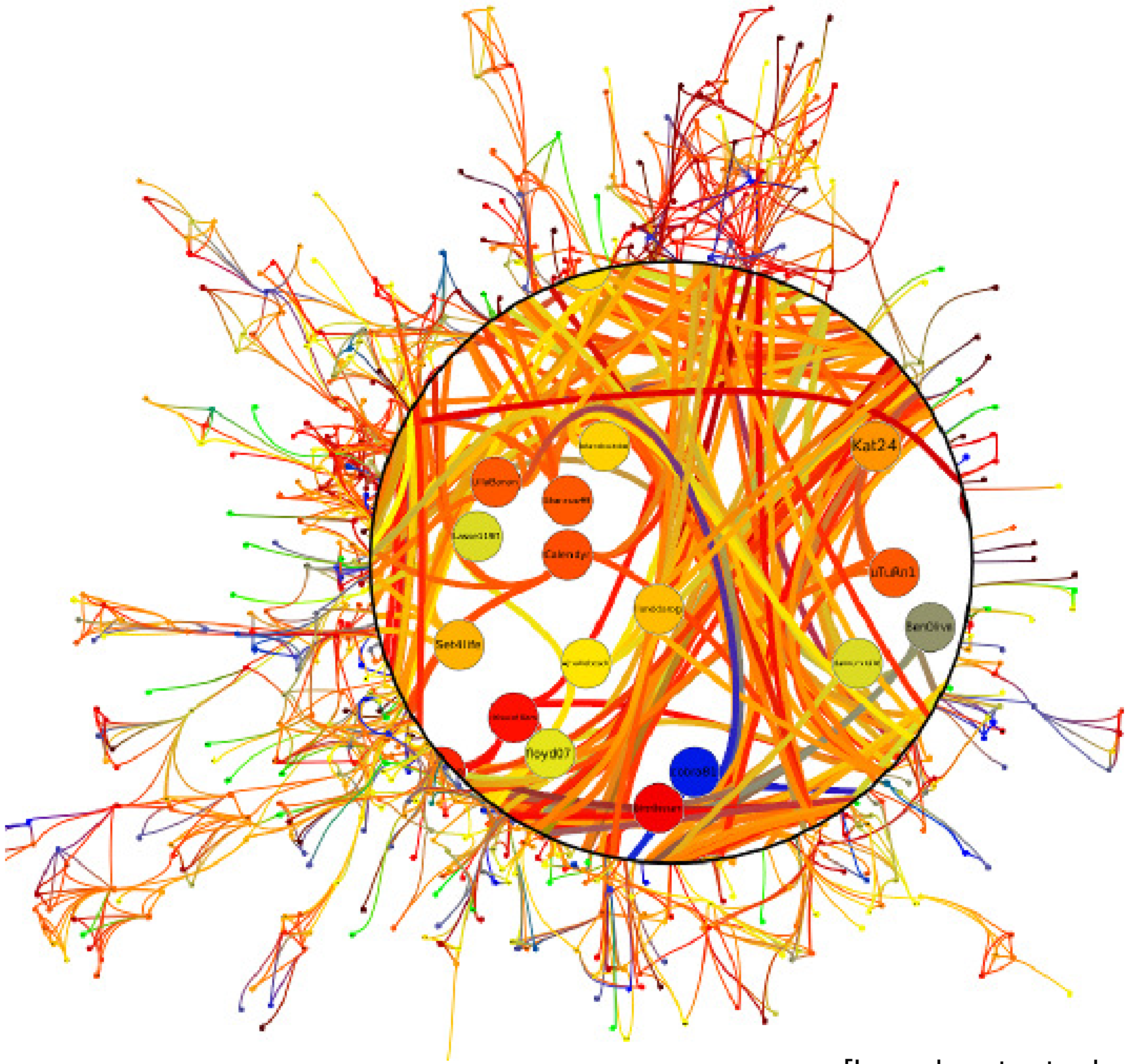
(b) Bring (step 2) – Neighbor nodes are pulled close to the selected node.



(c) Go – After selecting a neighbor (the green node in Fig. 4(b)), a short animation brings the focus towards a new neighborhood.

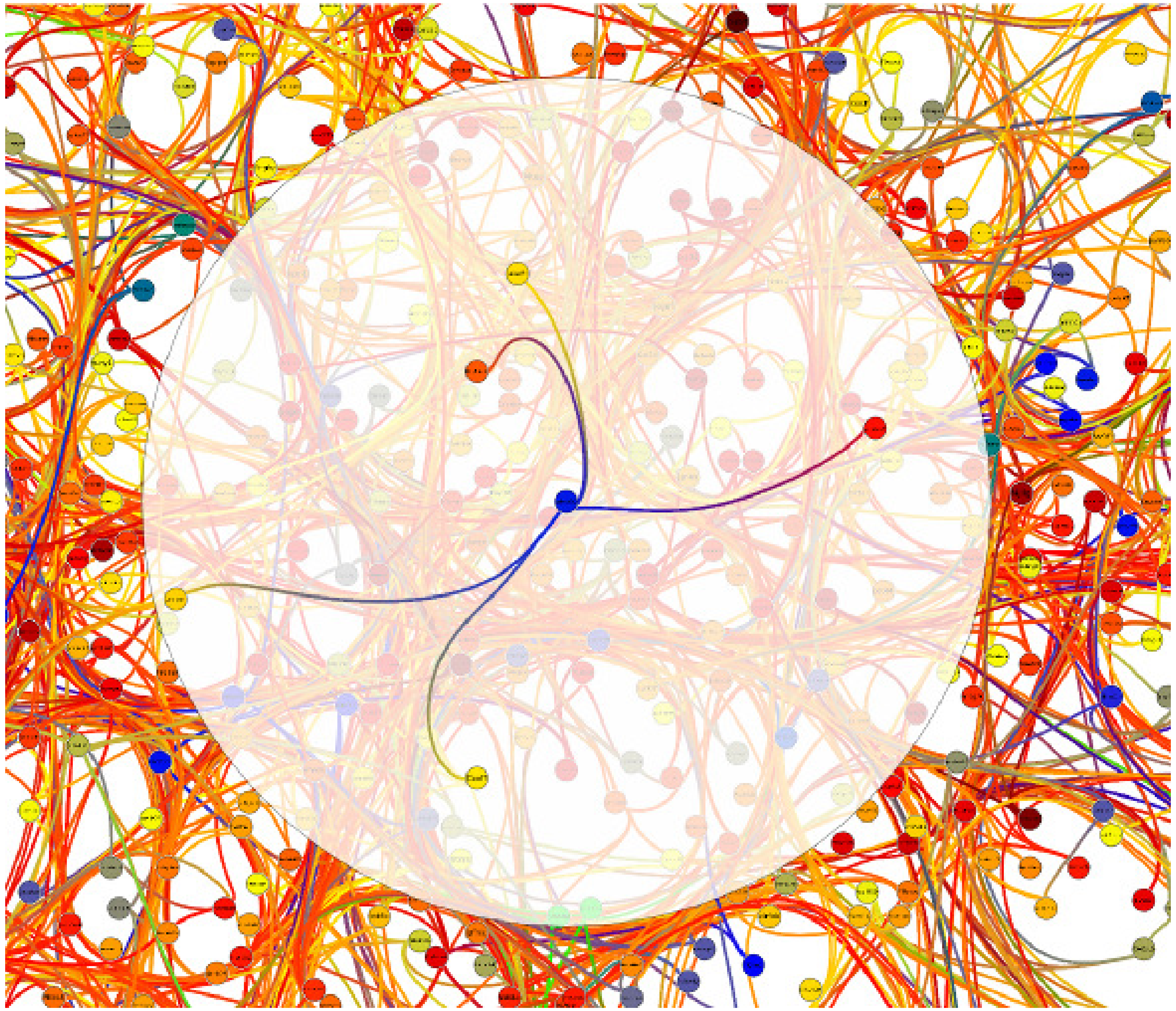
[Lambert et al., 2010]

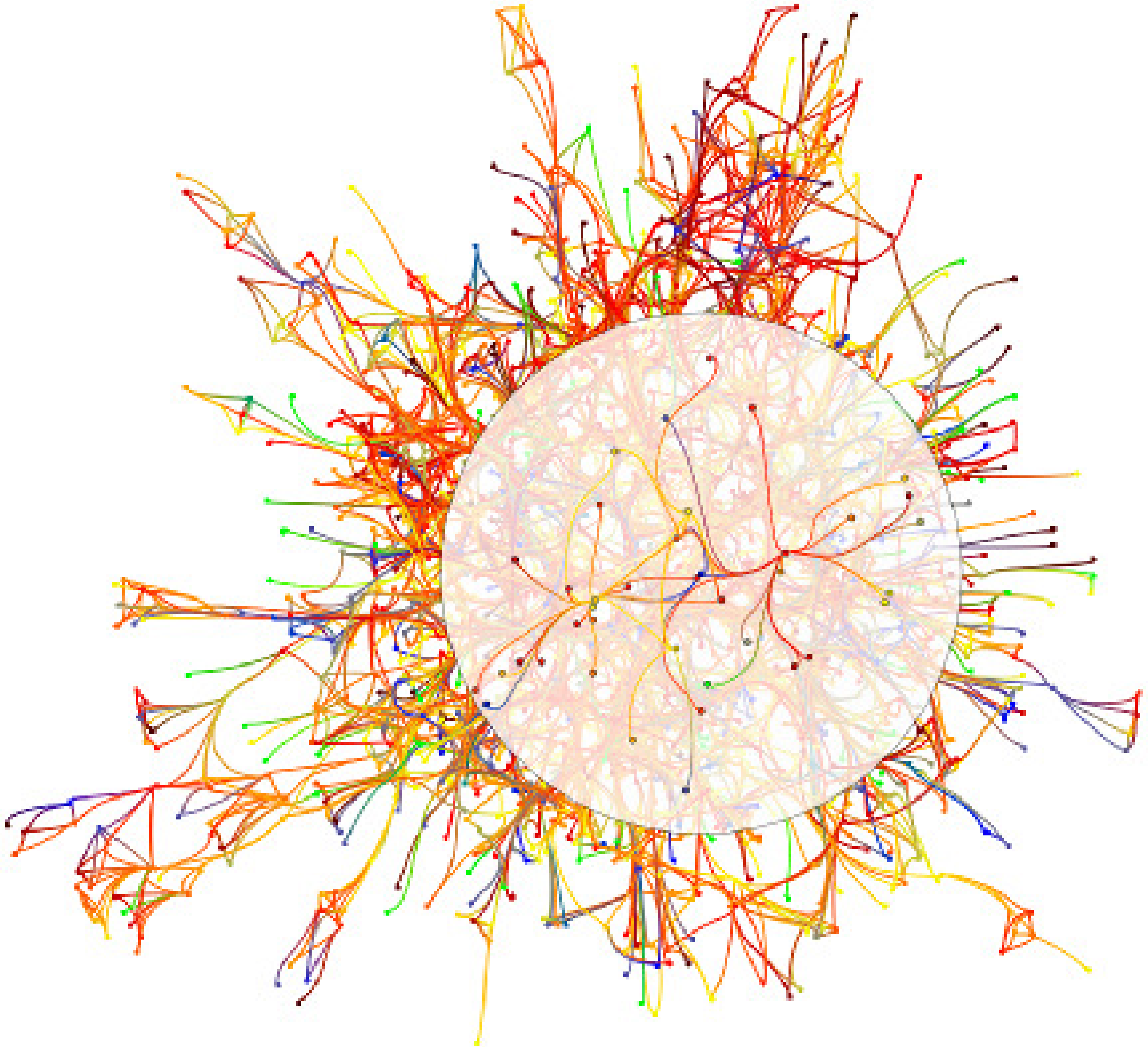
Focus+Context in Network Exploration



[Lambert et al., 2010]

Focus+Context in Network Exploration





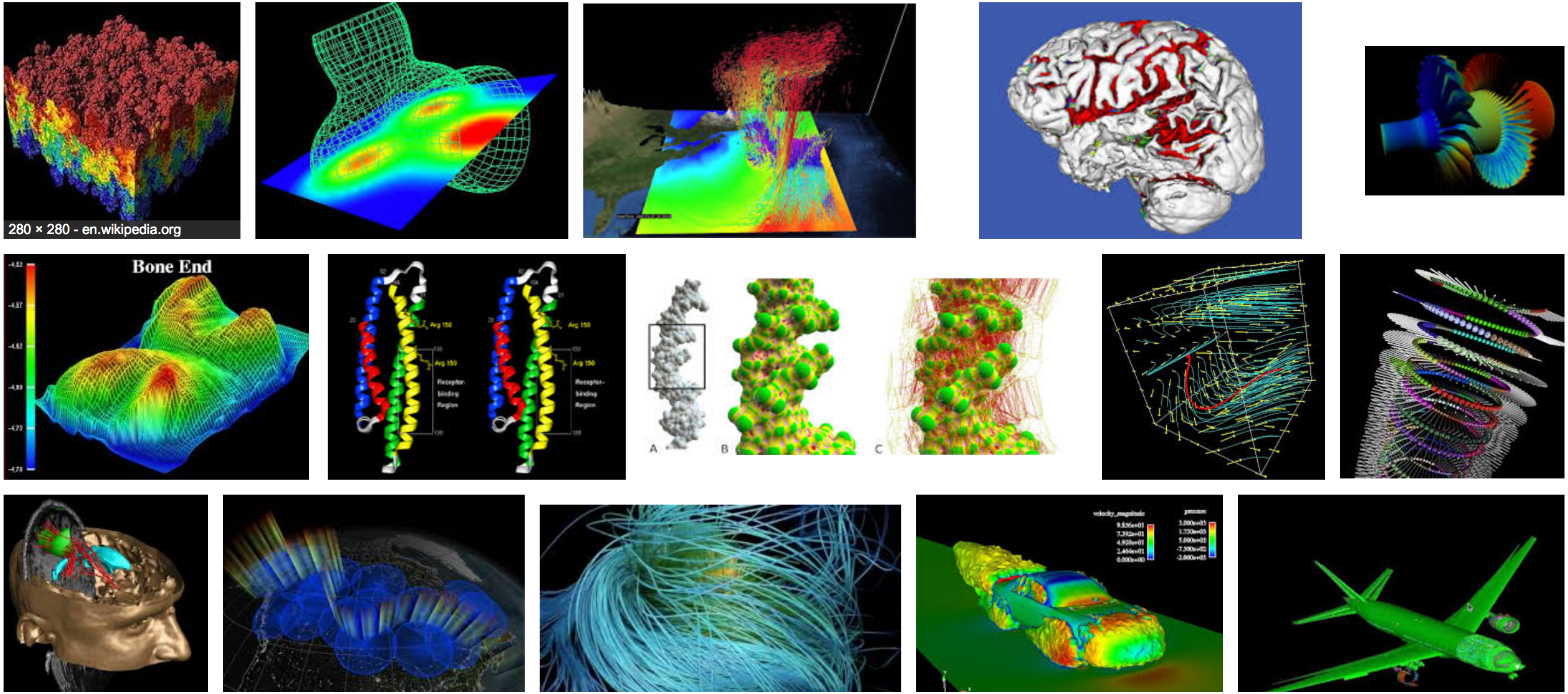
[Lambert et al., 2010]

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

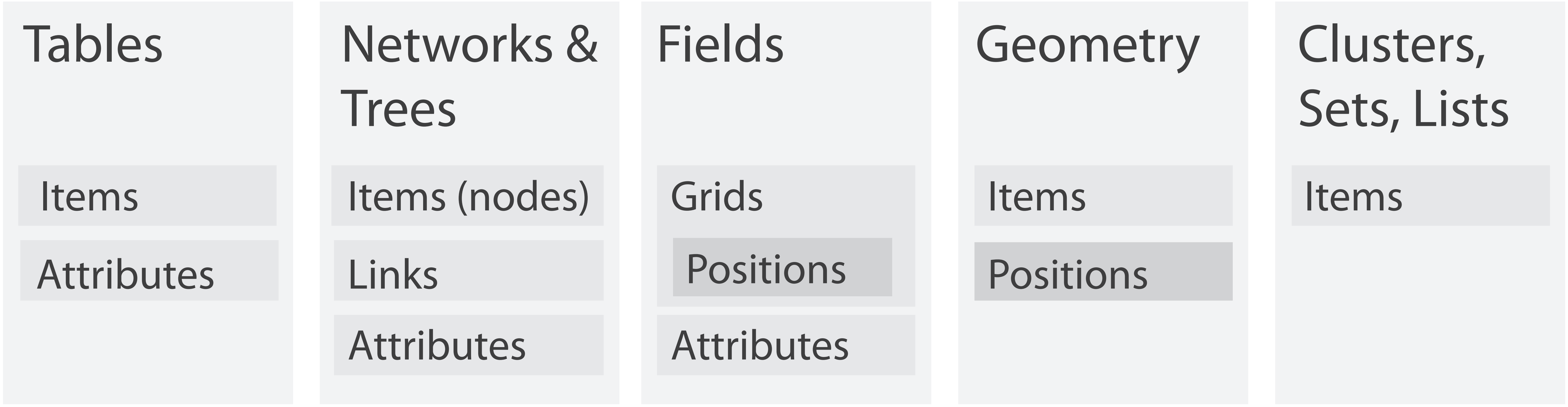


[Google Image Search for "scientific visualization", 2017]

InfoVis

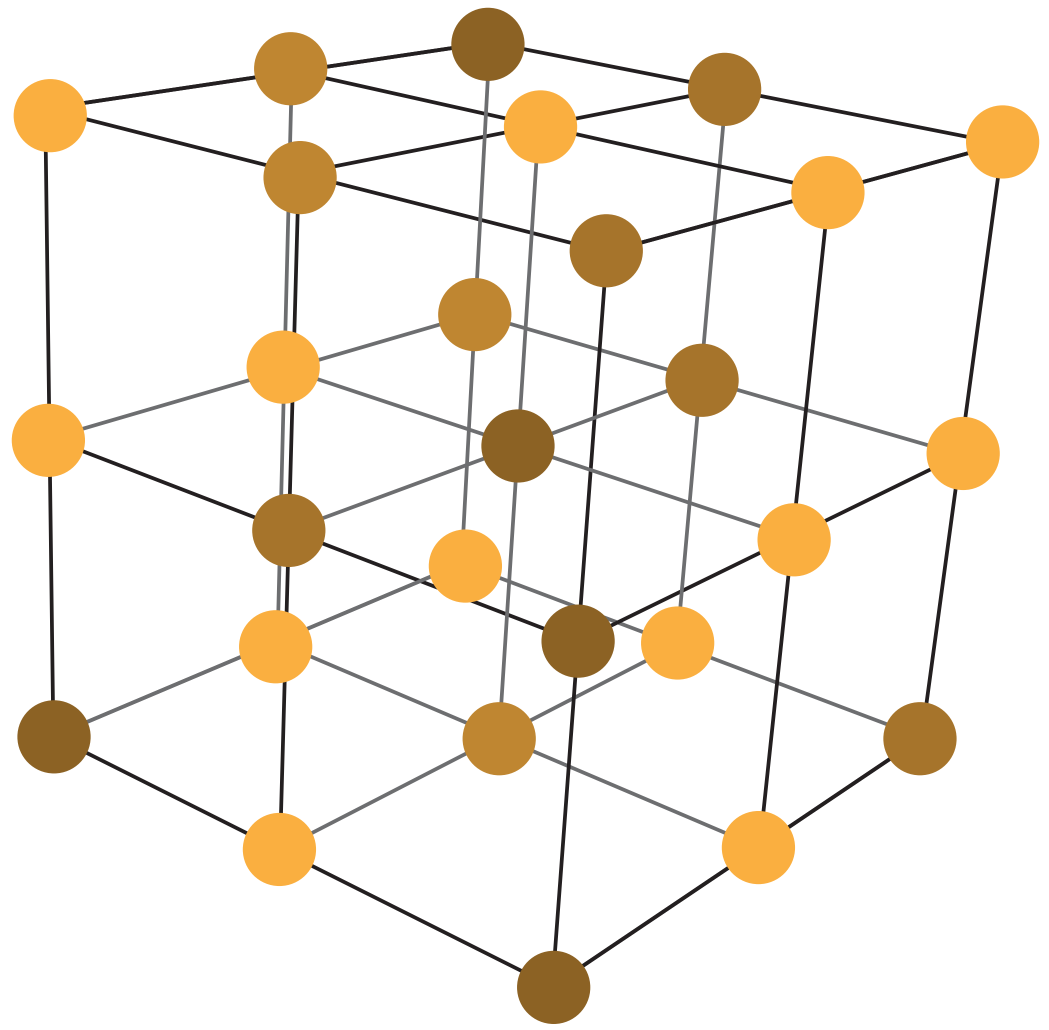
[Google Image Search for "information visualization", 2017]

Fields



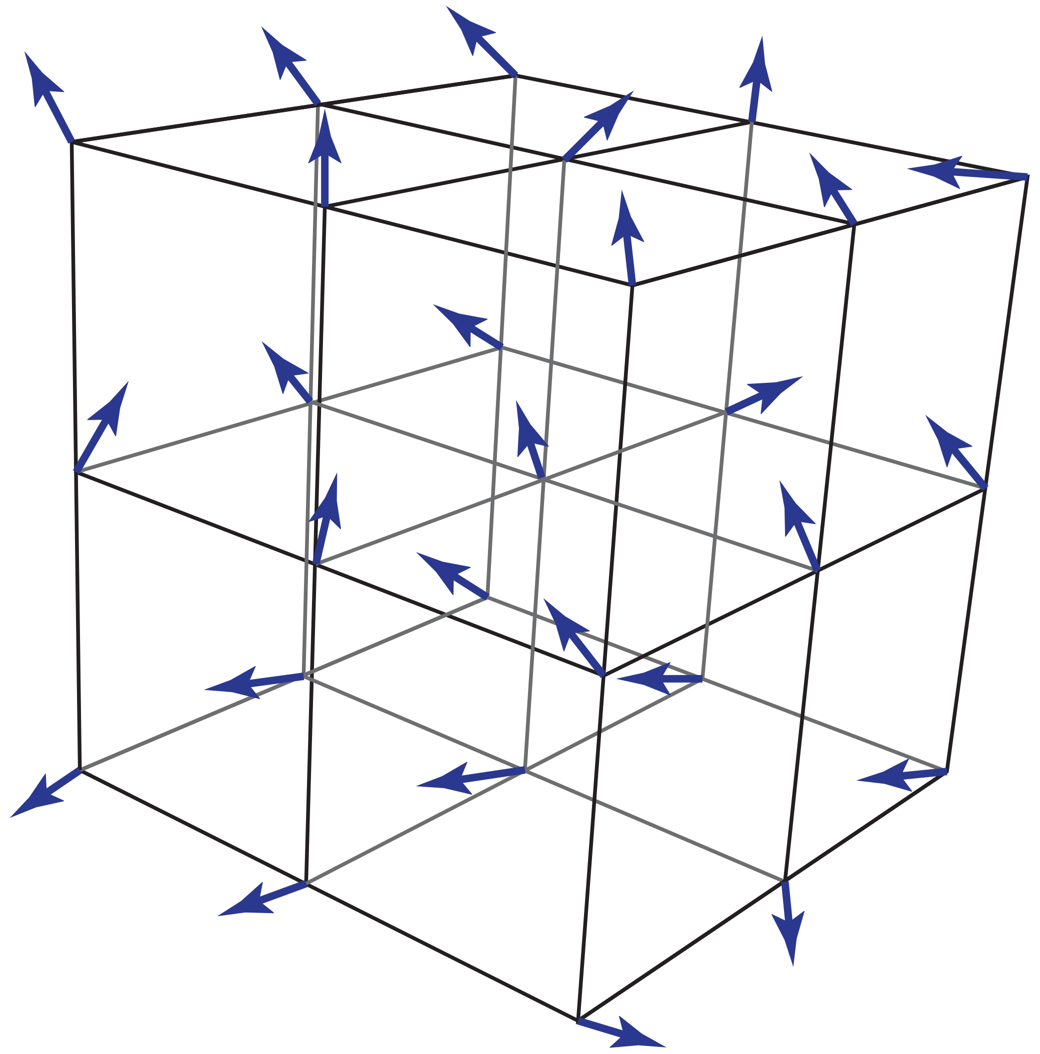
- Values come from a **continuous** domain, infinitely many values
- **Sampled** at certain positions to approximate the entire domain
- Positions are often aligned in **grids**
- Often measurements of natural or simulated phenomena
- Examples: temperature, wind speed, tissue density, pressure, speed,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

Fields in Visualization



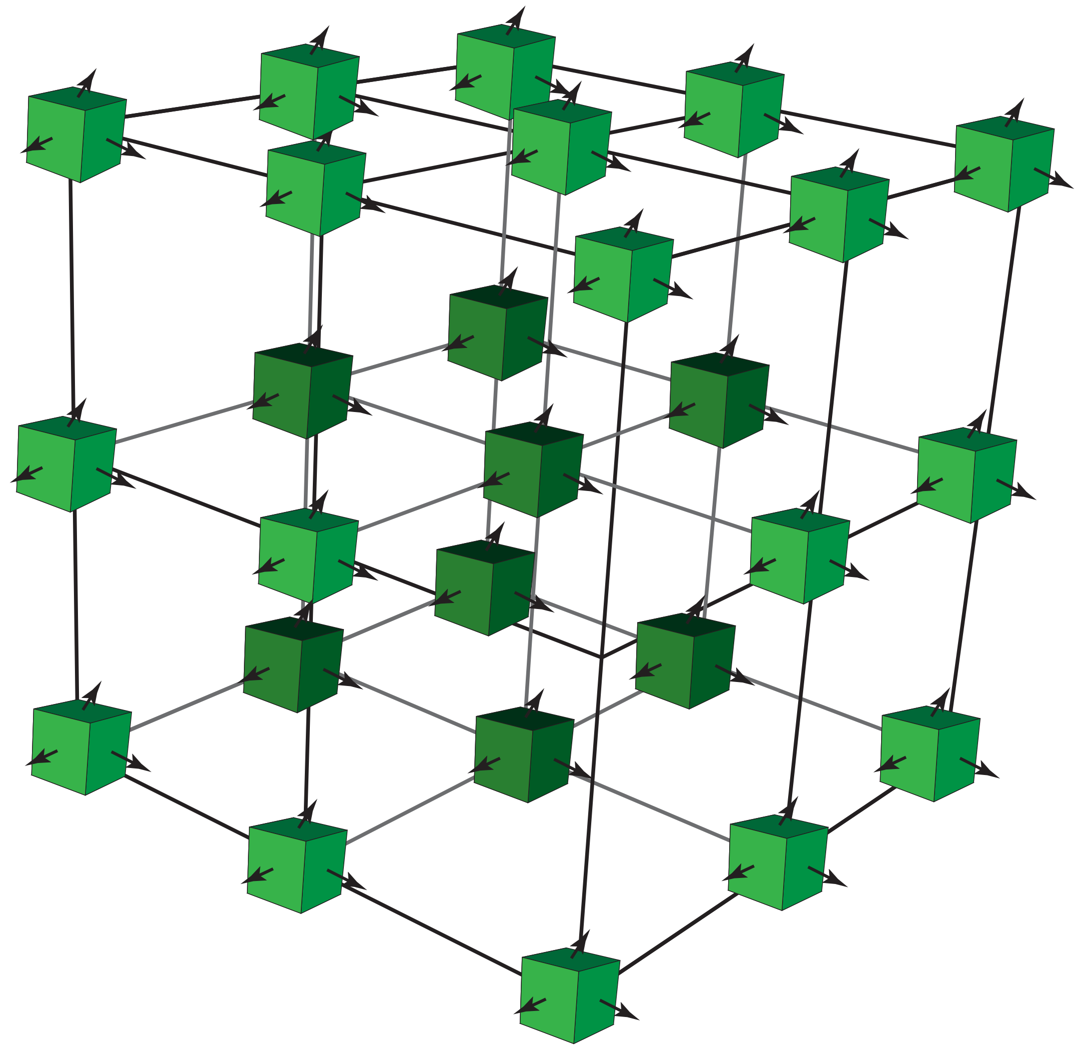
Scalar Fields

(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

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

- Geometry: the spatial positions of the data (points)

Grids

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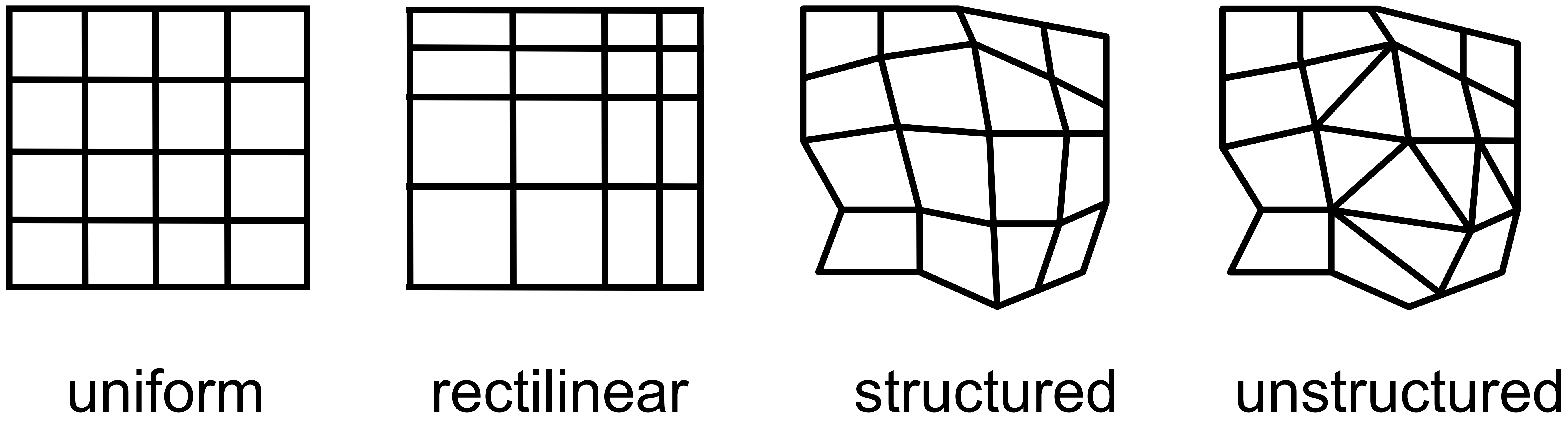
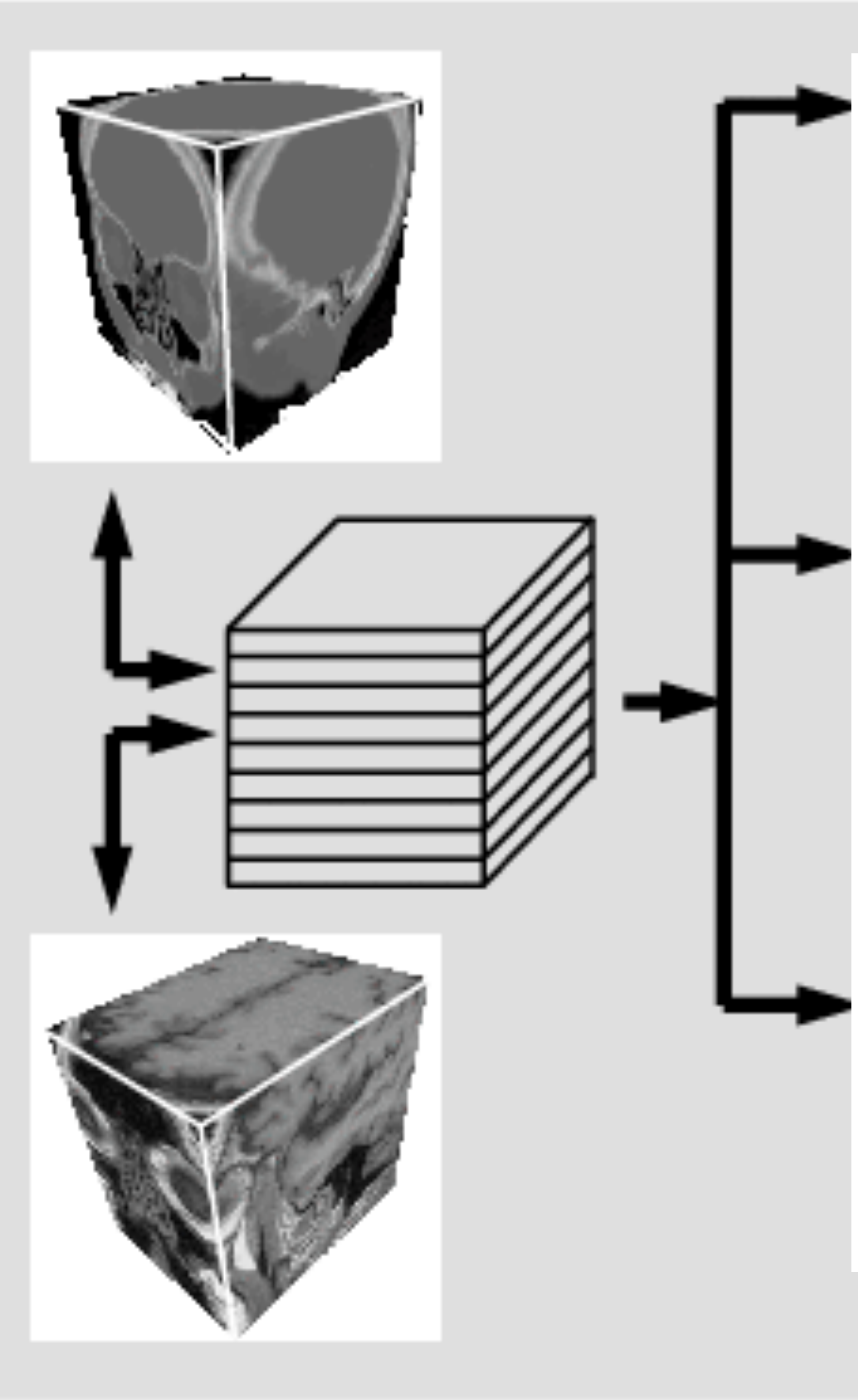


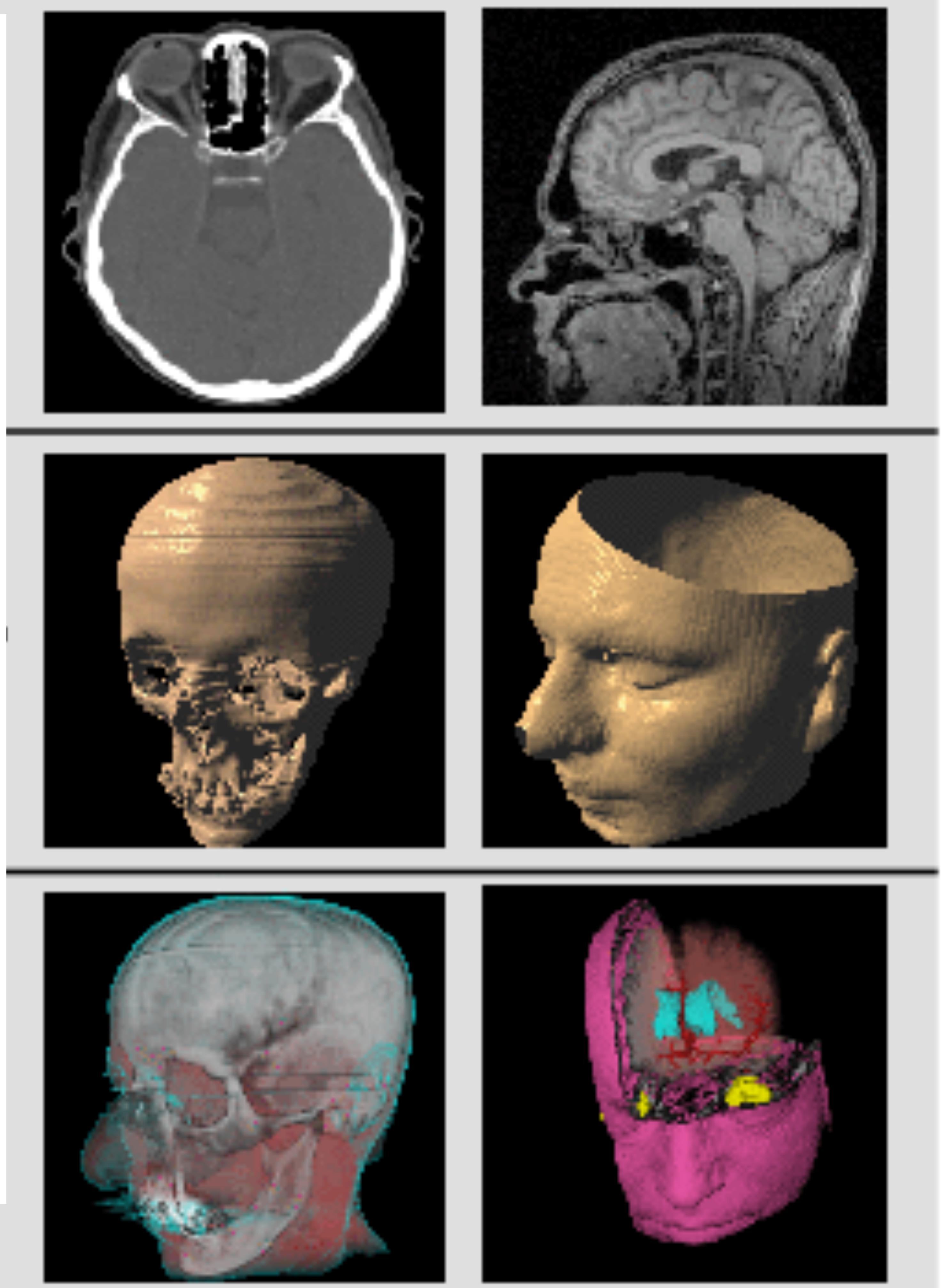
[© Weiskopf/Machiraju/Möller]

- 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



- 2D visualization slice images (or multi-planar reformating MPR)
- *Indirect* 3D visualization isosurfaces (or surface-shaded display SSD)
- *Direct* 3D visualization (direct volume rendering DVR)

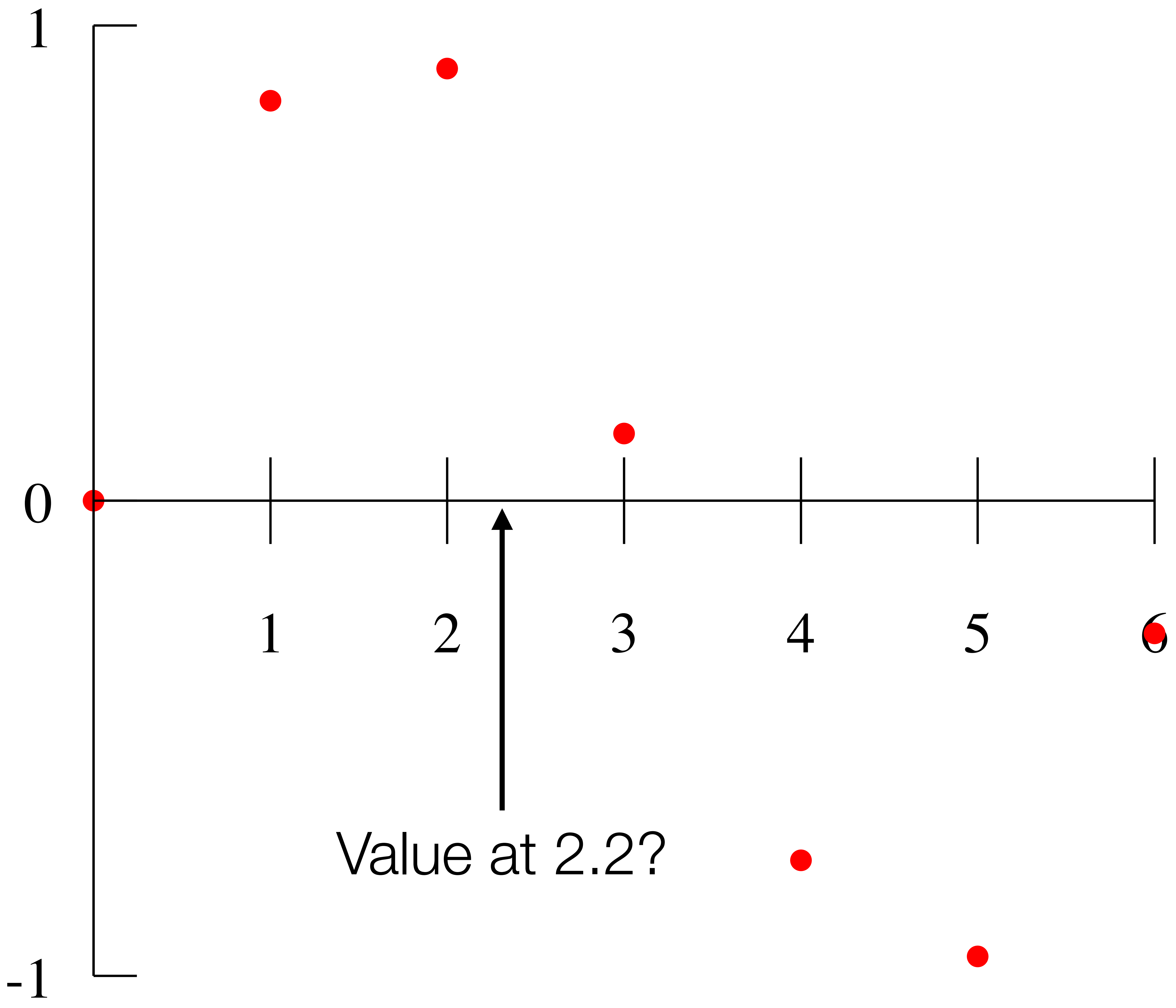


[© Weiskopf/Machiraju/Möller]

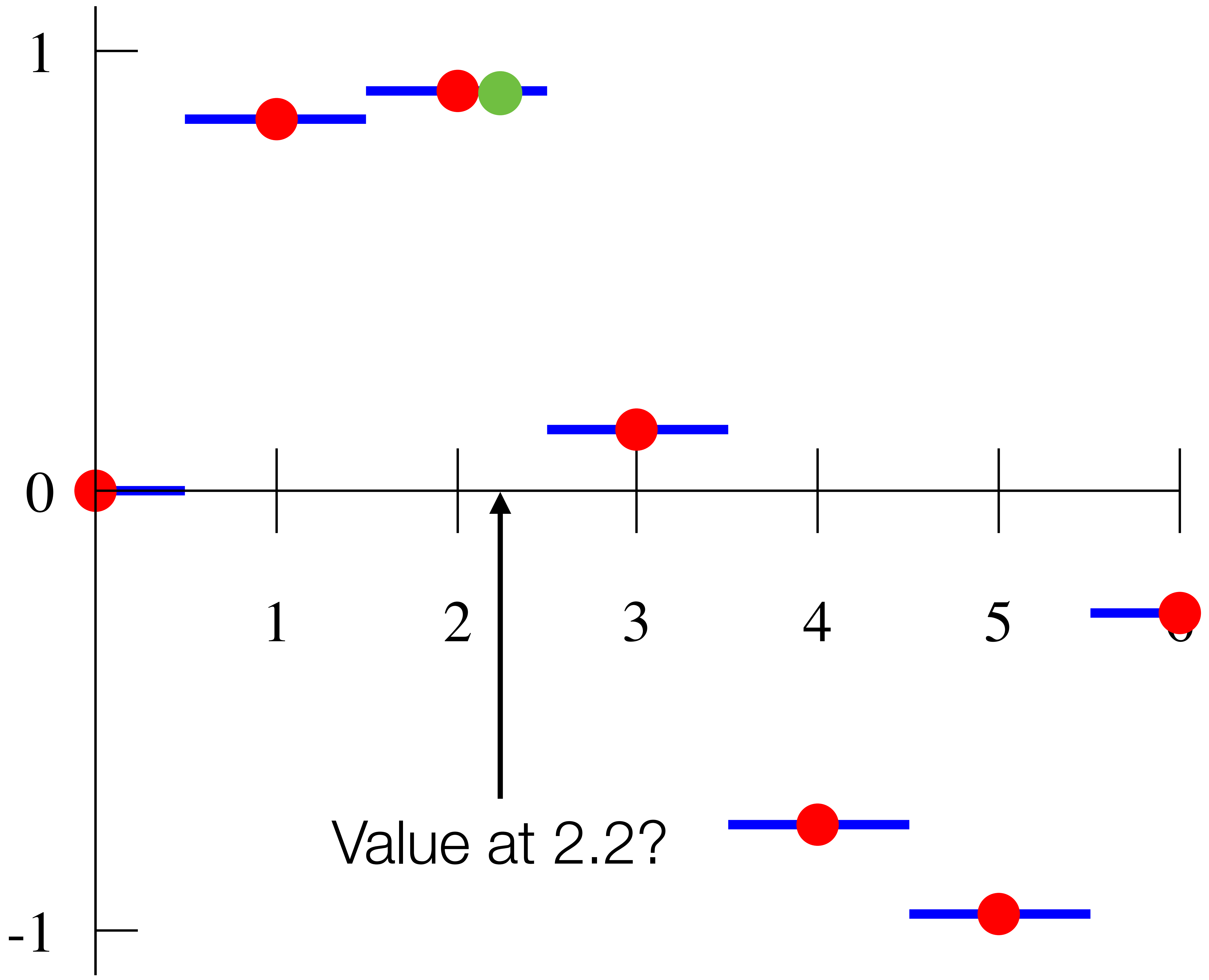
Data

- 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…

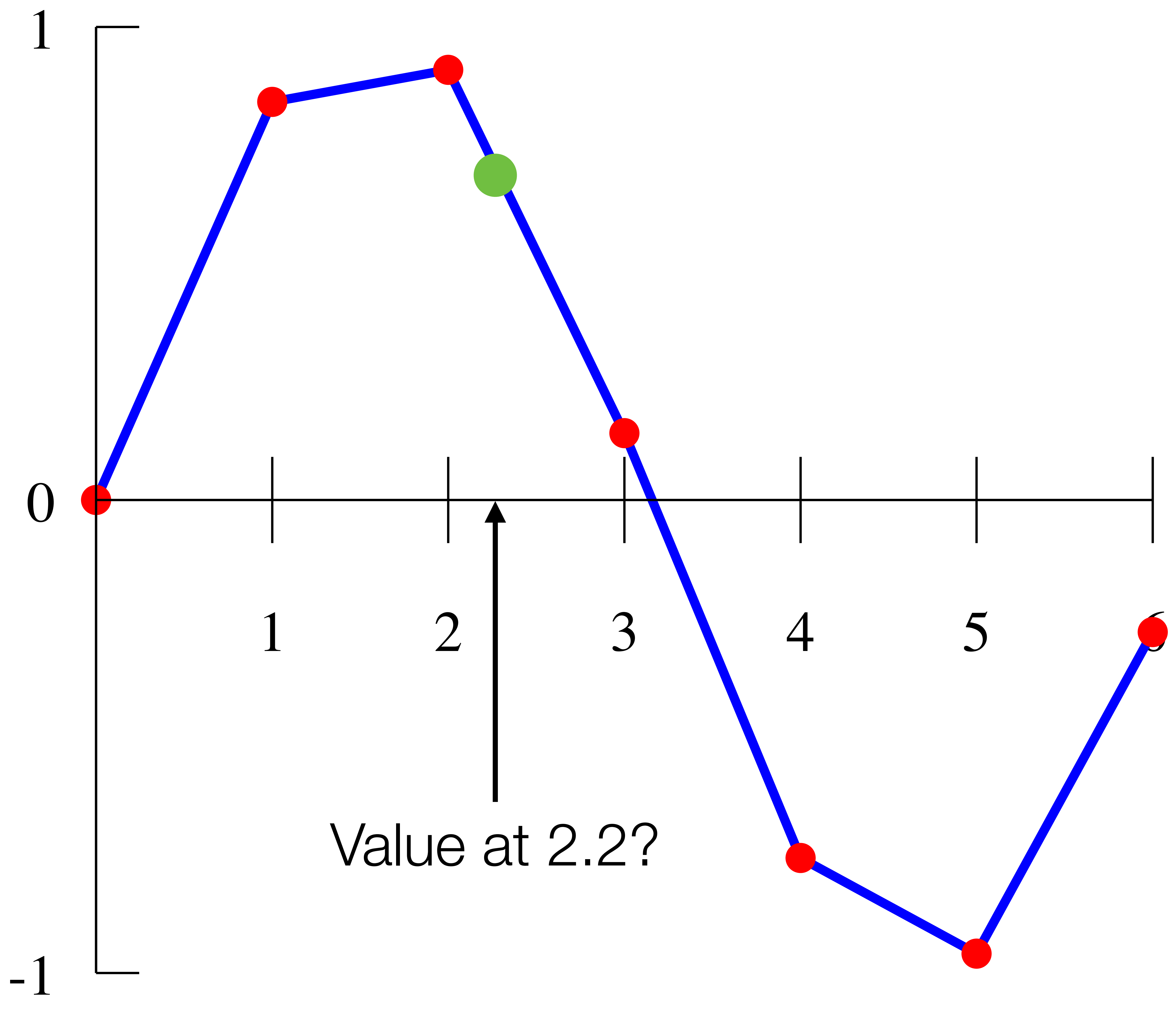
Interpolation



Nearest Neighbor Interpolation



Linear Interpolation



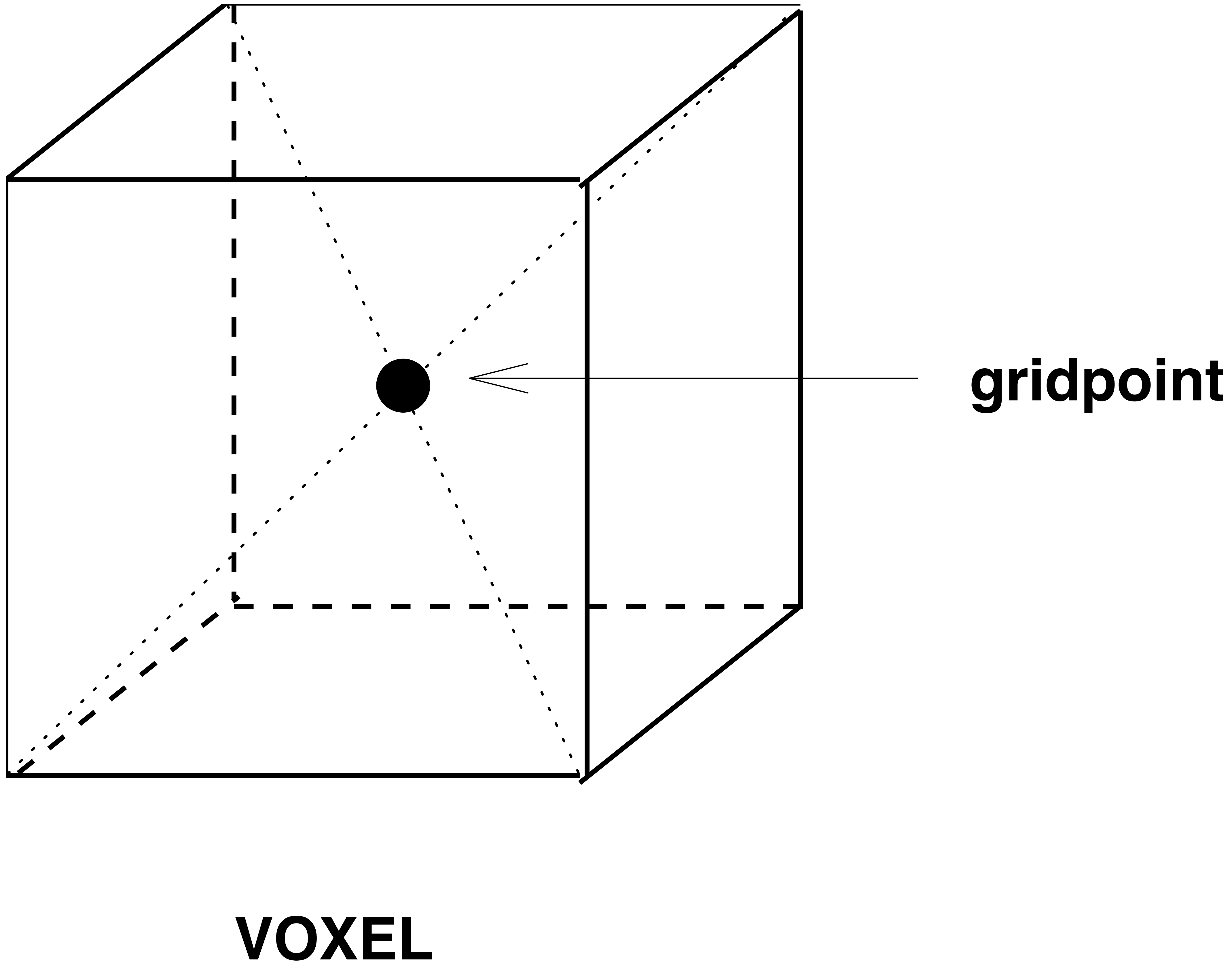
Interpolation

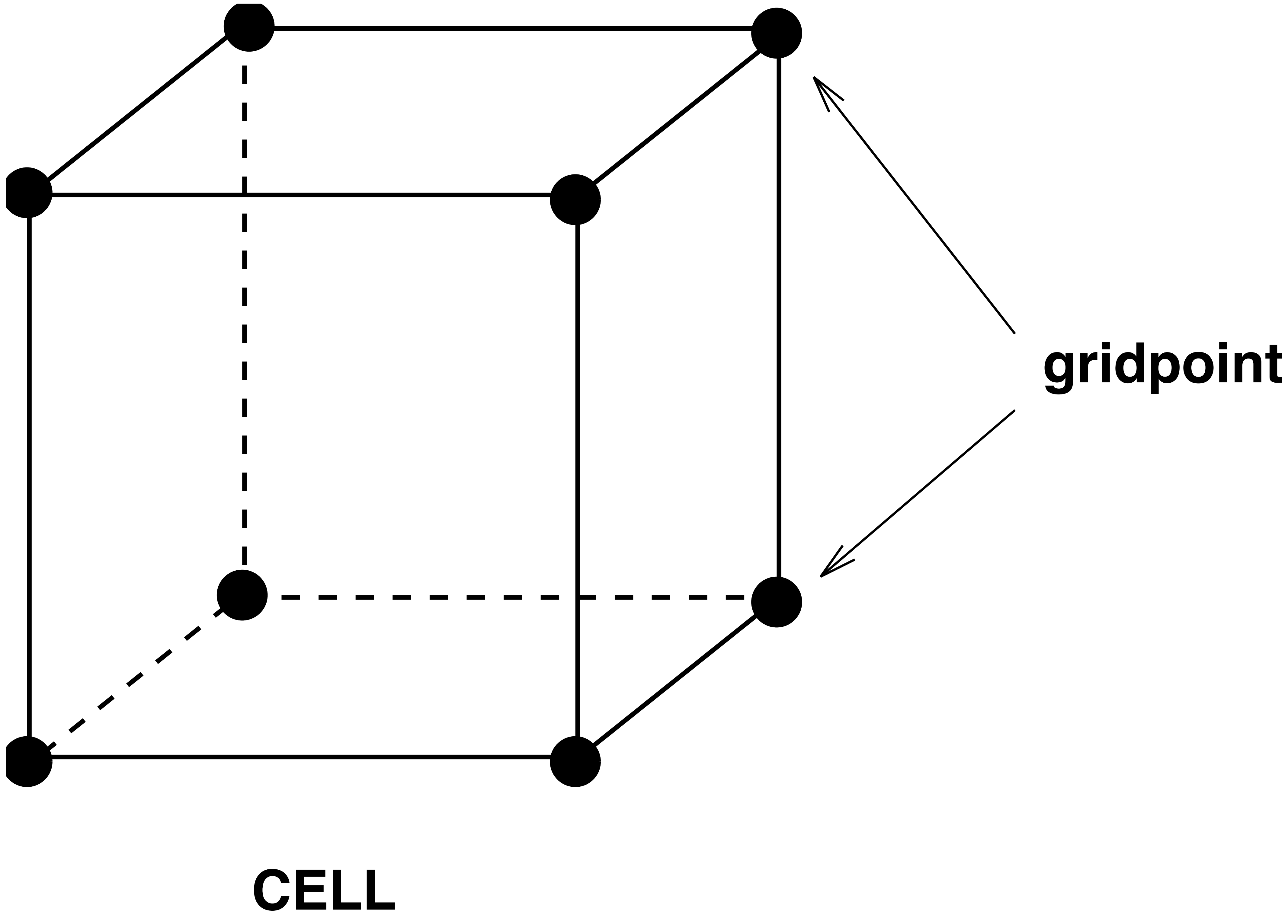
- Other schemes:
  - polynomial interpolation
  - splines
  - more…

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





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

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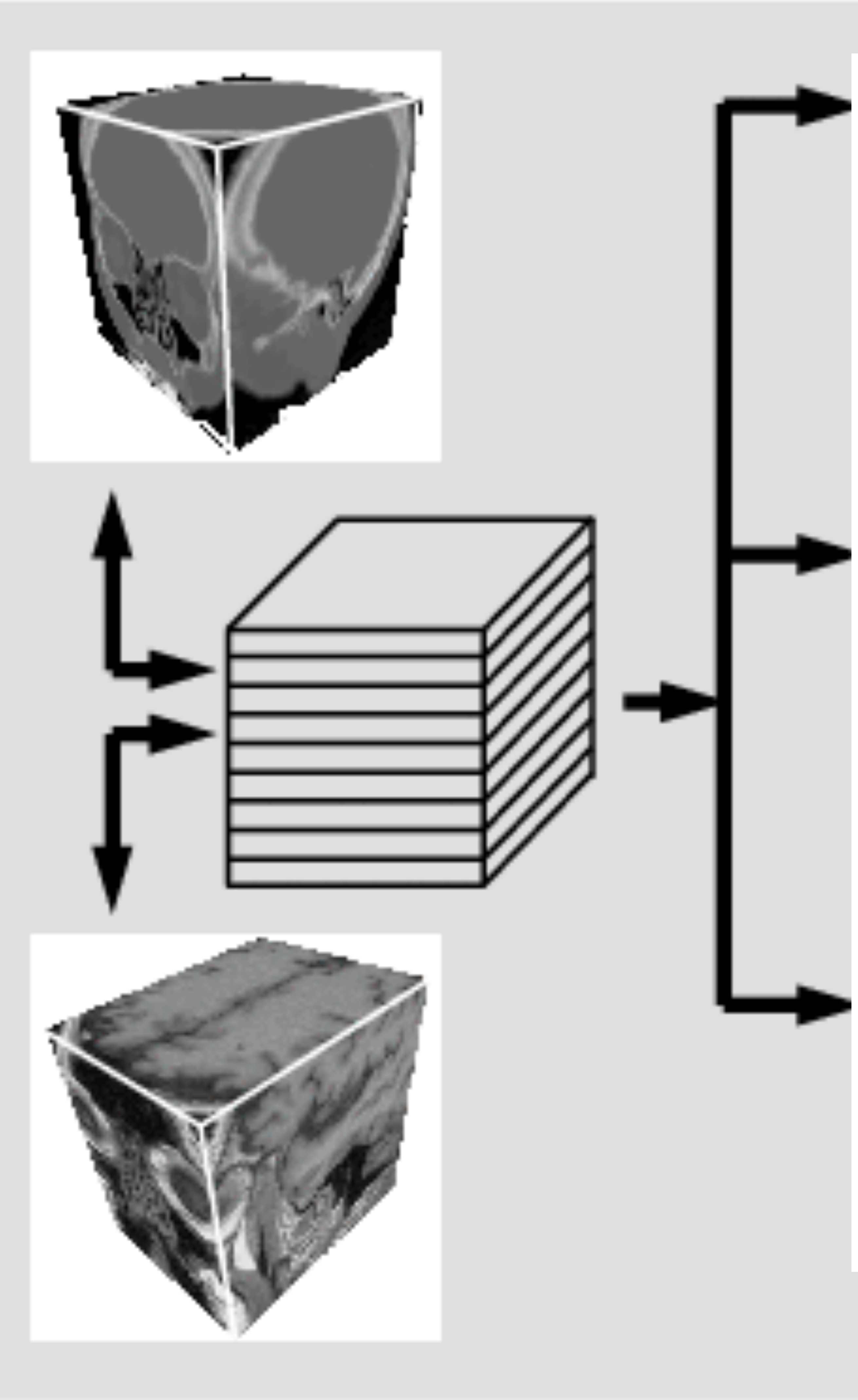

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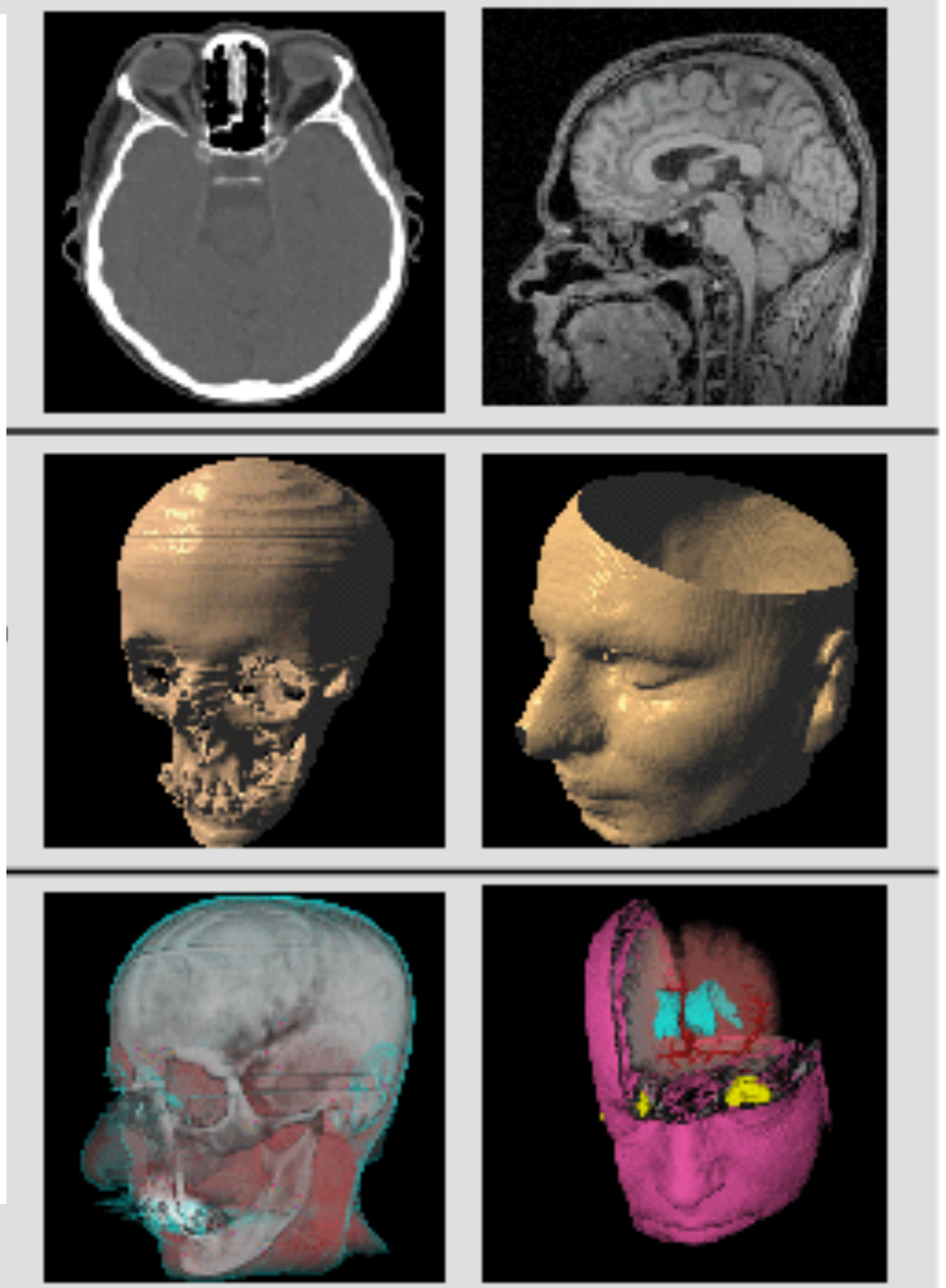
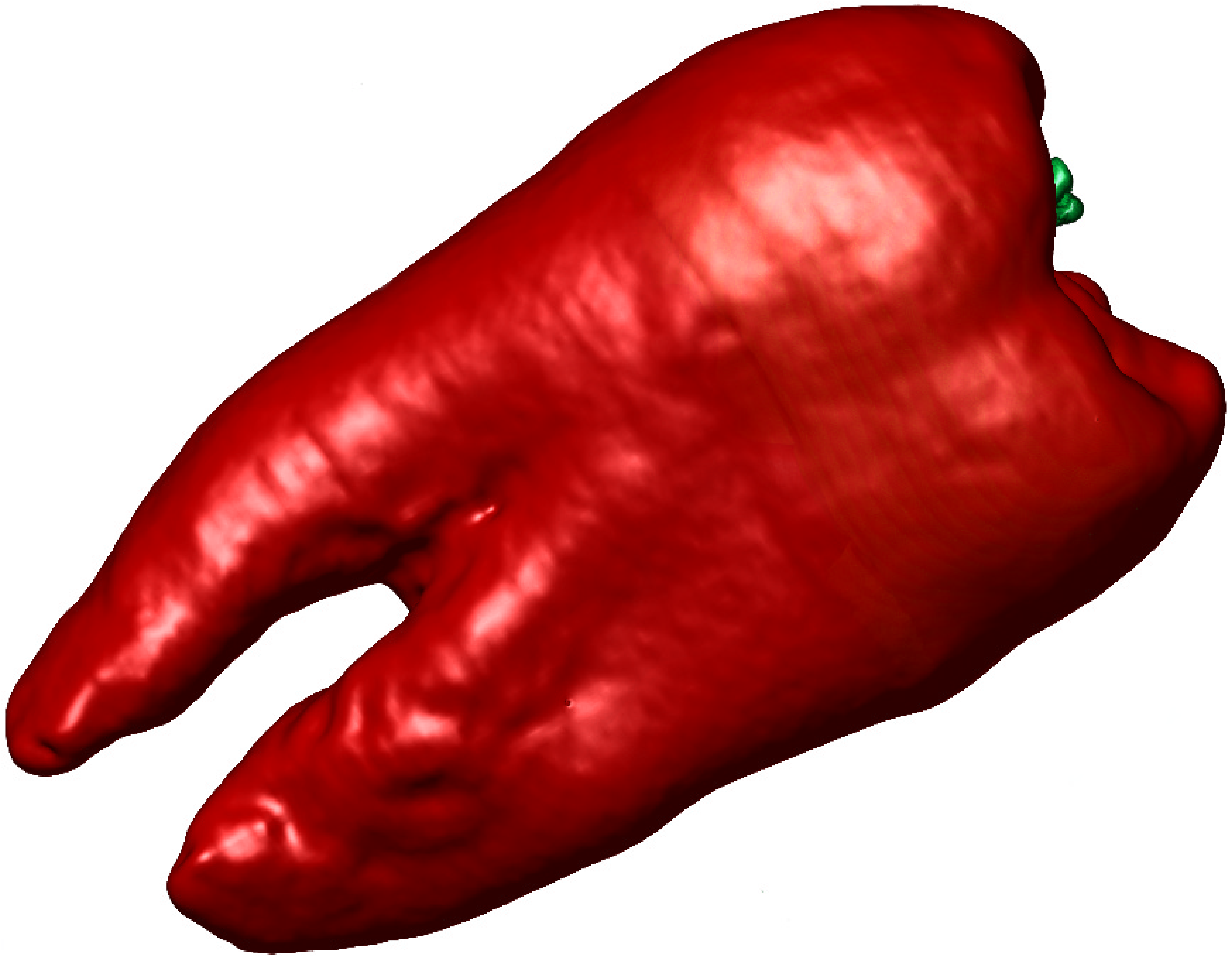
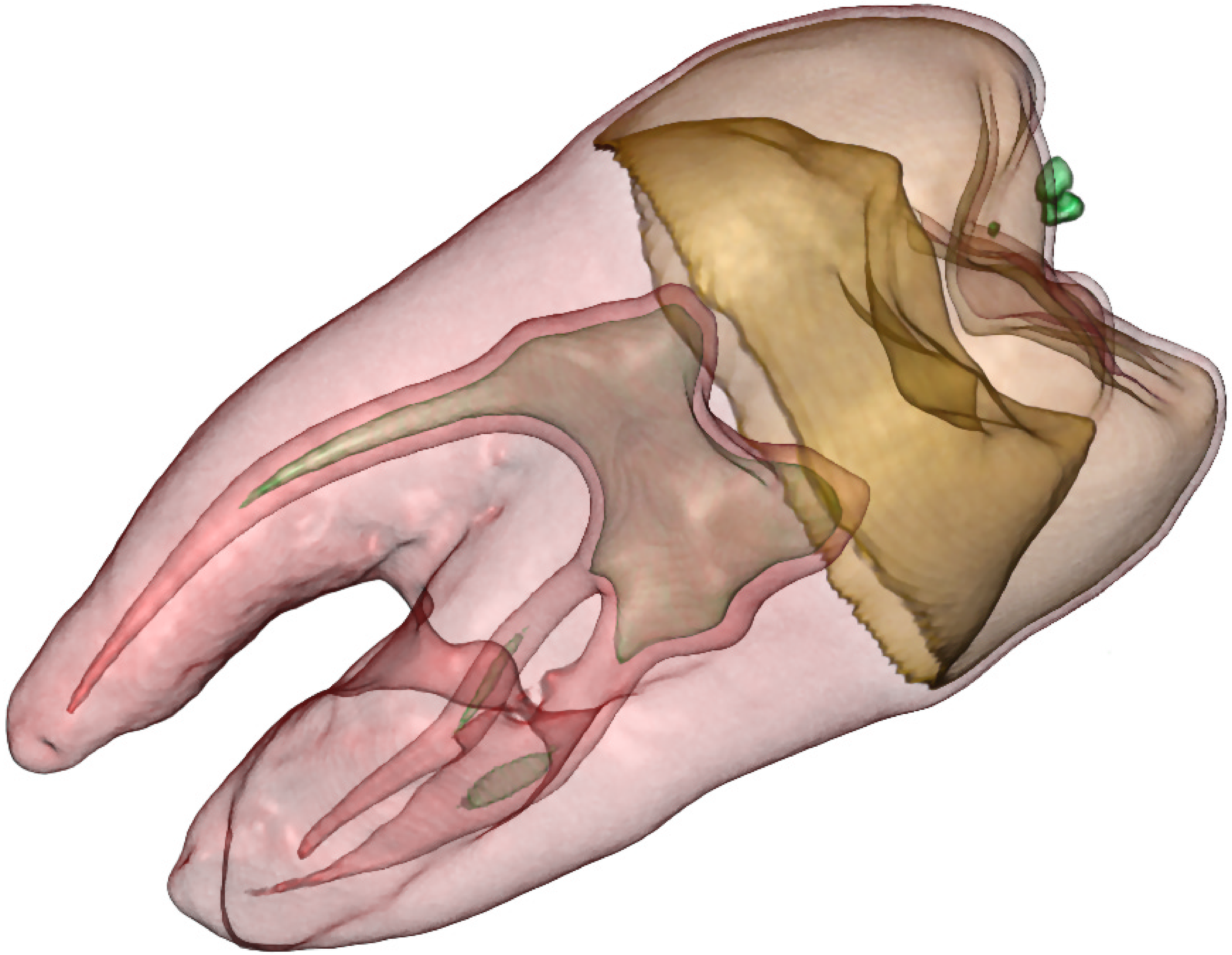


[© Weiskopf/Machiraju/Möller]

Visualizing Volume (3D) Data



(a) An isosurfaced tooth.

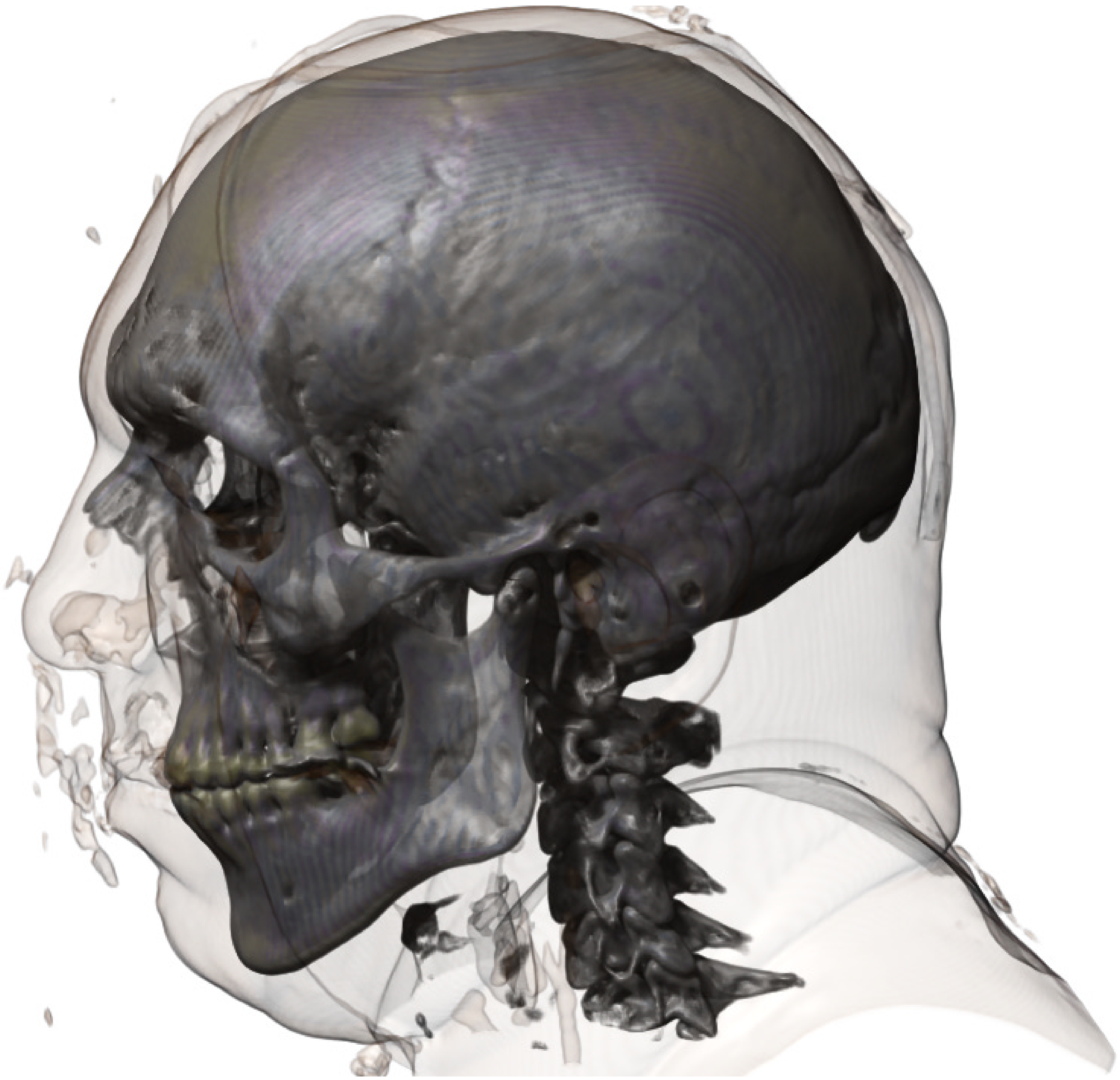


(b) Multiple isosurfaces.

[J. Kniss, 2002]

Visualizing Volume (3D) Data

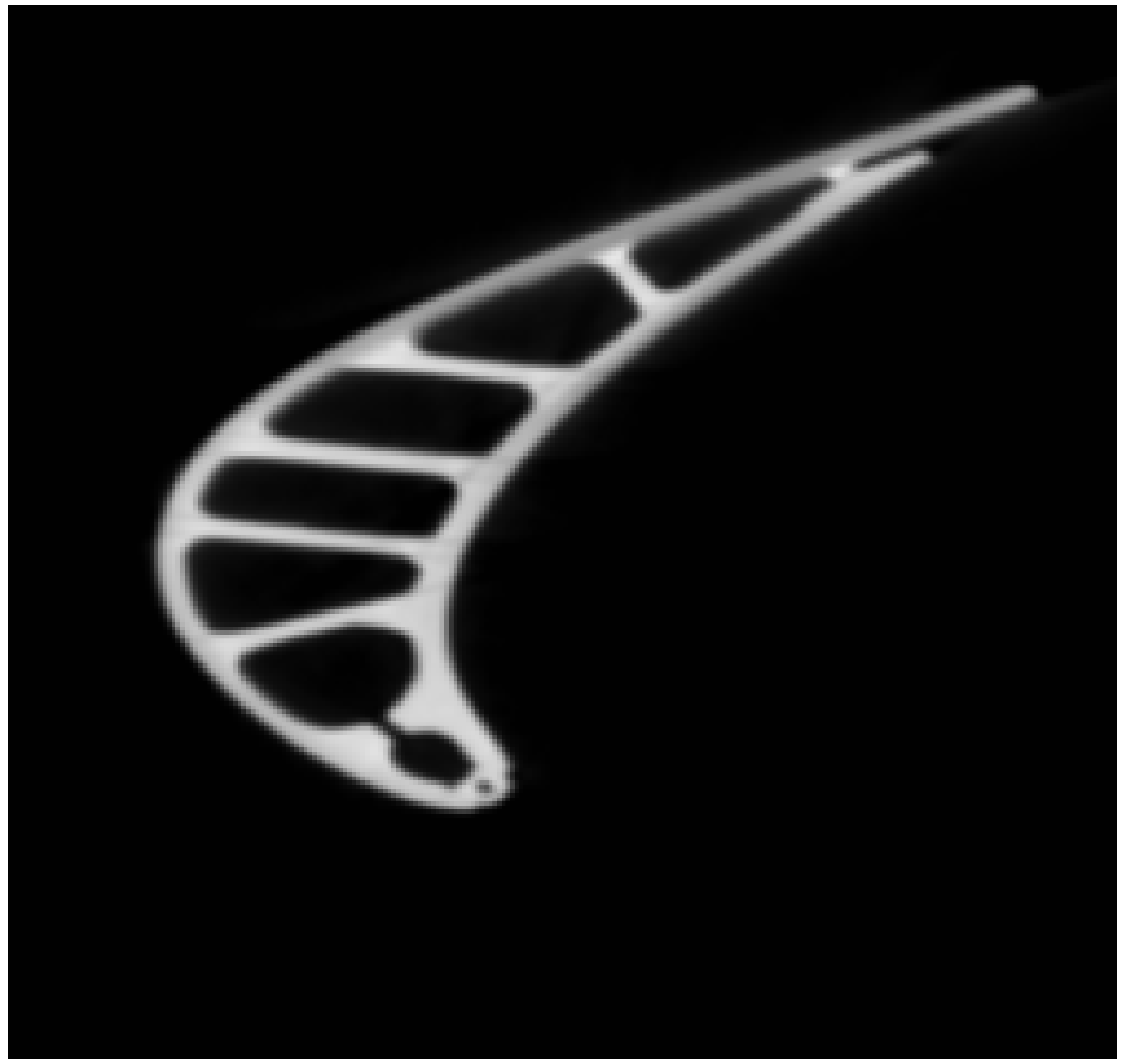
(a) 2D slice



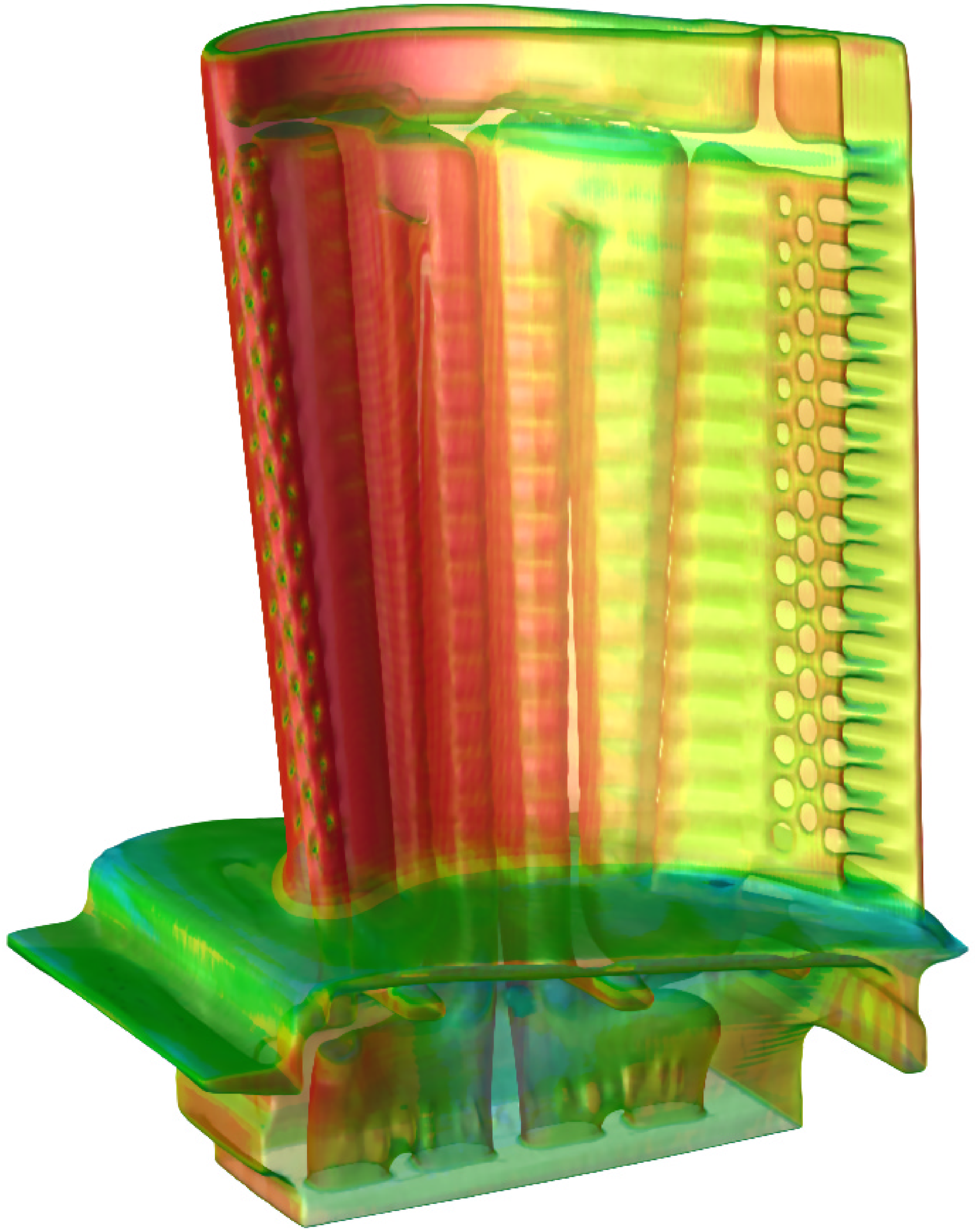
(b) Volume Rendering

[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