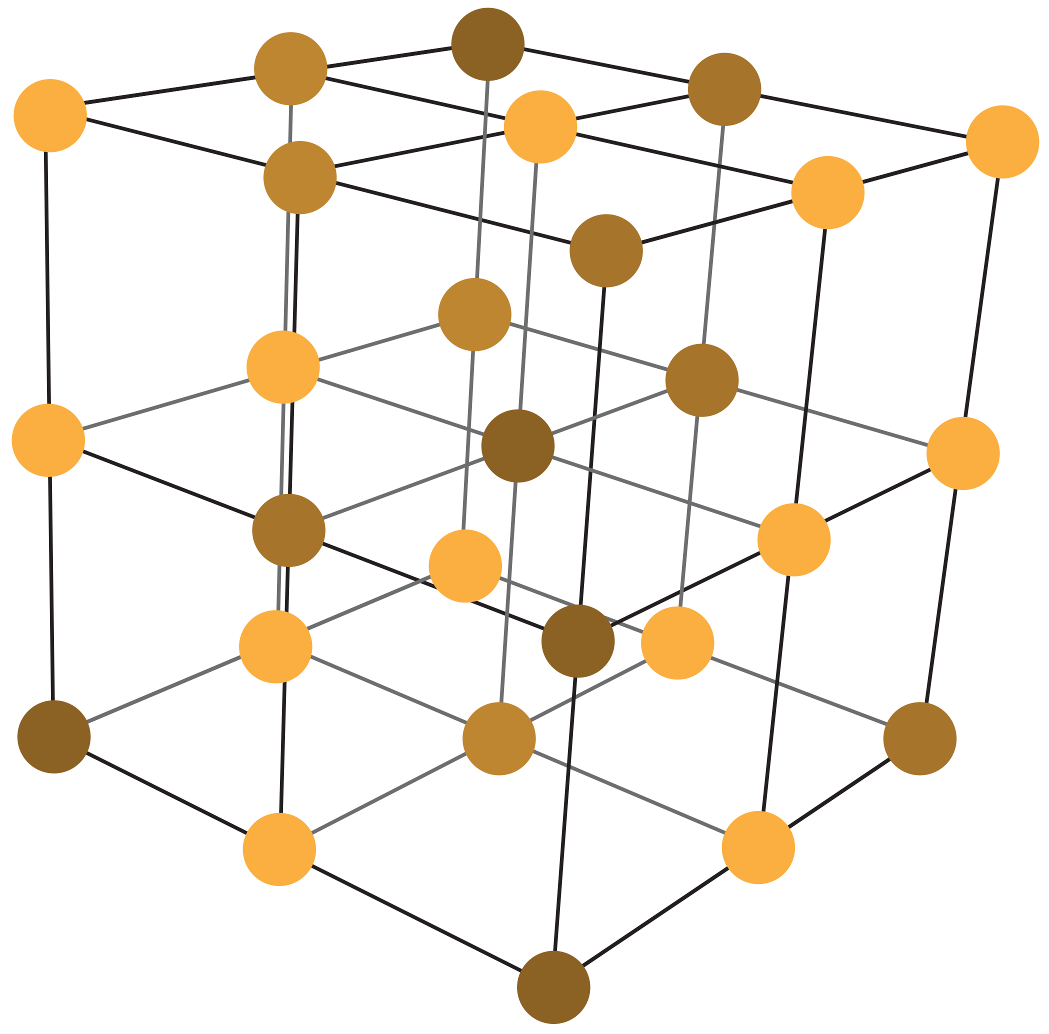
Data Visualization (CSCI 490/680)

Review

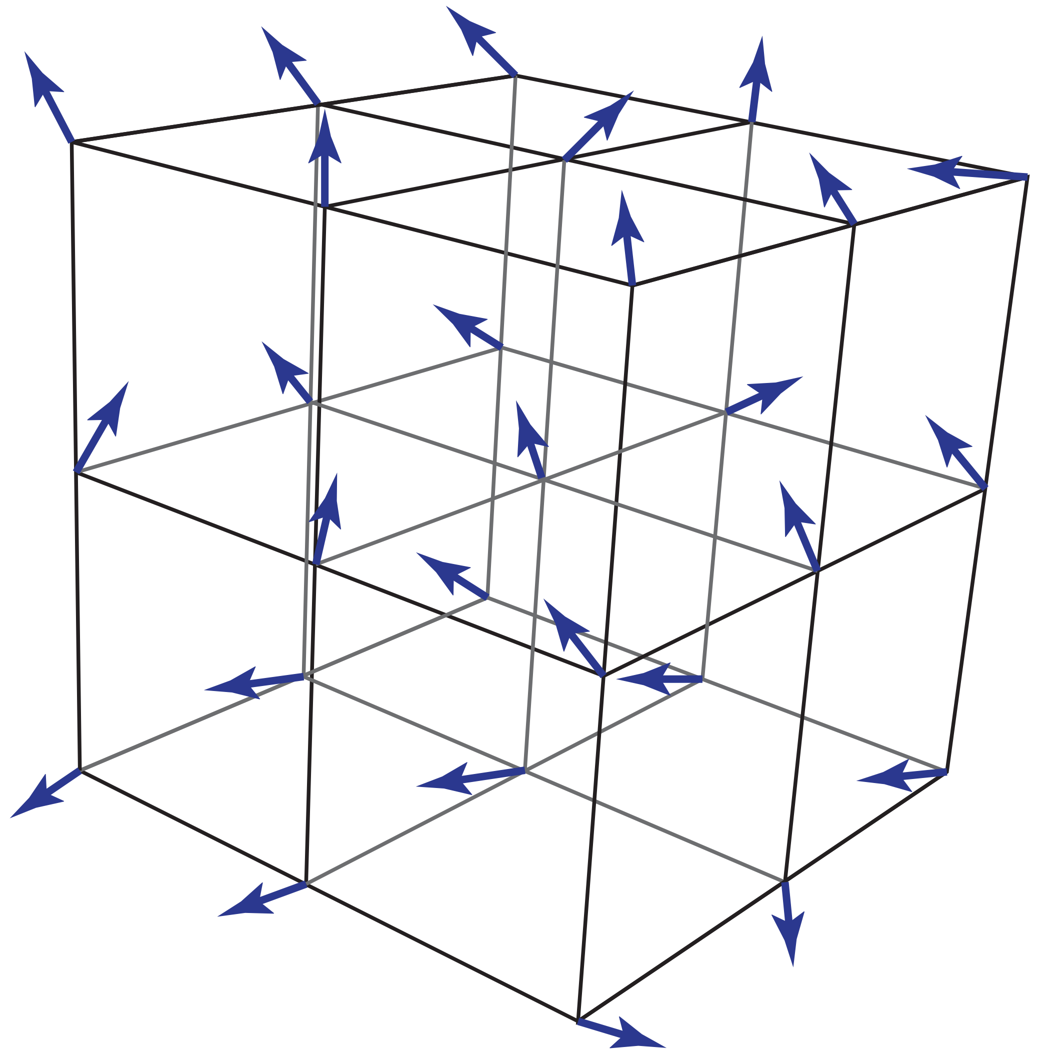
Dr. David Koop

Fields in Visualization



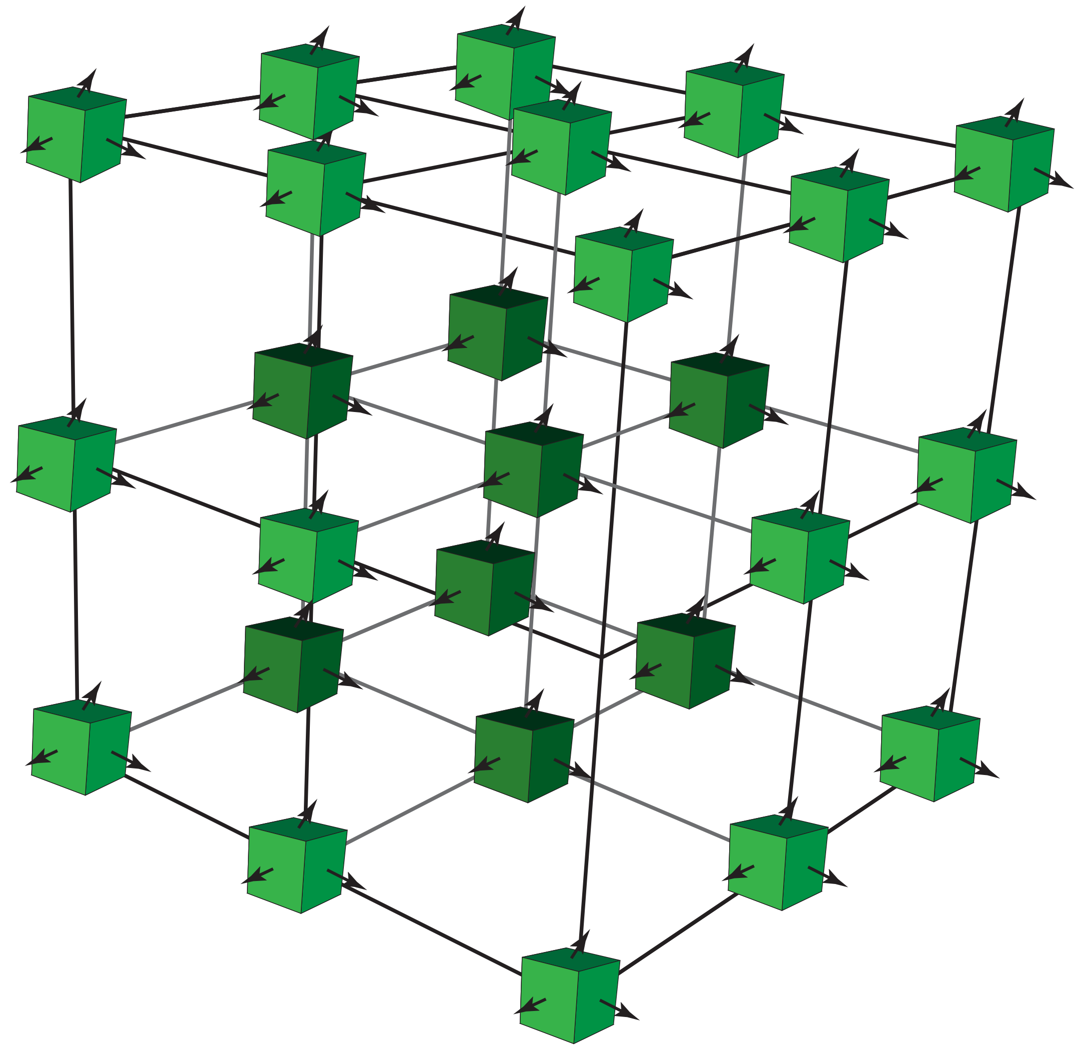
Scalar Fields

(Order-0 Tensor Fields)



Vector Fields

(Order-1 Tensor Fields)



Tensor Fields

(Order-2+)

Each point in space has an associated...

$$s_0$$

Scalar

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

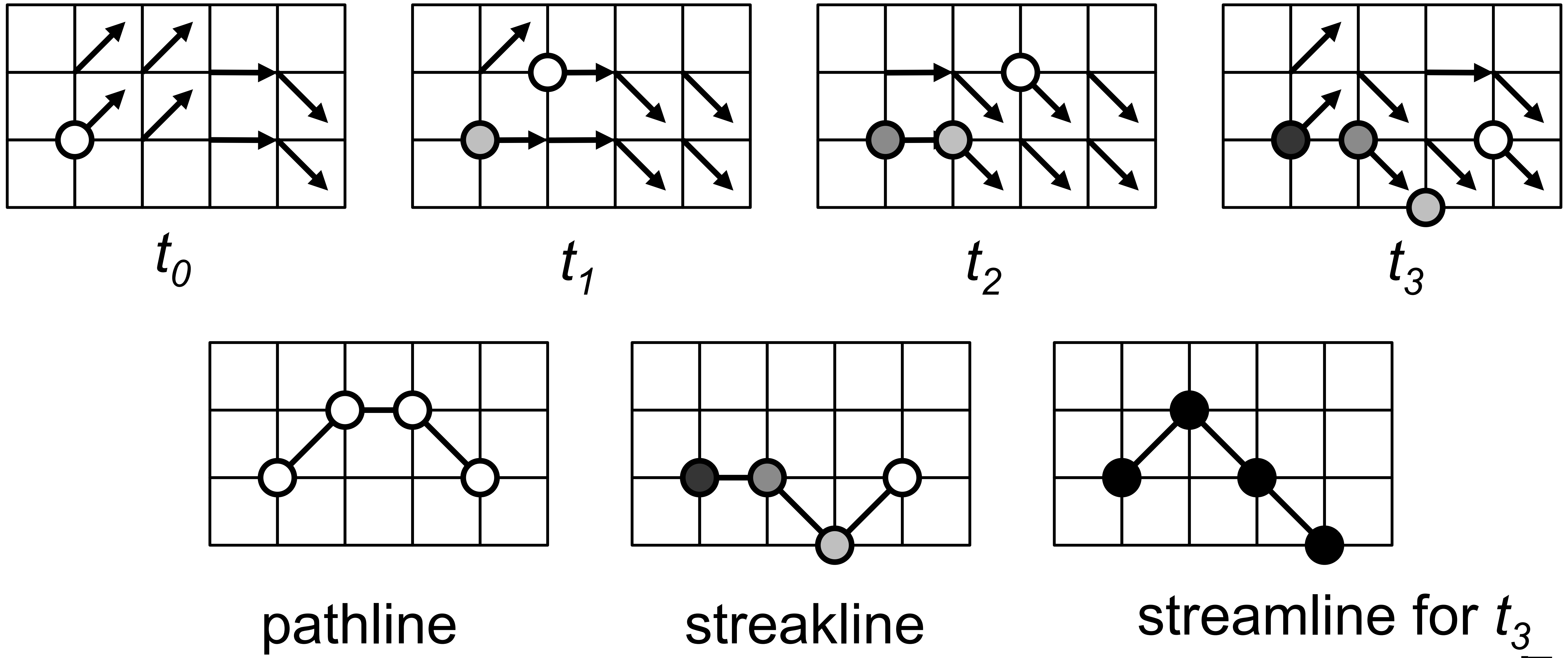
Vector

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

Tensor

Streamlines & Variants

- Steady vs. **Unsteady** flows
  - In unsteady flows, the vector field **changes** over time
- Variants: **Pathlines** and **Streaklines**



[T. Möller]

Streamlines & Variants

- Steady vs. **Unsteady** flows
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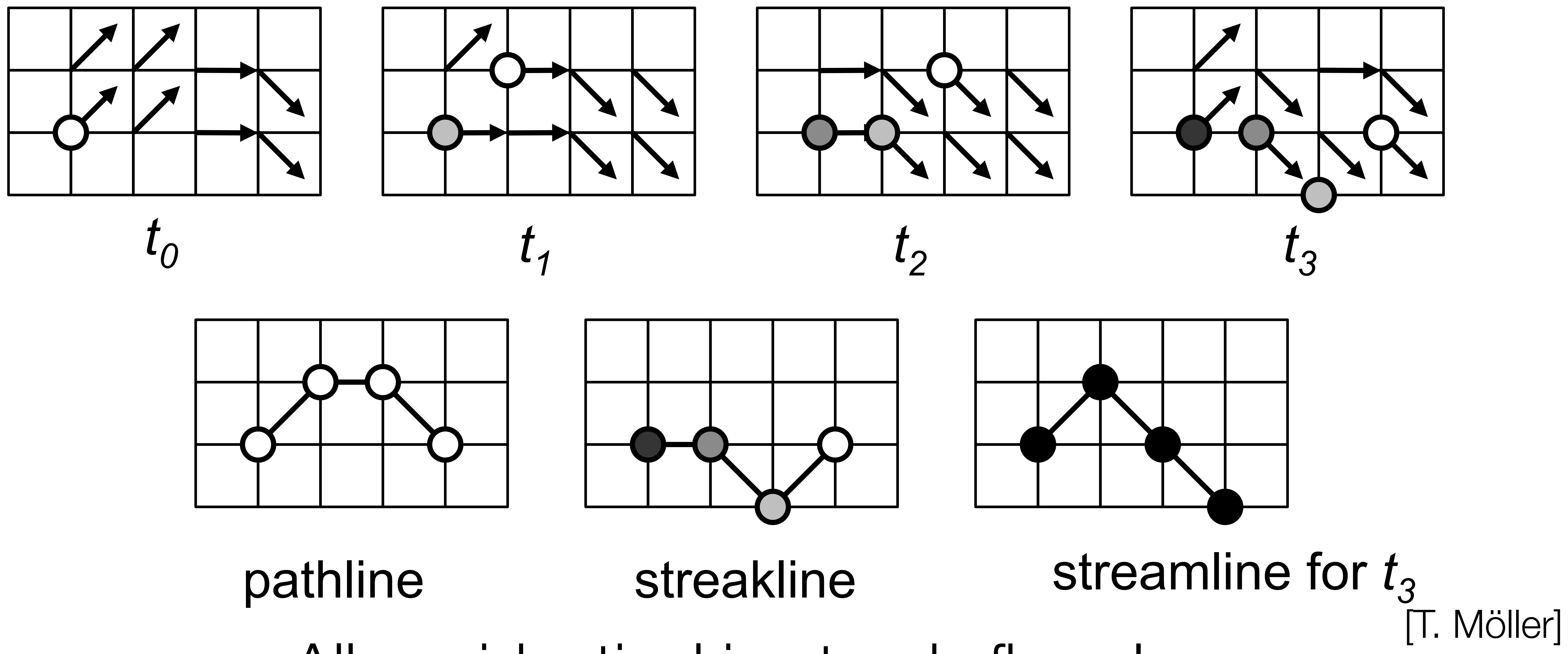
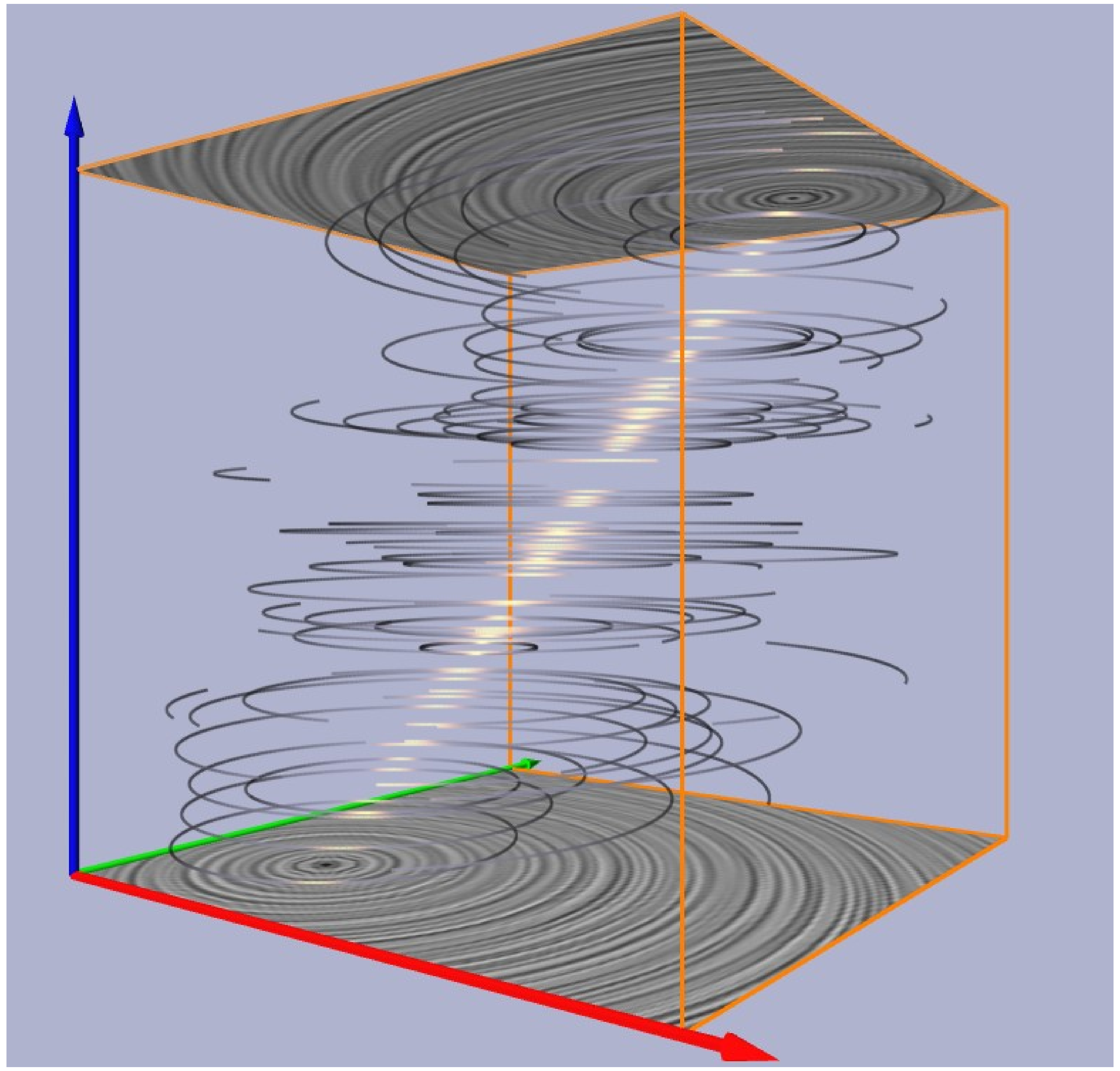
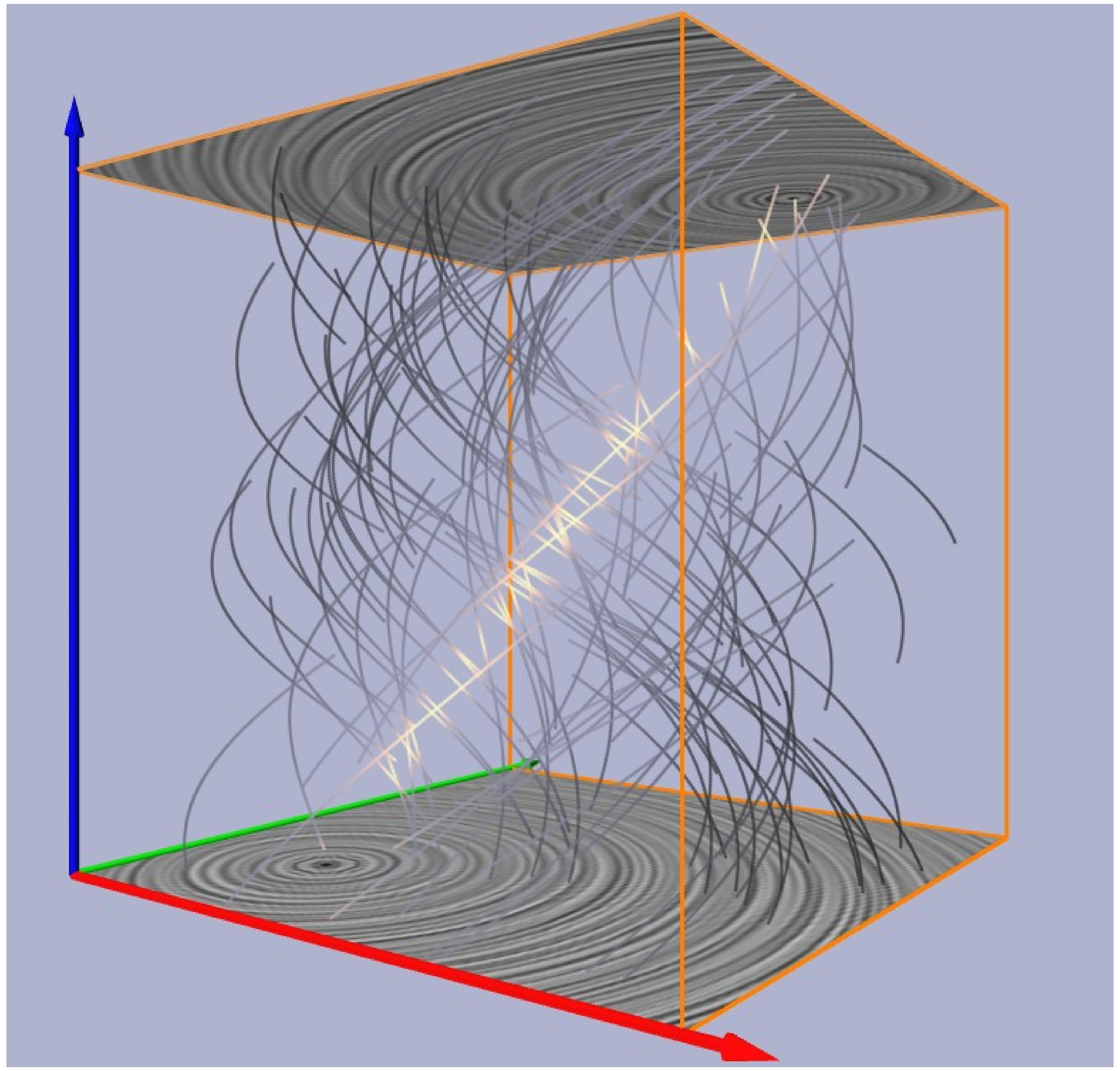


All are identical in steady flows!

Streamlines vs. Pathlines



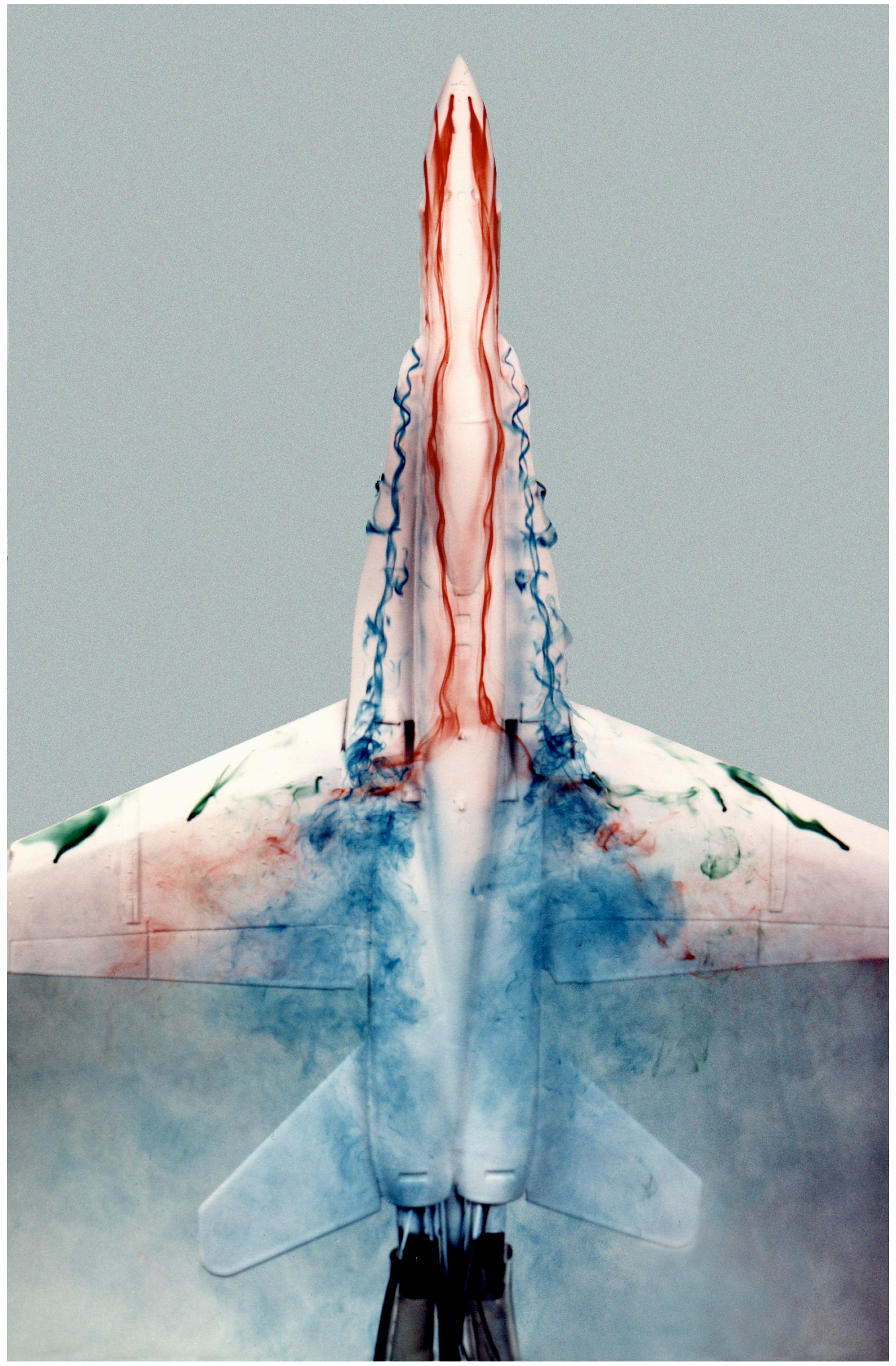
Streamlines



Pathlines

[Weinkauf & Theisel, 2010]

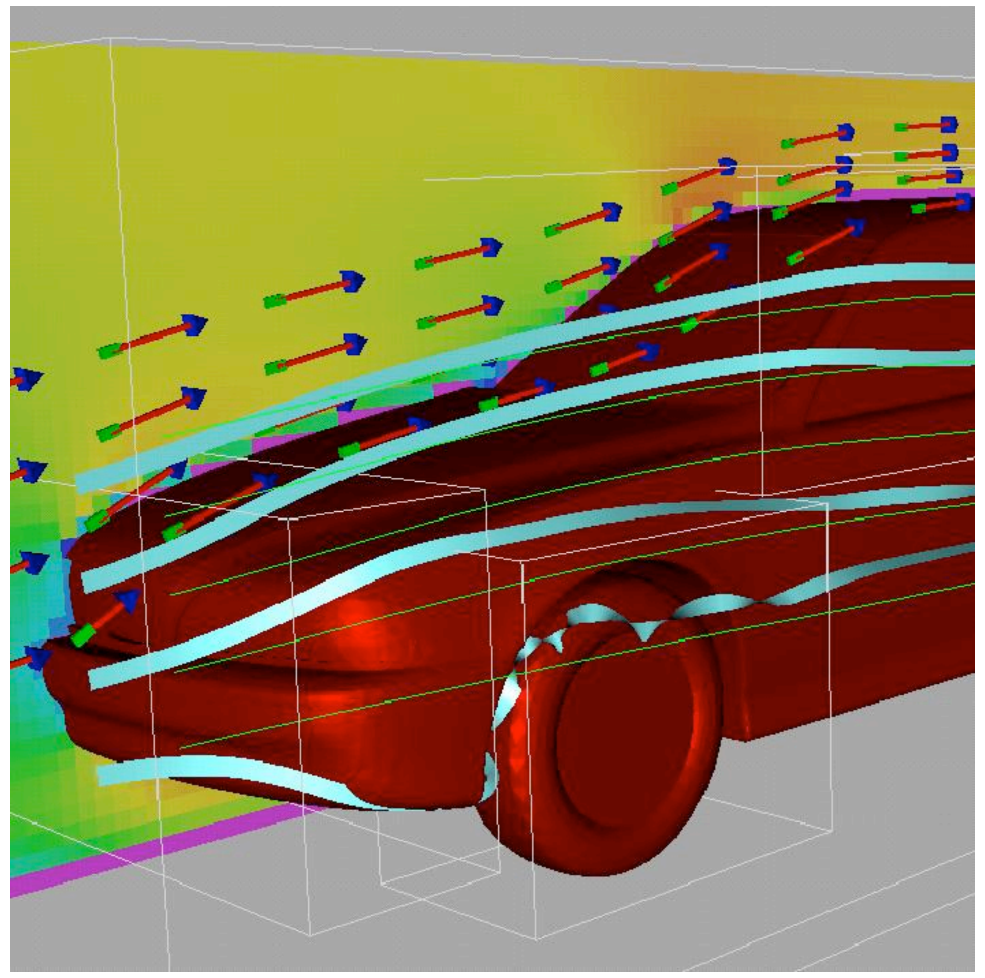
Streamline Variants



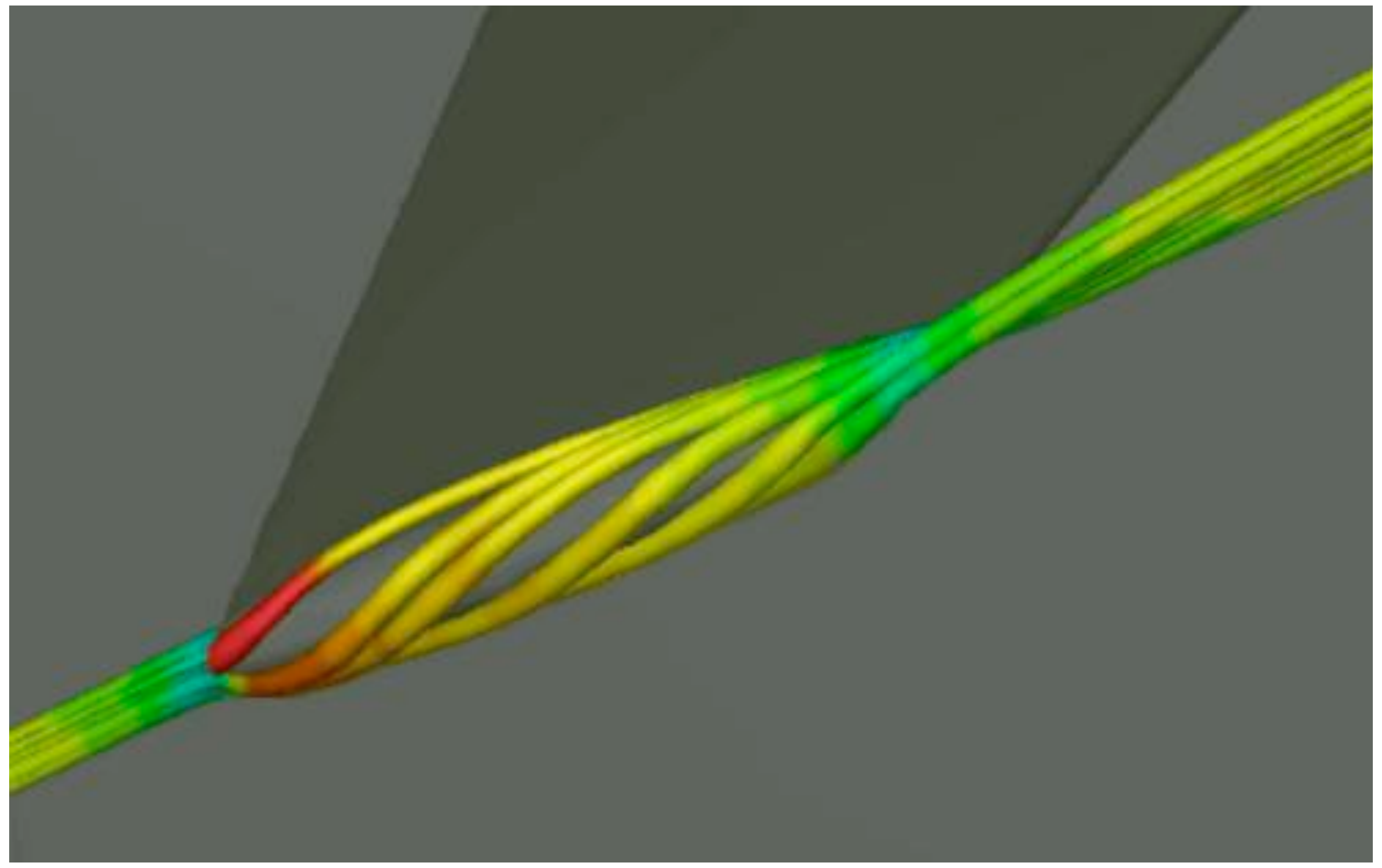
NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: ECN-33298-03 Date: 1985

1/48-scale model of an F-18 aircraft in Flow Visualization Facility (FVF)

Streaklines [NASA]



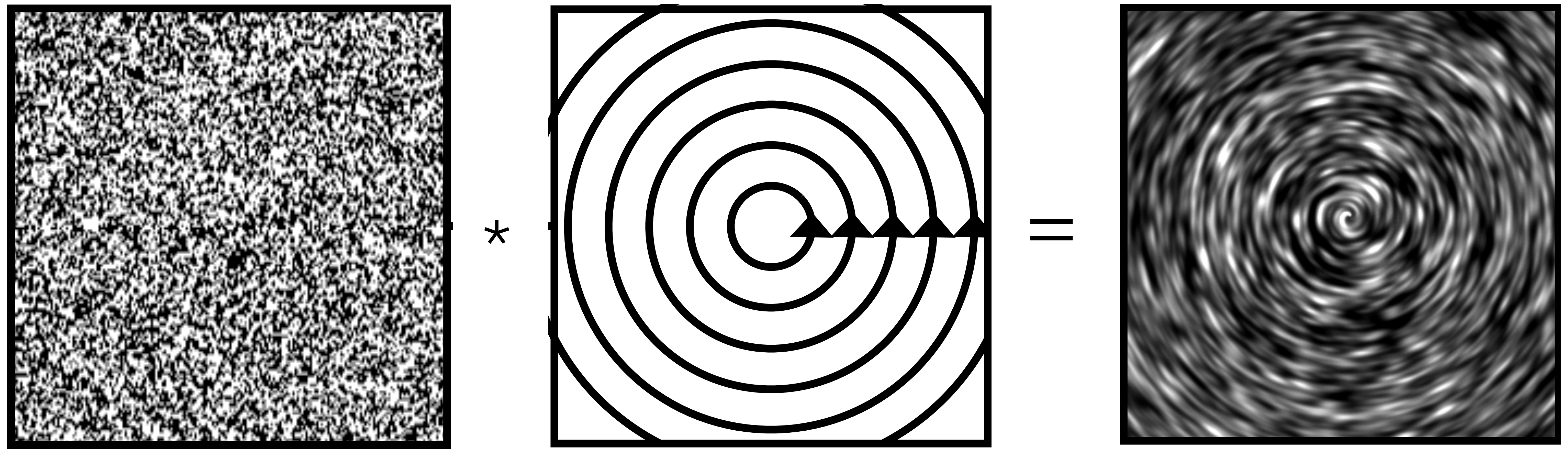
Stream Ribbons [Weiskopf/Machiraju/Möller]



Stream Tubes [Weiskopf/Machiraju/Möller]

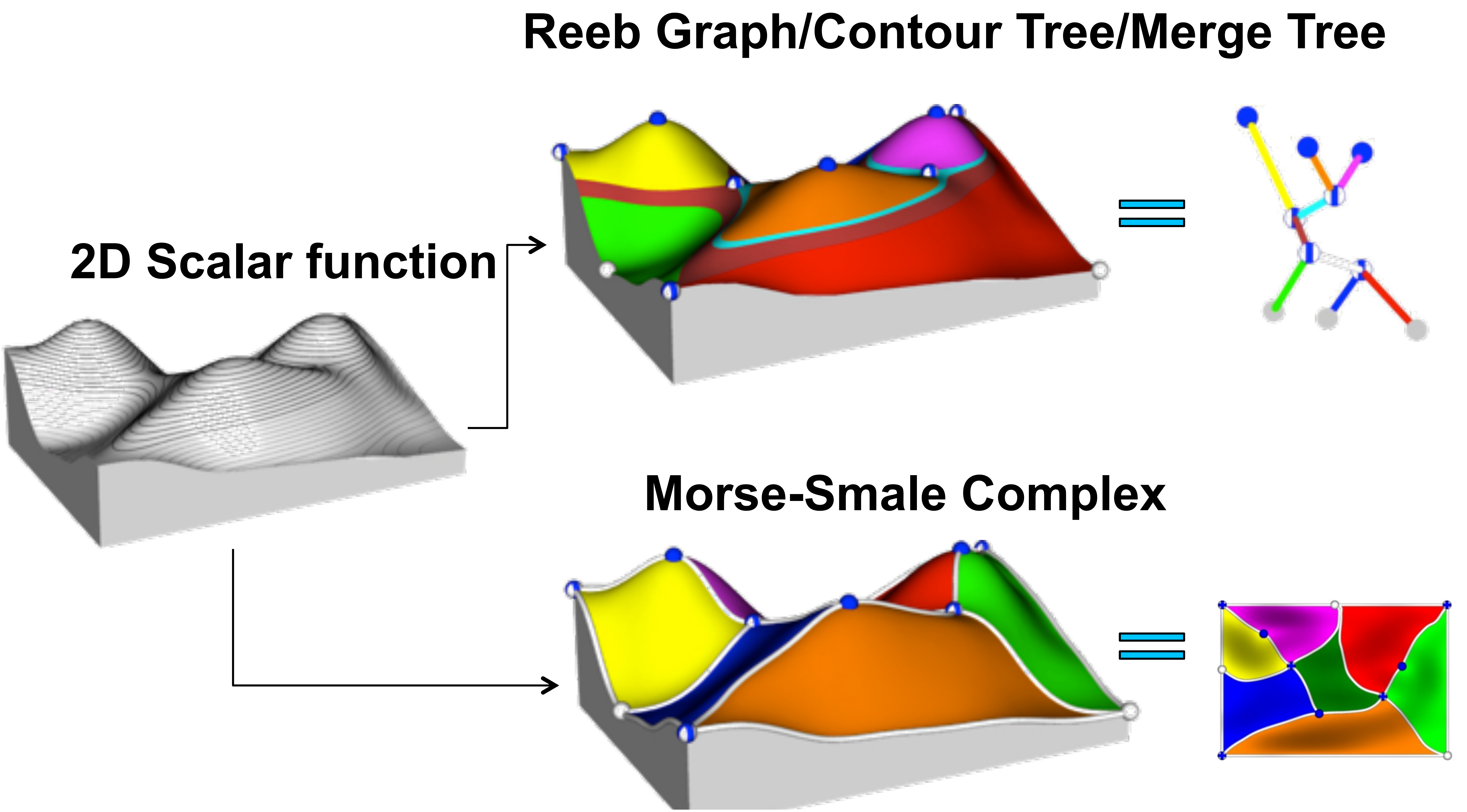
Line Integral Convolution

- Goal: provide a global view of a steady vector field while avoiding issues with clutter, seeds, etc.
- Remember convolution?
- Start with random noise texture
- Smear according to the vector field
- Need structured data



[Weiskopf/Machiraju/Möller]

Scalar Field Topology



[via Levine]

Vector Field Topology

- Instead of "guessing" correct seed points for streamlines to understand the field, try to identify structure (topology) of the field

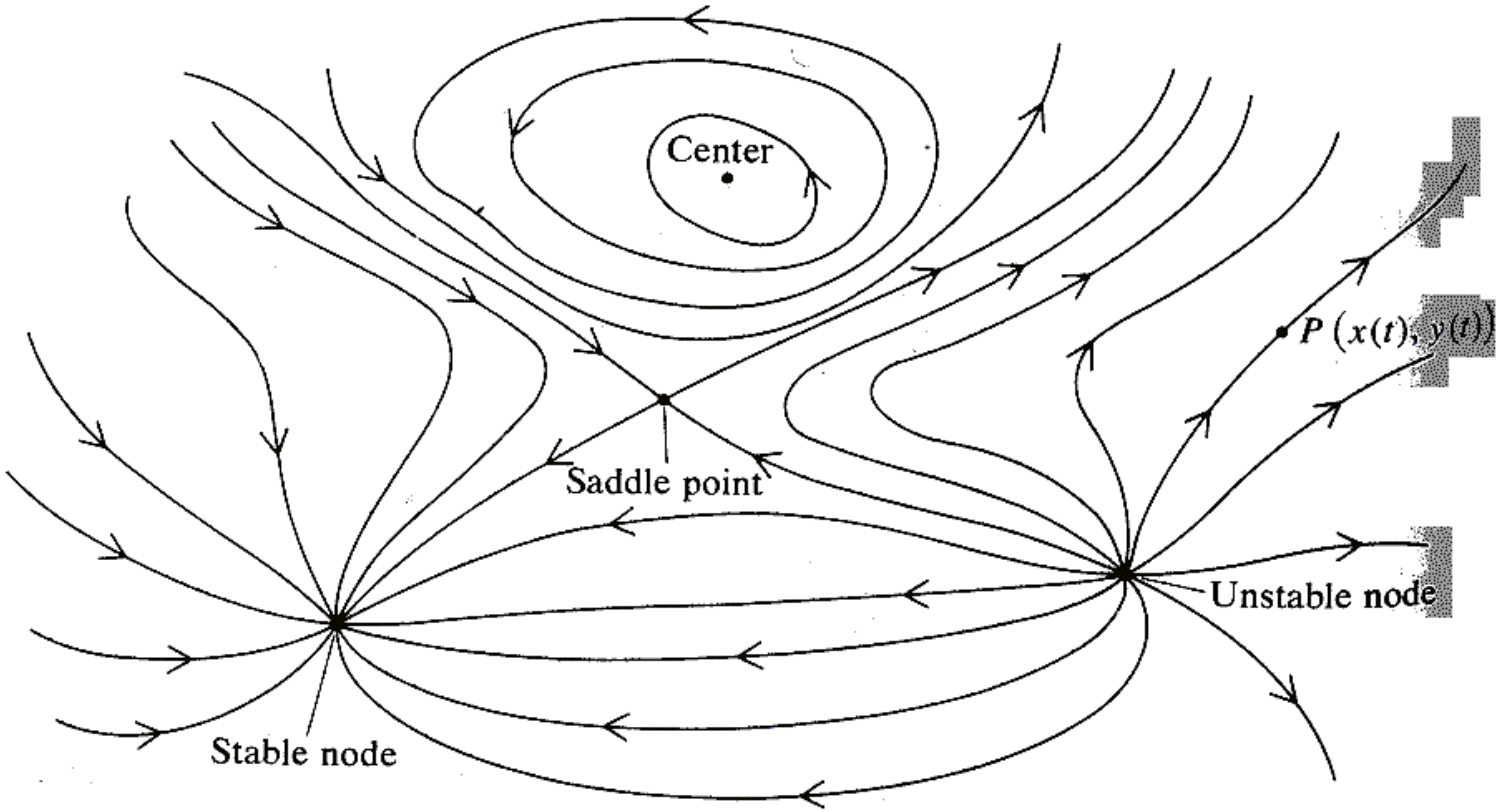
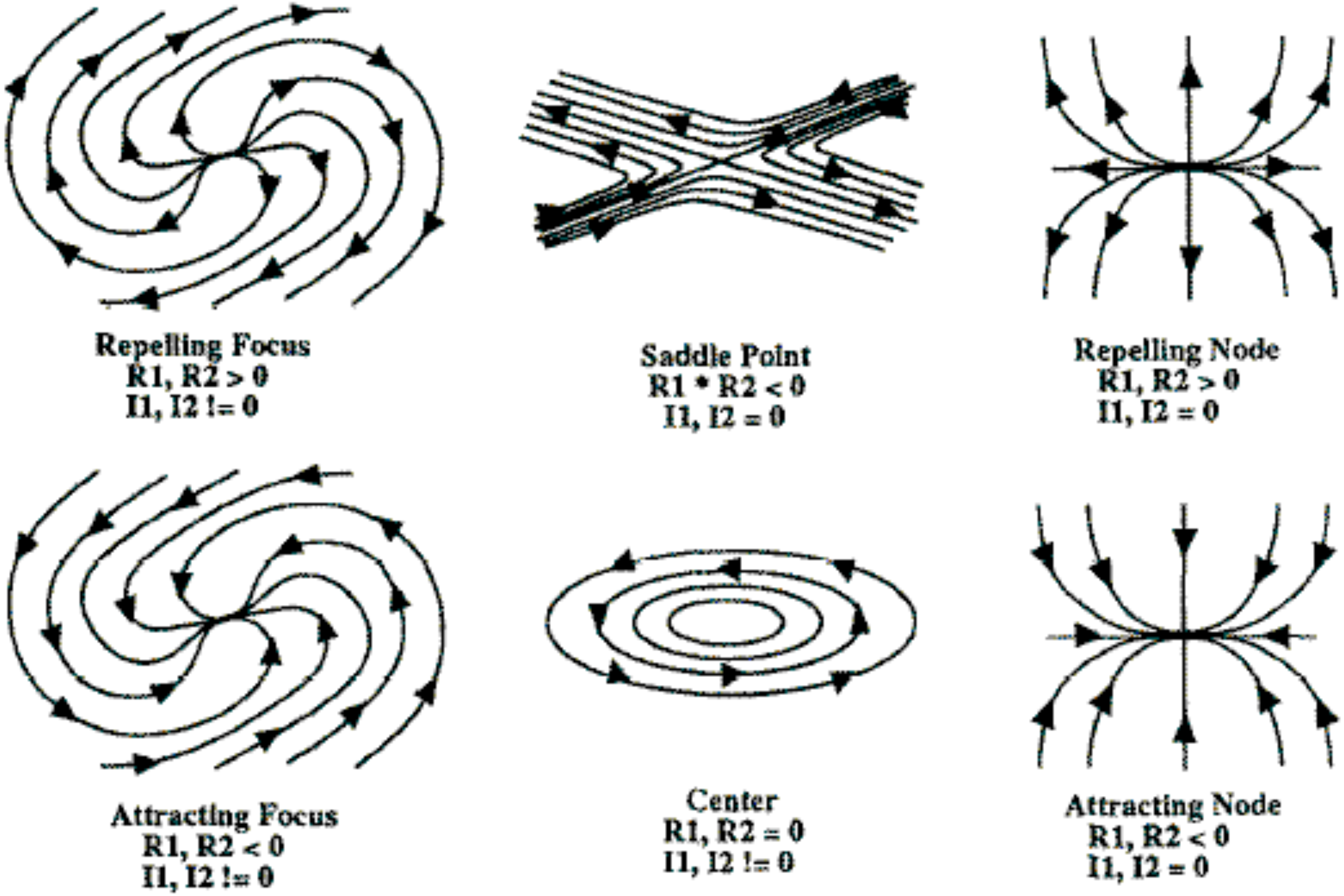


Figure 7.1 A phase portrait.

[M. Henle]

Critical Points



[Helman & Hesselink]

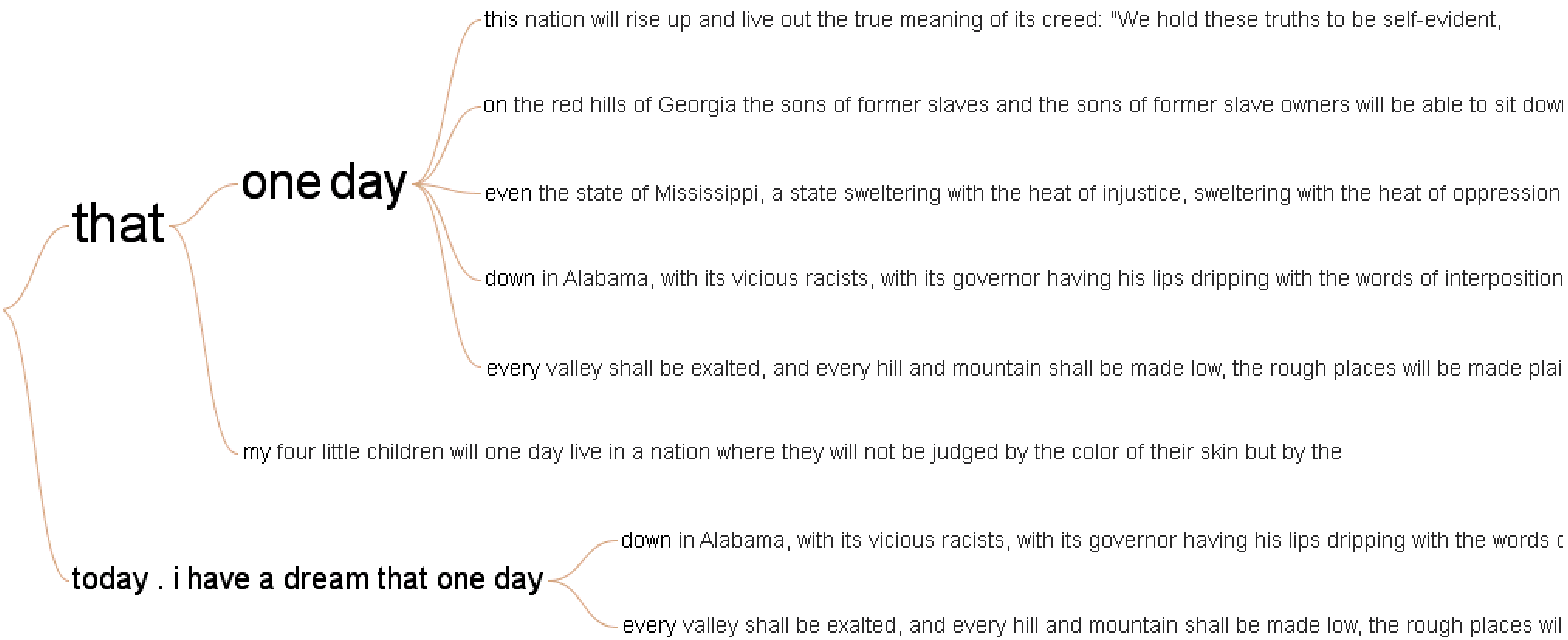
Text Visualization

- Why visualize text? Text is already visual, right?
- How much text? What granularity? (What is an item?)
  - Single string
  - Words/lines
  - One document
  - Multiple documents (corpus)
- Considerations:
  - Legibility
  - Variable length
  - Locality
  - Occurence

Tag Cloud (One Document)

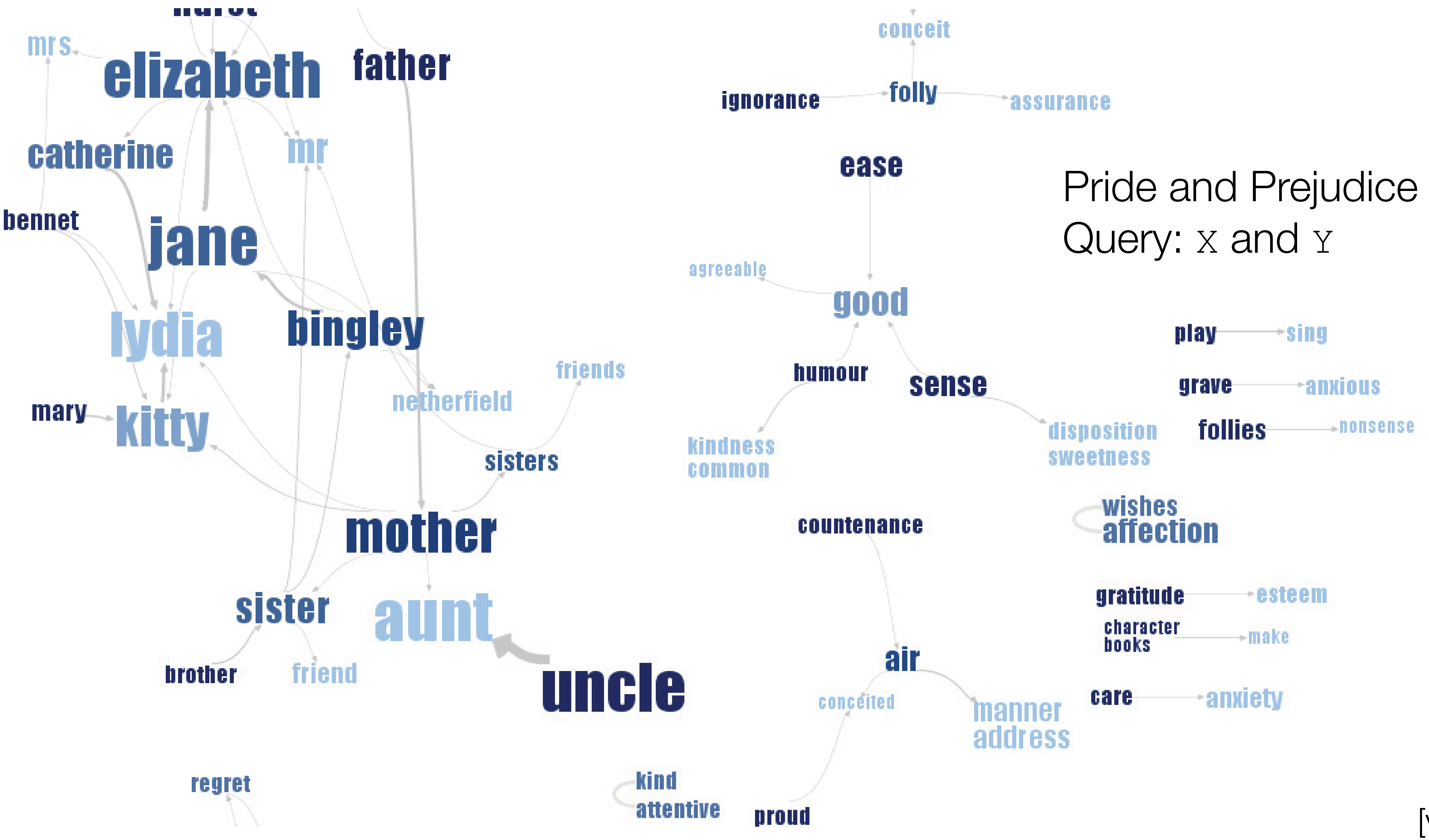
- Derived data: number of occurrences of words
- Channel: Font size
- Potential problem: Think about ink…

Word Tree (One Document)



[Wattenberg & Viegas, 2007]

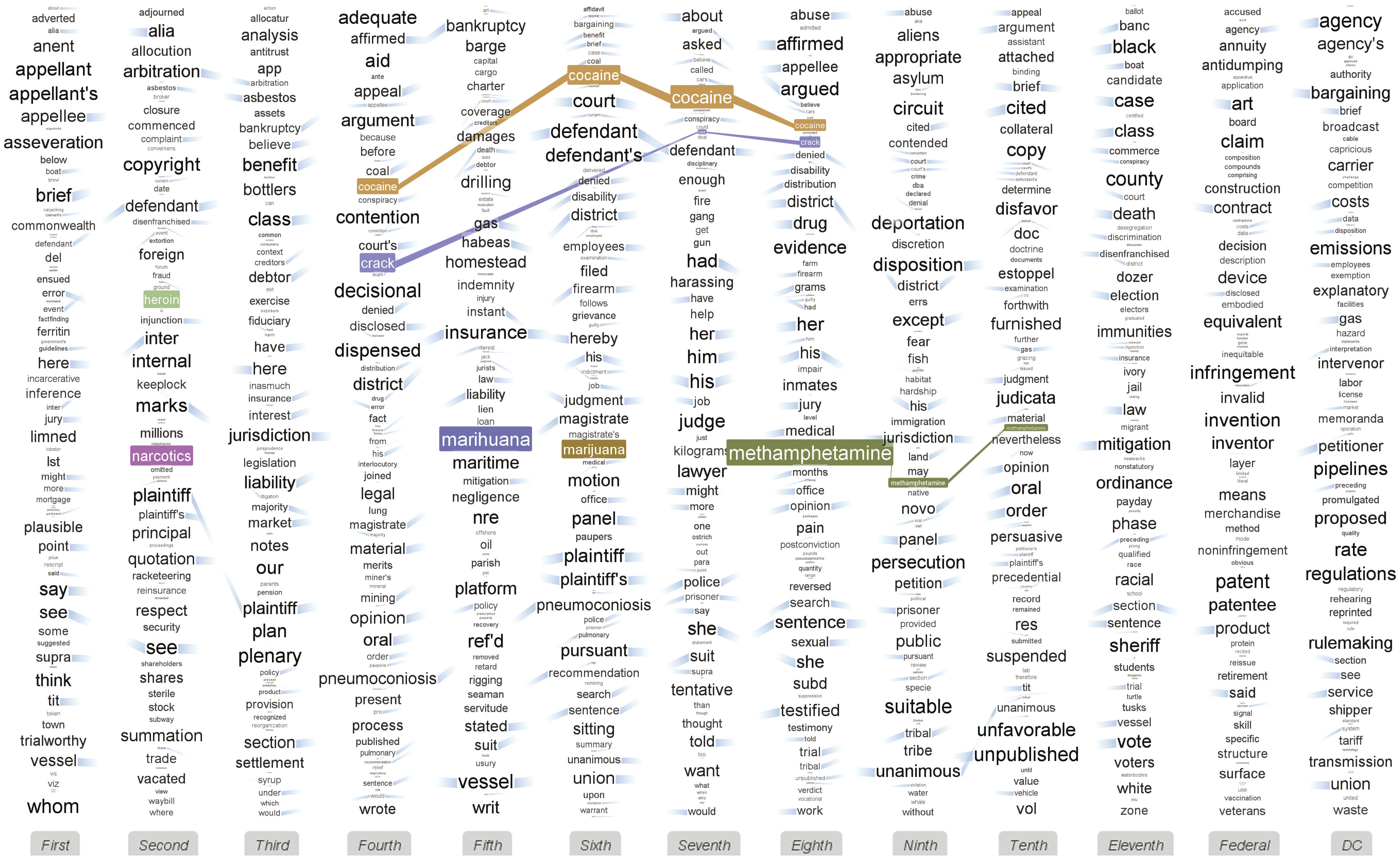
Phrase Nets



Pride and Prejudice
Query: X and Y

[van Ham, 2009]

Parallel Tag Clouds (Multiple Documents)



[Collins et al., 2009]

Project

- Presentations on **Thursday**:
  - Turn in code for the visualization to **Blackboard** by **Dec. 4 at 11:59pm**
  - **5 minutes** per presenter
  - Showcase the visualization (not slides)
    - Brief introduction to your data and questions
    - Discuss design decisions
    - Demonstrate the interactive features of your project
  - Should run in a web browser so we will use my laptop
- Have until Dec. 6 to turn in final code and report

Final Exam

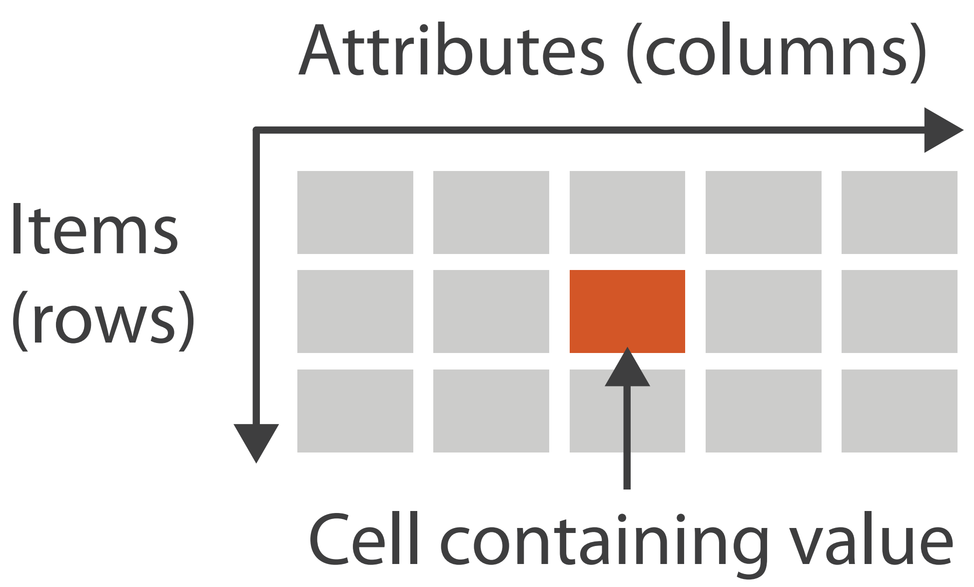
- Thursday, Dec. 12, **10-11:50am**
- Covers all topics but emphasizes second half of the course
- Similar format as Midterm (multiple choice, free response)
- As with the Midterm, 680 students will have a few questions related to the research papers

"Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively."

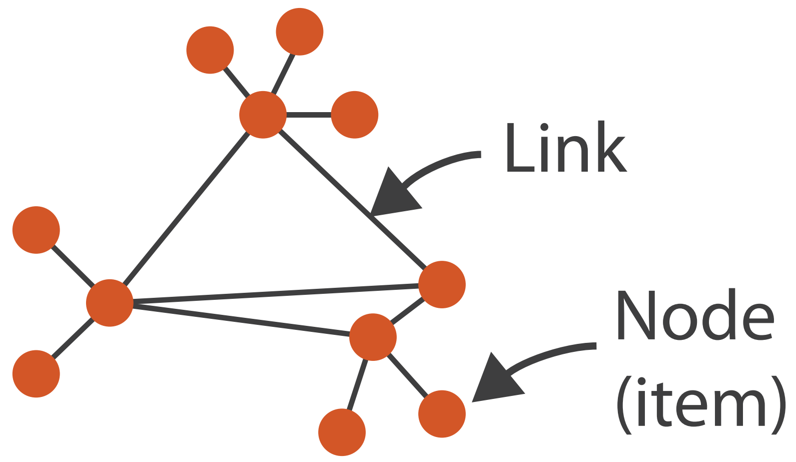
— T. Munzner

Dataset Types

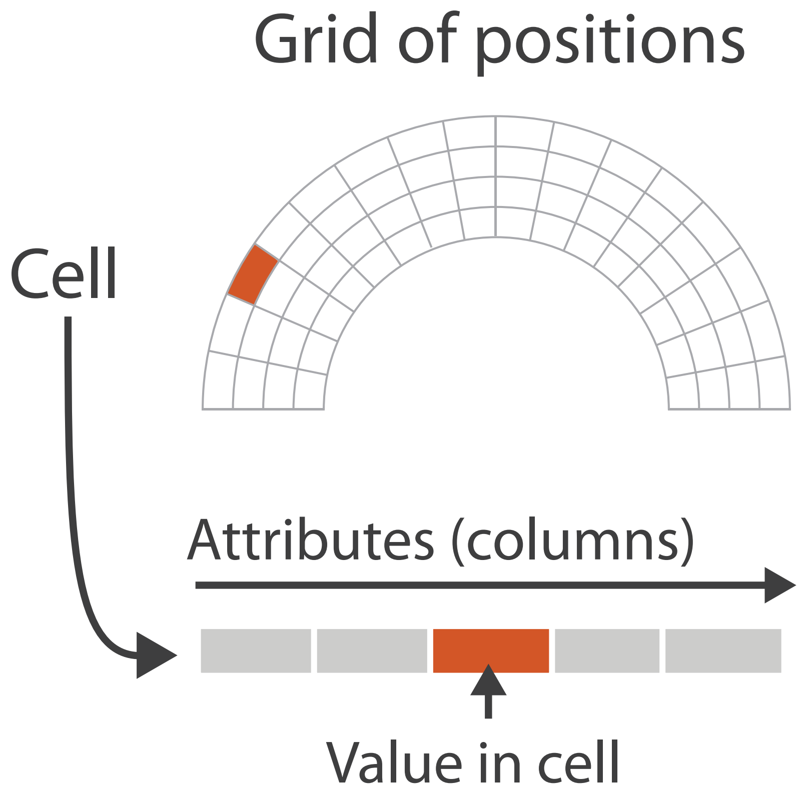
➔ Tables



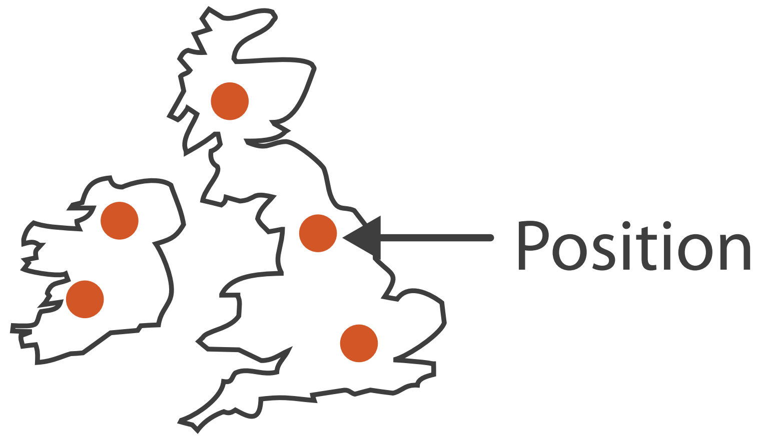
➔ Networks



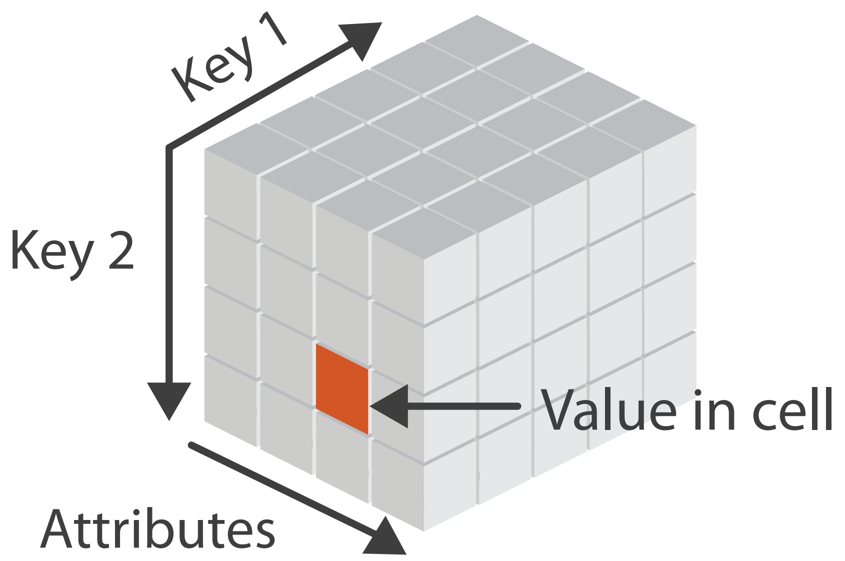
➔ Fields (Continuous)



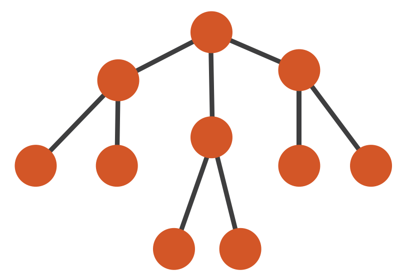
➔ Geometry (Spatial)



➔ *Multidimensional Table*



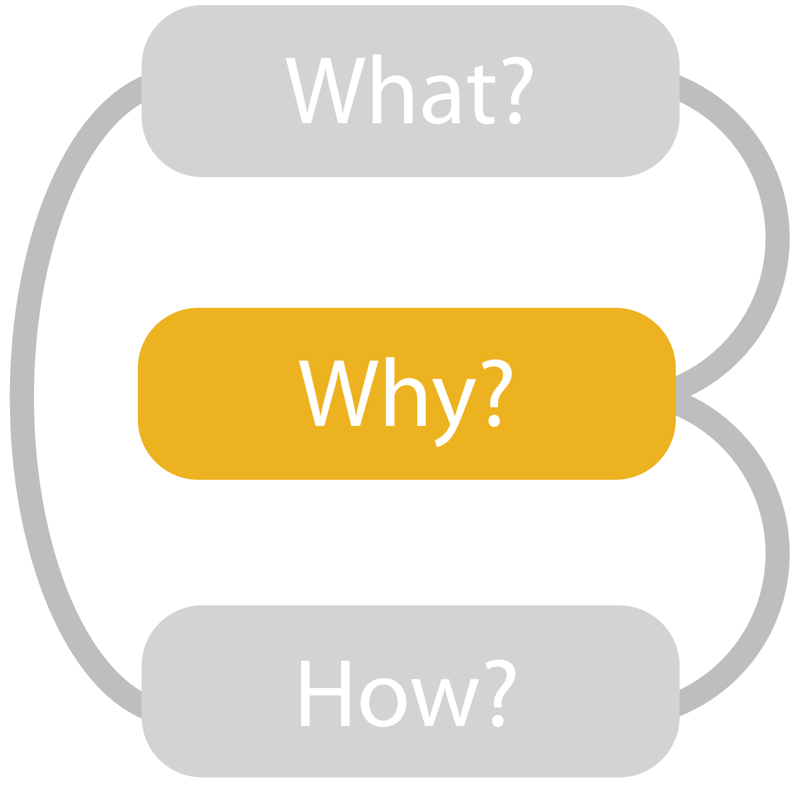
➔ *Trees*

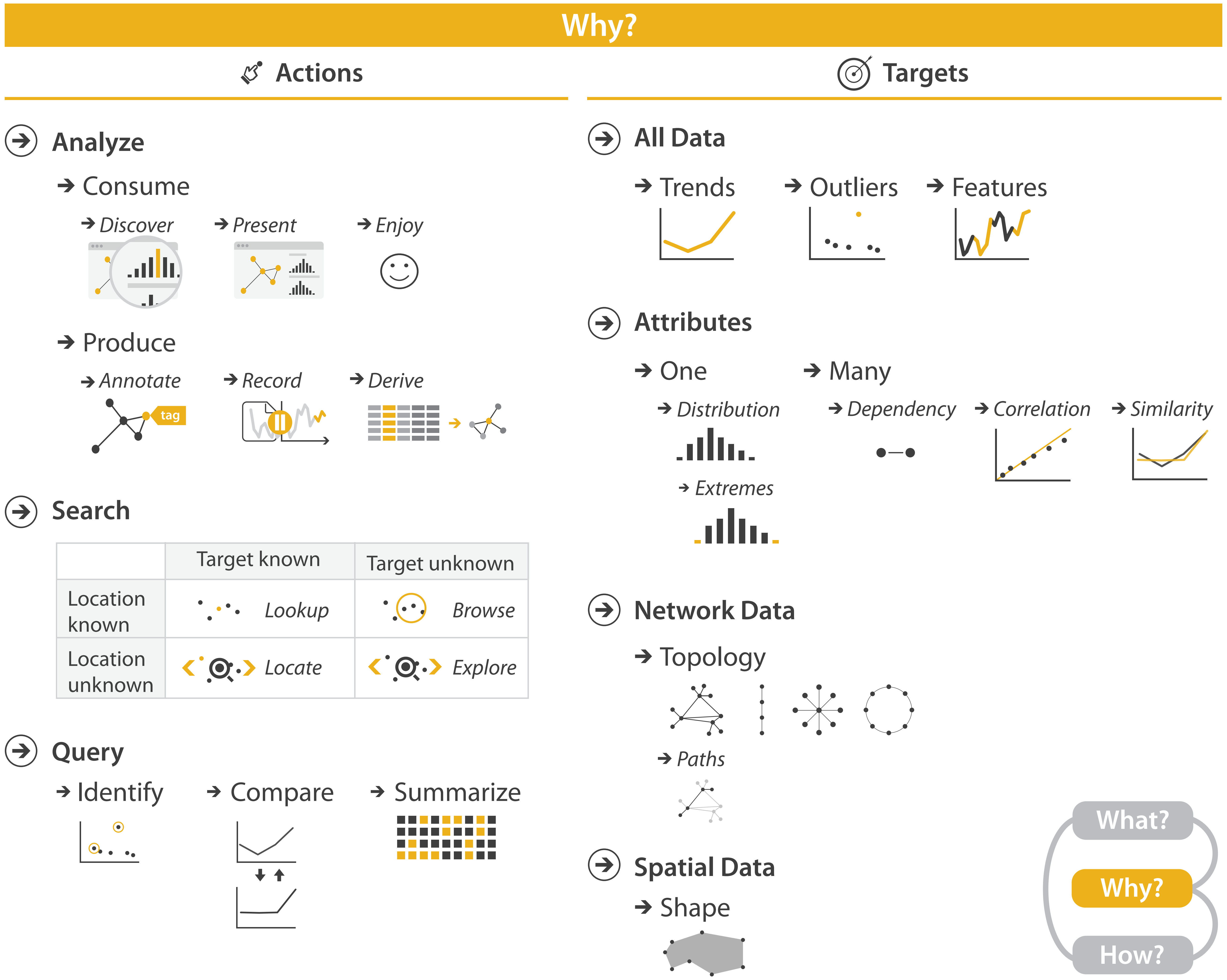


\+ Sets
\+ Text

[Munzner (ill. Maguire), 2014]

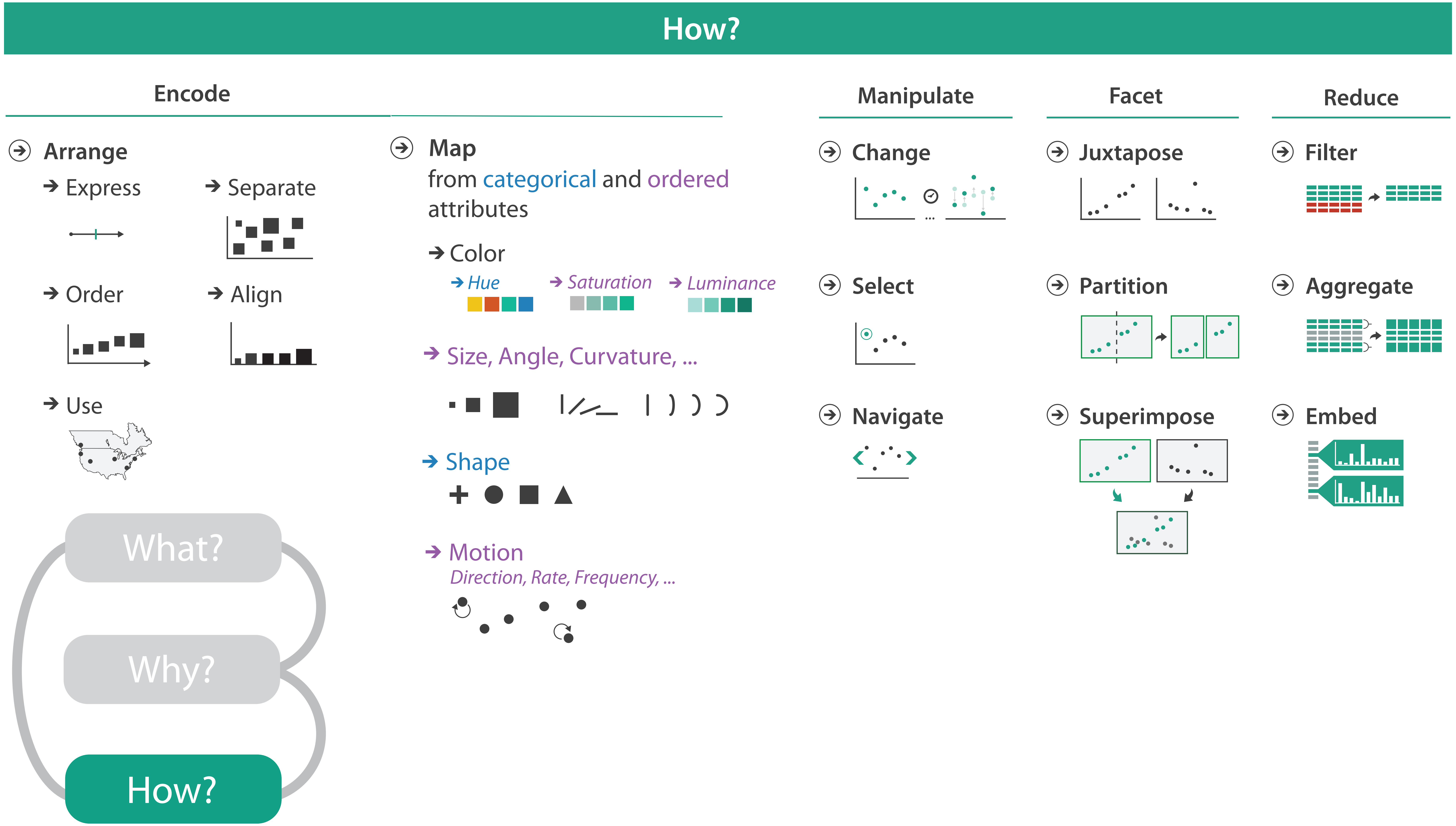
Tasks





[Munzner (ill. Maguire), 2014]

How do we do visualization?

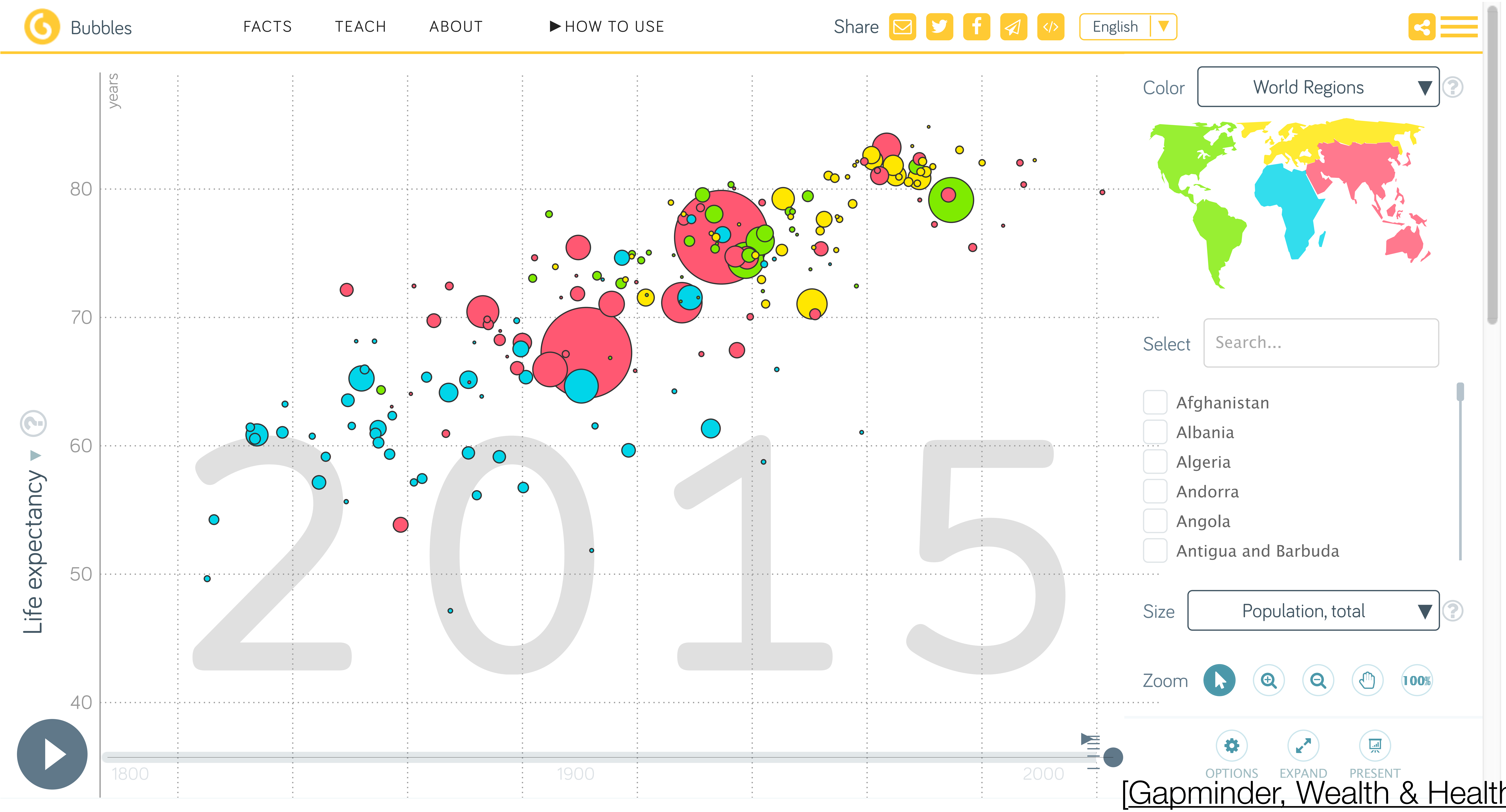


[Munzner (ill. Maguire), 2014]

Nested Visualization Design

[Munzner (ill. Maguire), 2014]

Visual Encoding



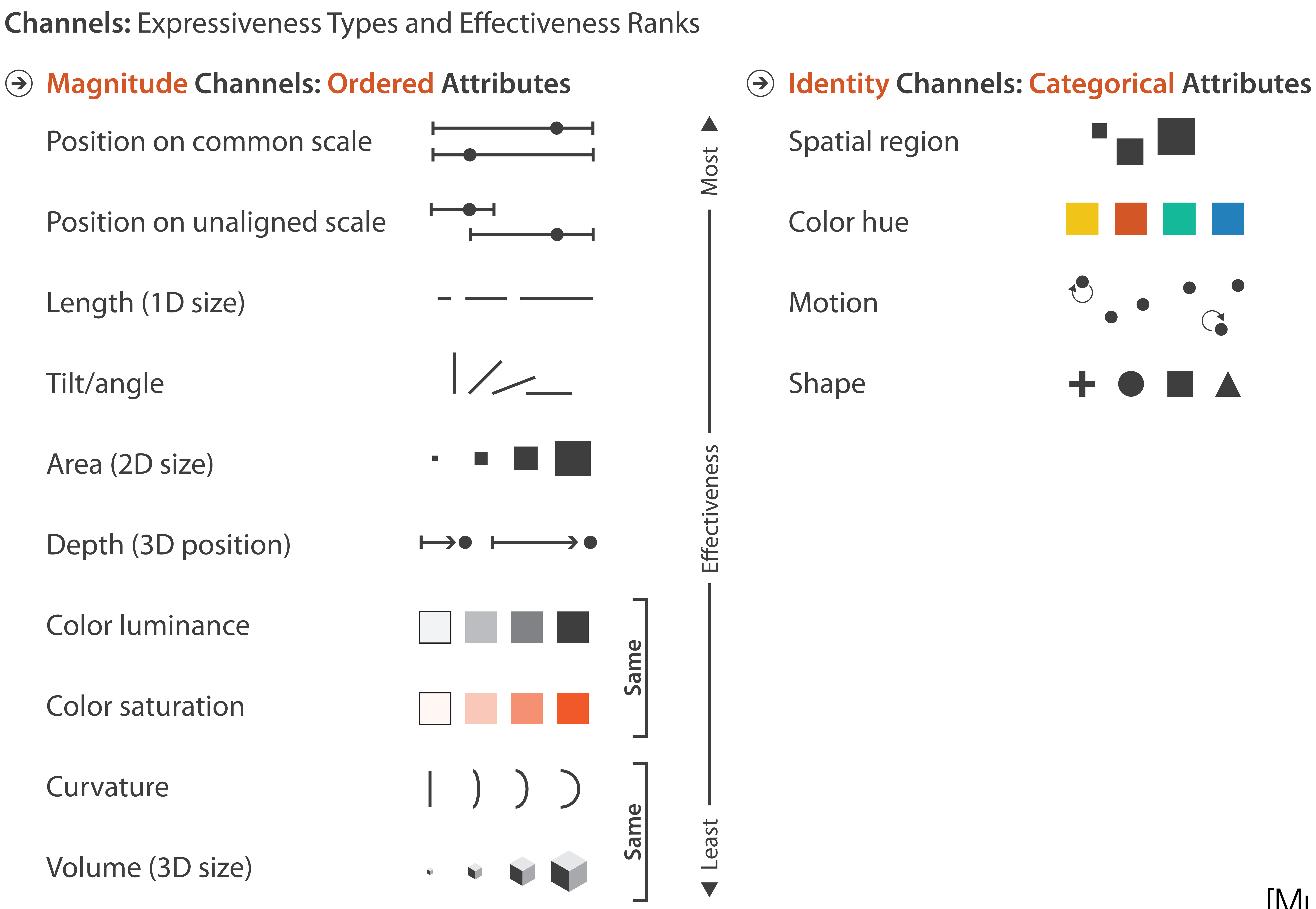
[Gapminder, Wealth & Health of Nations]

Visual Encoding

- How do we encode data visually?
  - **Marks** are the basic graphical elements in a visualization
  - **Channels** are ways to control the appearance of the marks
- Marks classified by dimensionality:

- Also can have surfaces, volumes
- Think of marks as a mathematical definition, or if familiar with tools like Adobe

Channels by Effectiveness

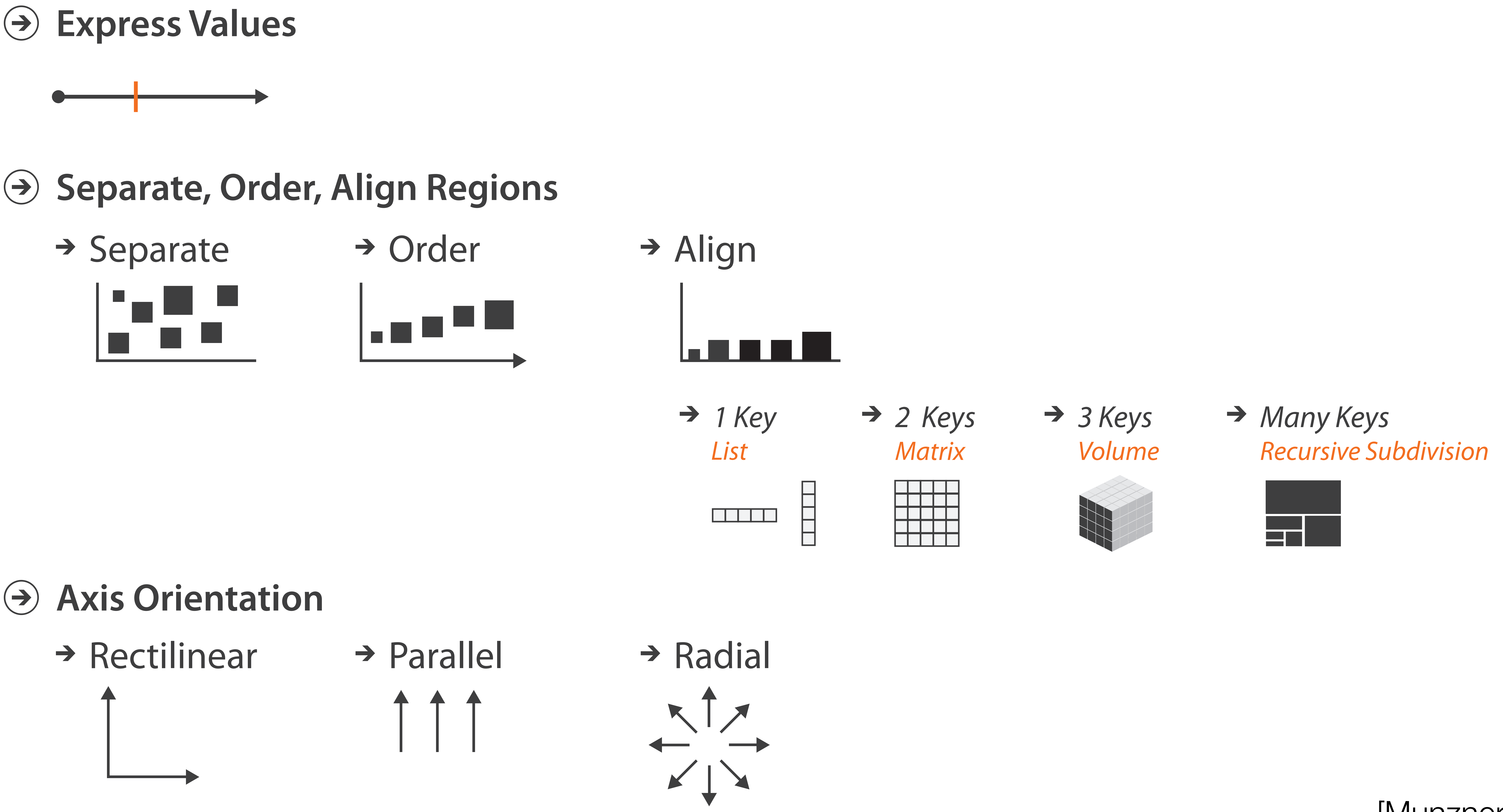


[Munzner (ill. Maguire), 2014]

D3

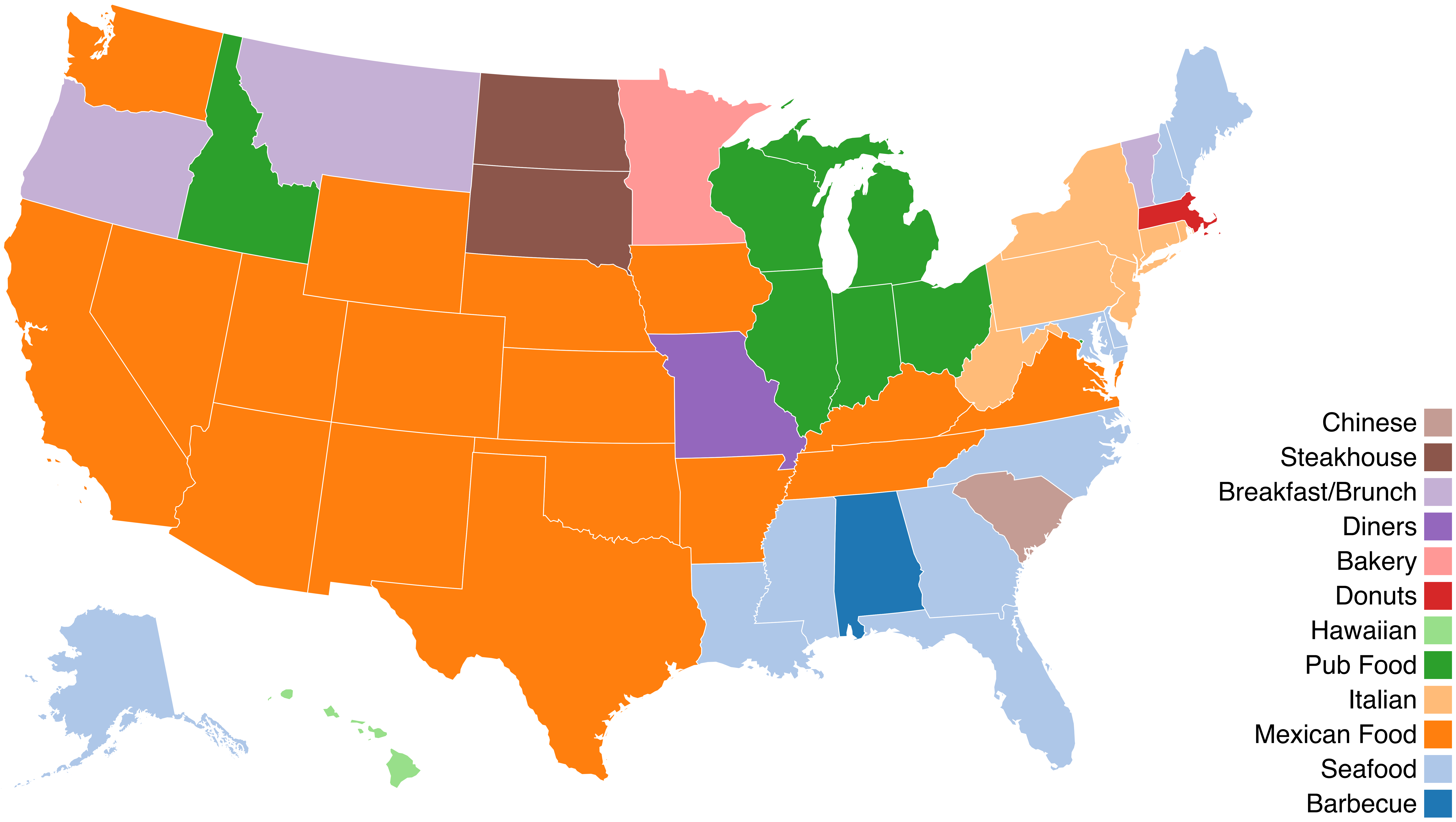
- http://d3js.org/
- Supports data as a core piece of Web elements
  - **Correspondence** between data and DOM elements
  - Dealing with changing data (joins, enter/update/exit)
  - Data drives the marks and channels
- Selections (similar to CSS) that allow greater manipulation
- Integrated layout algorithms, axes calculations, etc.
- Focus on interaction support
  - Straightforward support for transitions
  - Event handling support for user-initiated changes

Arrange Tables

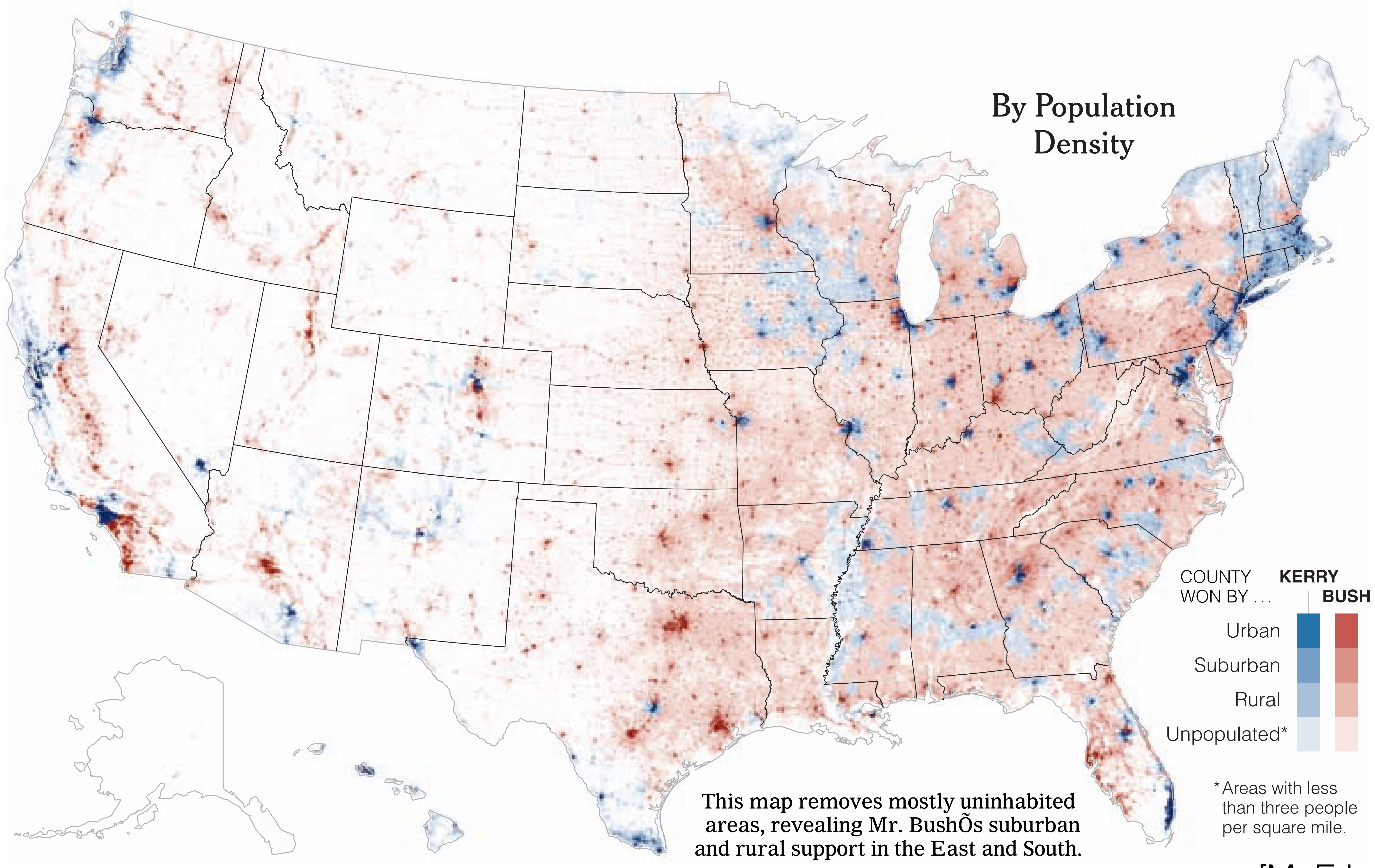


[Munzner (ill. Maguire), 2014]

Categorical Map

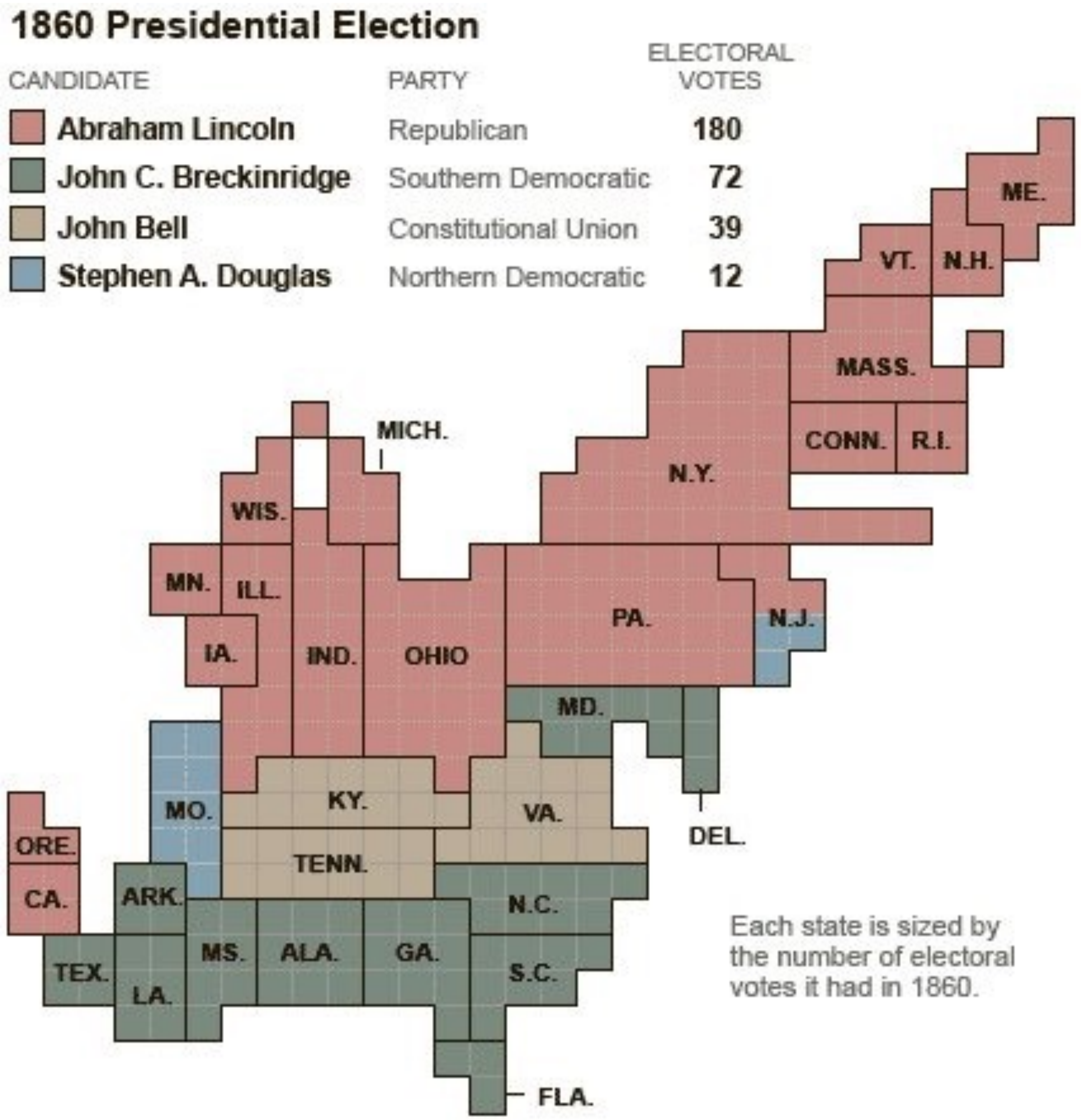


Map with Two Variables



[M. Ericson, New York Times]

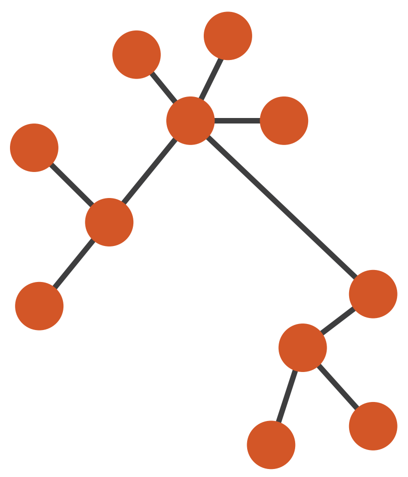
Rectangular Cartogram



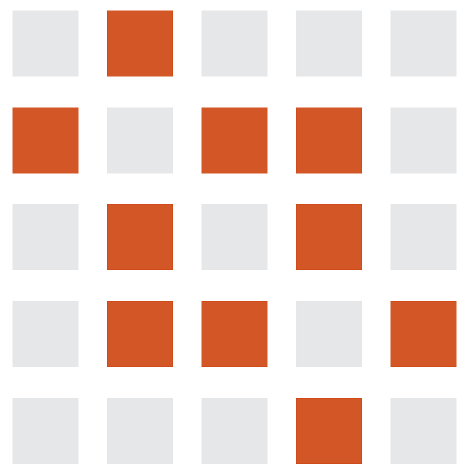
[New York Times]

Arrange Networks and Trees

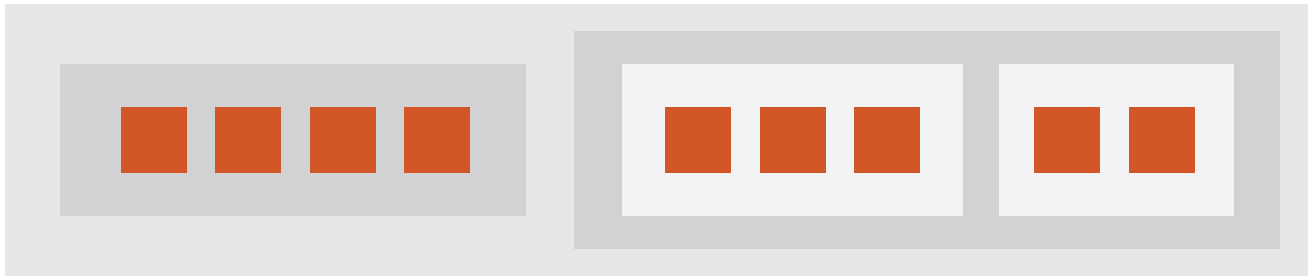
Node–Link Diagrams
Connection Marks
✔ NETWORKS ✔ TREES



Adjacency Matrix
Derived Table
✔ NETWORKS ✔ TREES

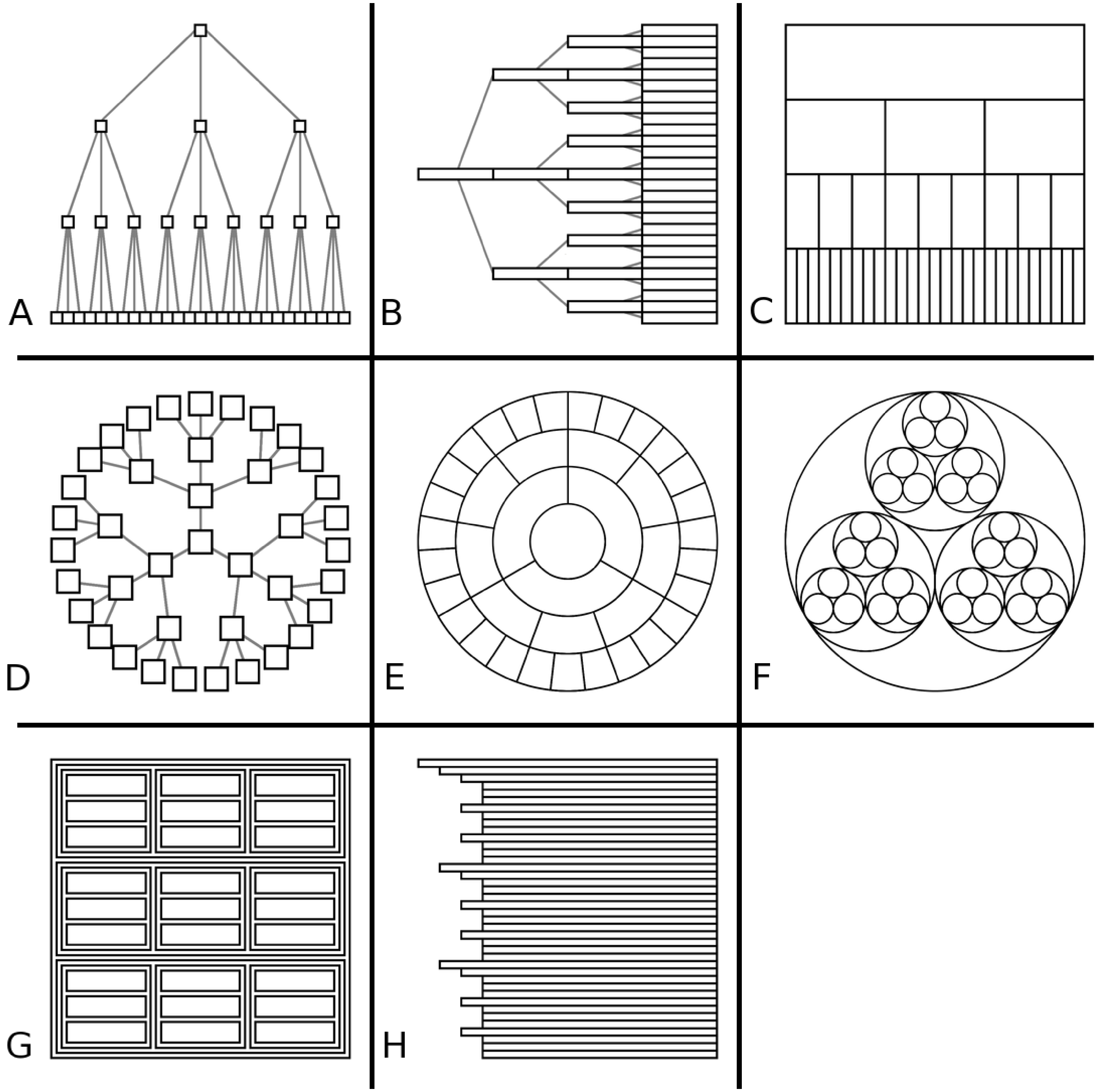


Enclosure
Containment Marks
✖ NETWORKS ✔ TREES



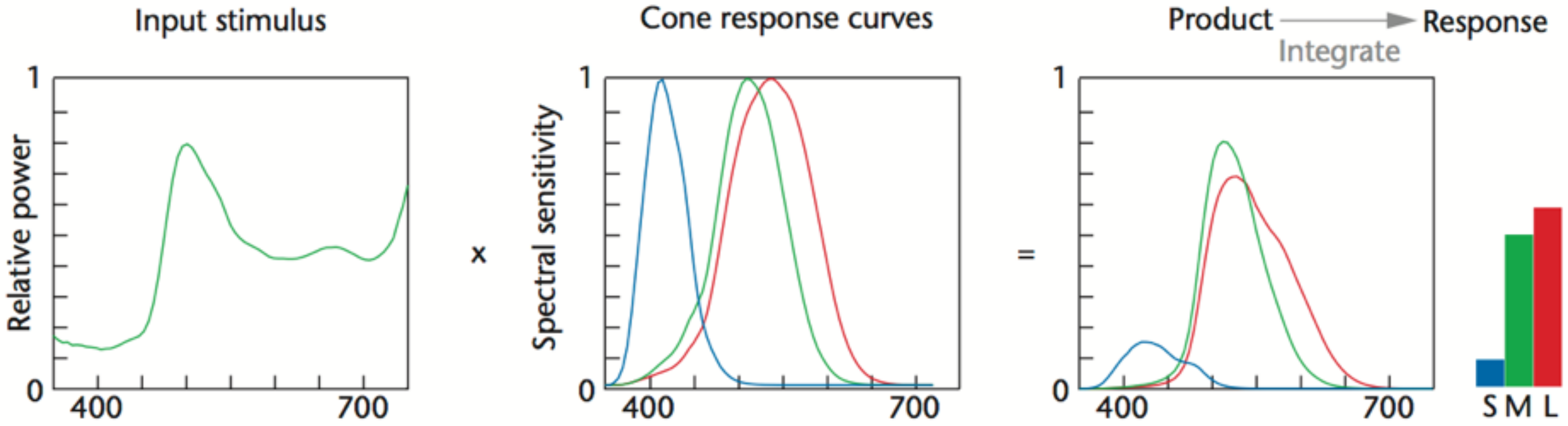
[Munzner (ill. Maguire), 2014]

Tree Visualizations



[McGuffin and Robert, 2010]

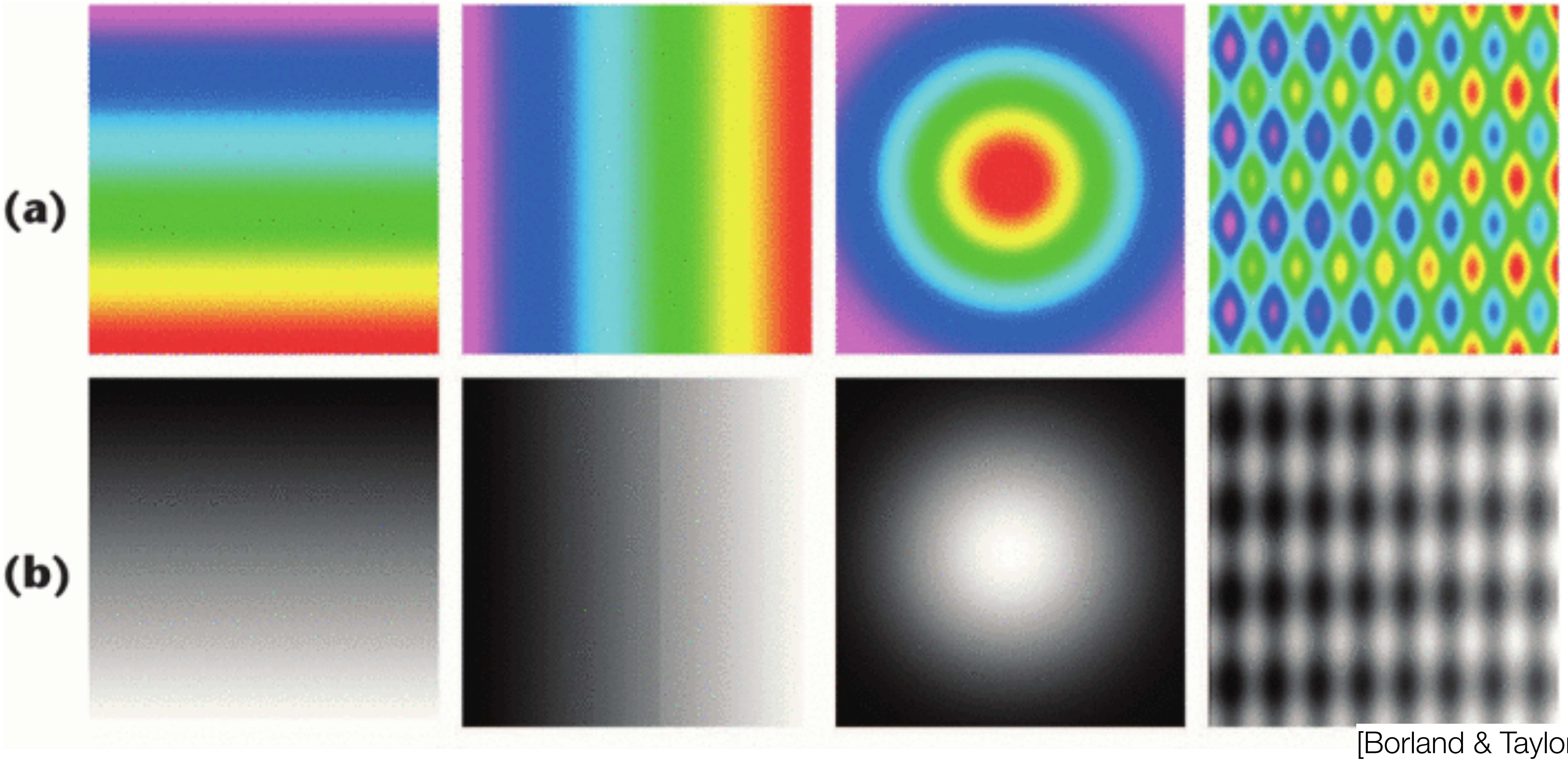
Human Color Perception



Metamerism: same three responses == same color

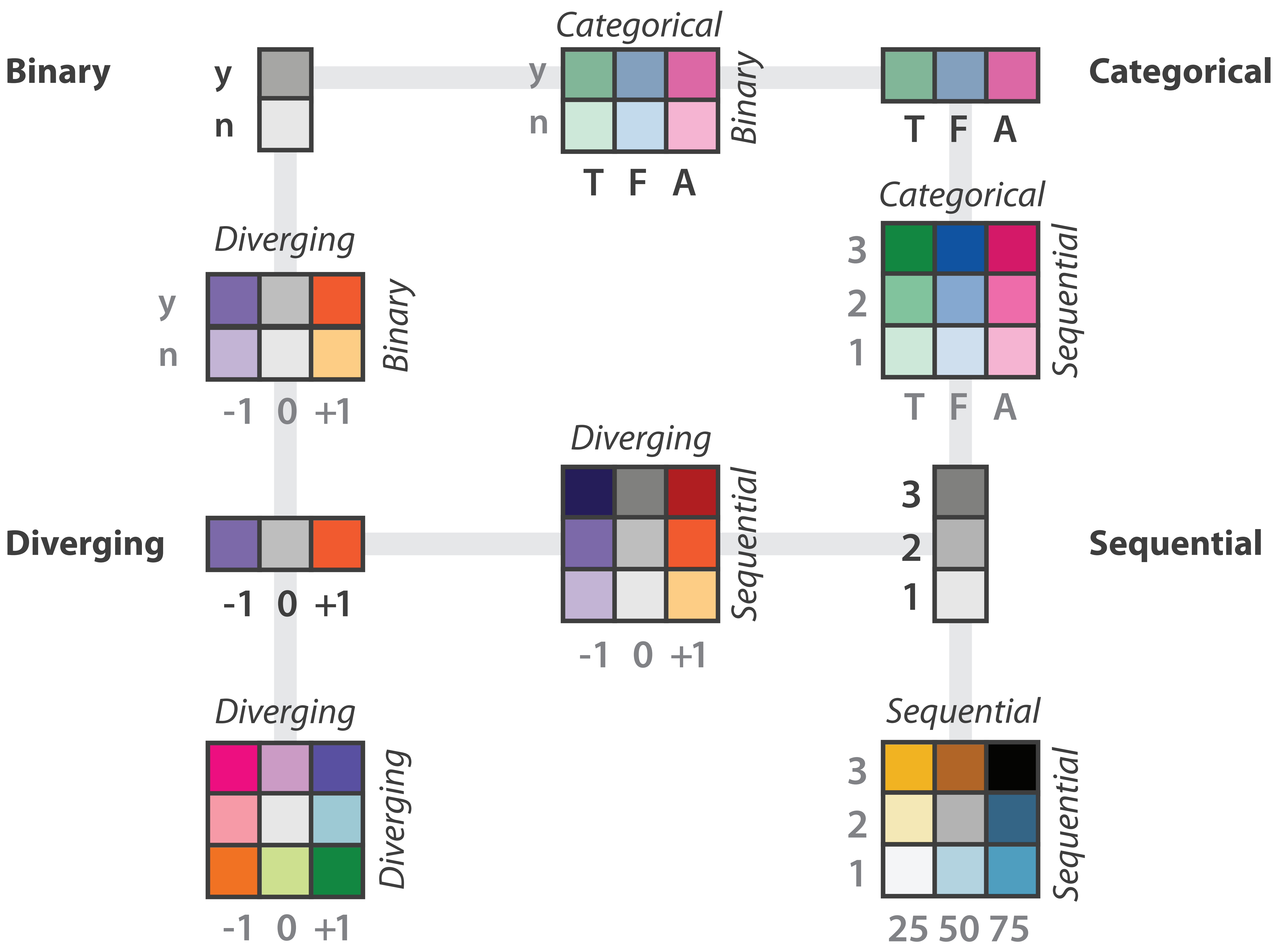
[via M. Meyer]

Avoid Rainbow Colormaps!



[Borland & Taylor, 2007]

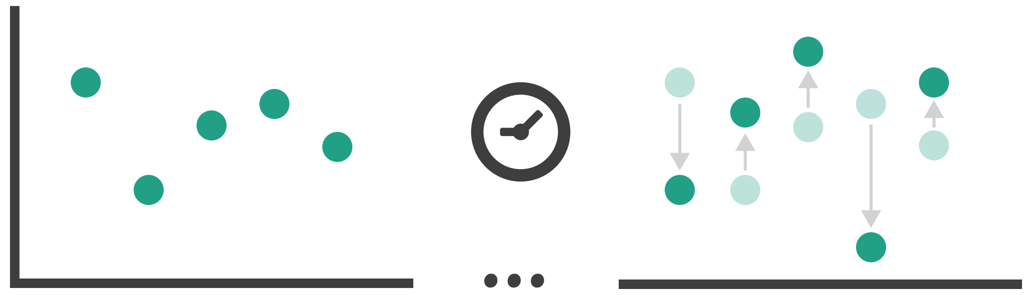
Colormaps



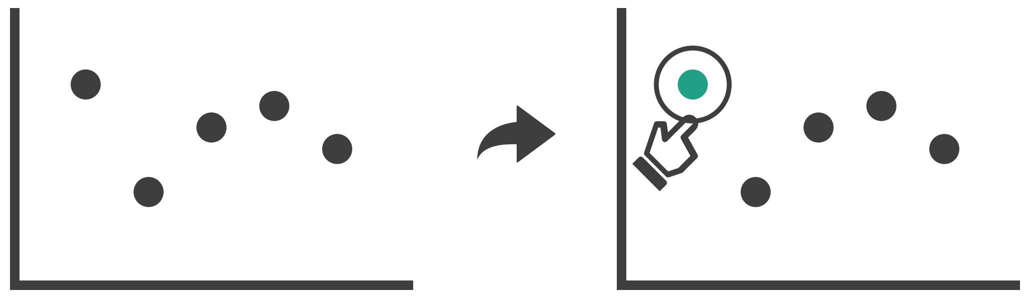
[Munzner (ill. Maguire), 2014]

Interaction Overview

➔ Change over Time



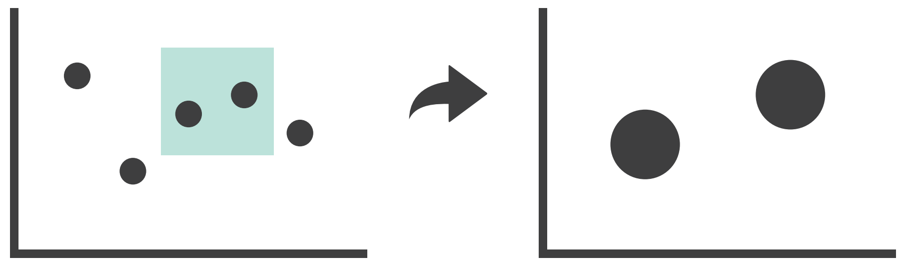
➔ Select



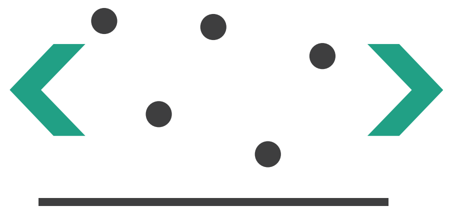
➔ Navigate

➔ Item Reduction

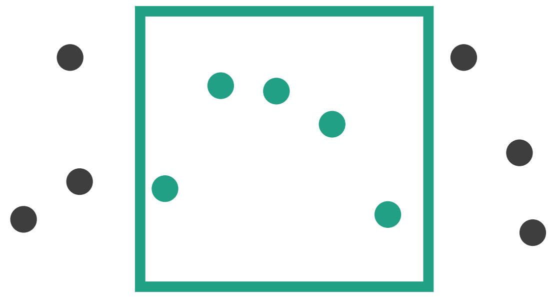
➔ *Zoom*
Geometric or *Semantic*



➔ *Pan/Translate*



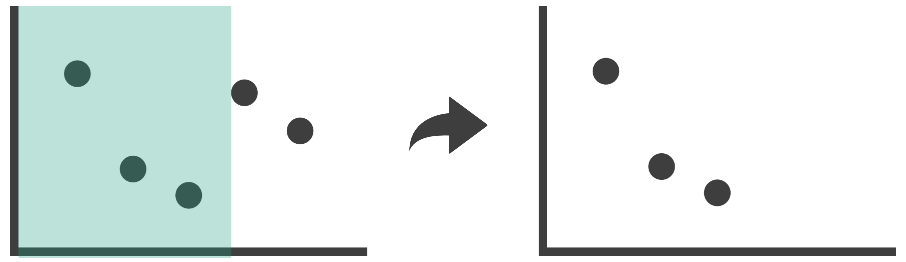
➔ *Constrained*



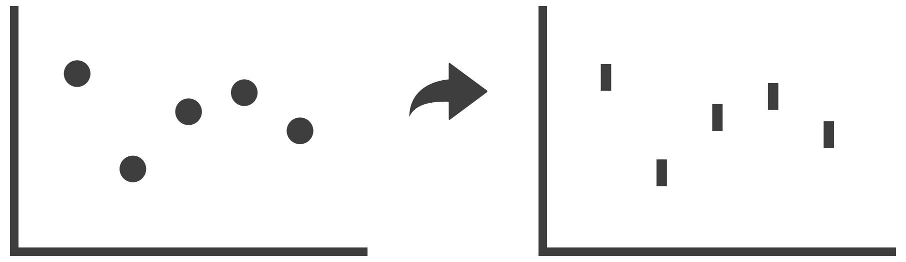
➔ Attribute Reduction

➔ *Slice*

➔ *Cut*

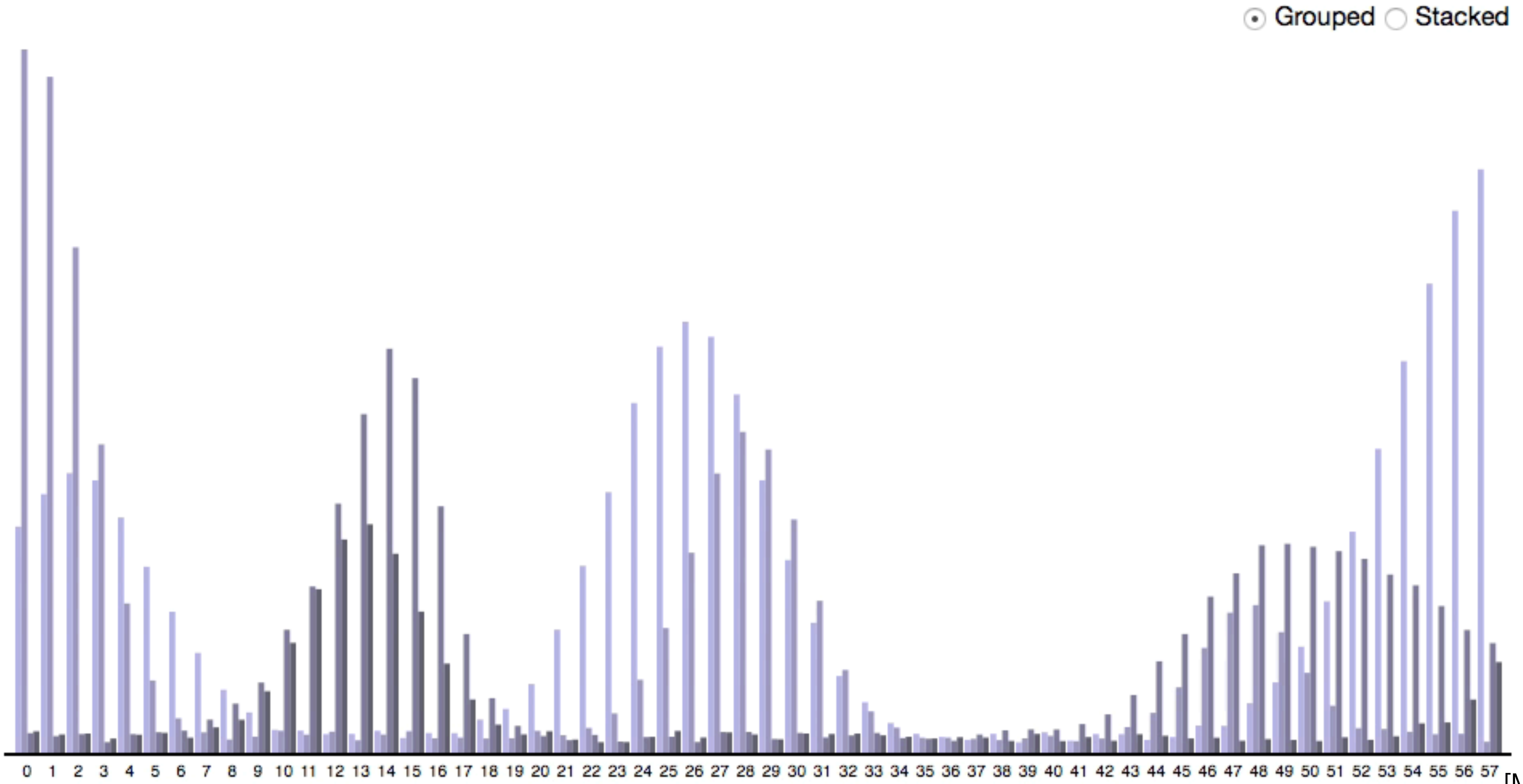


➔ *Project*



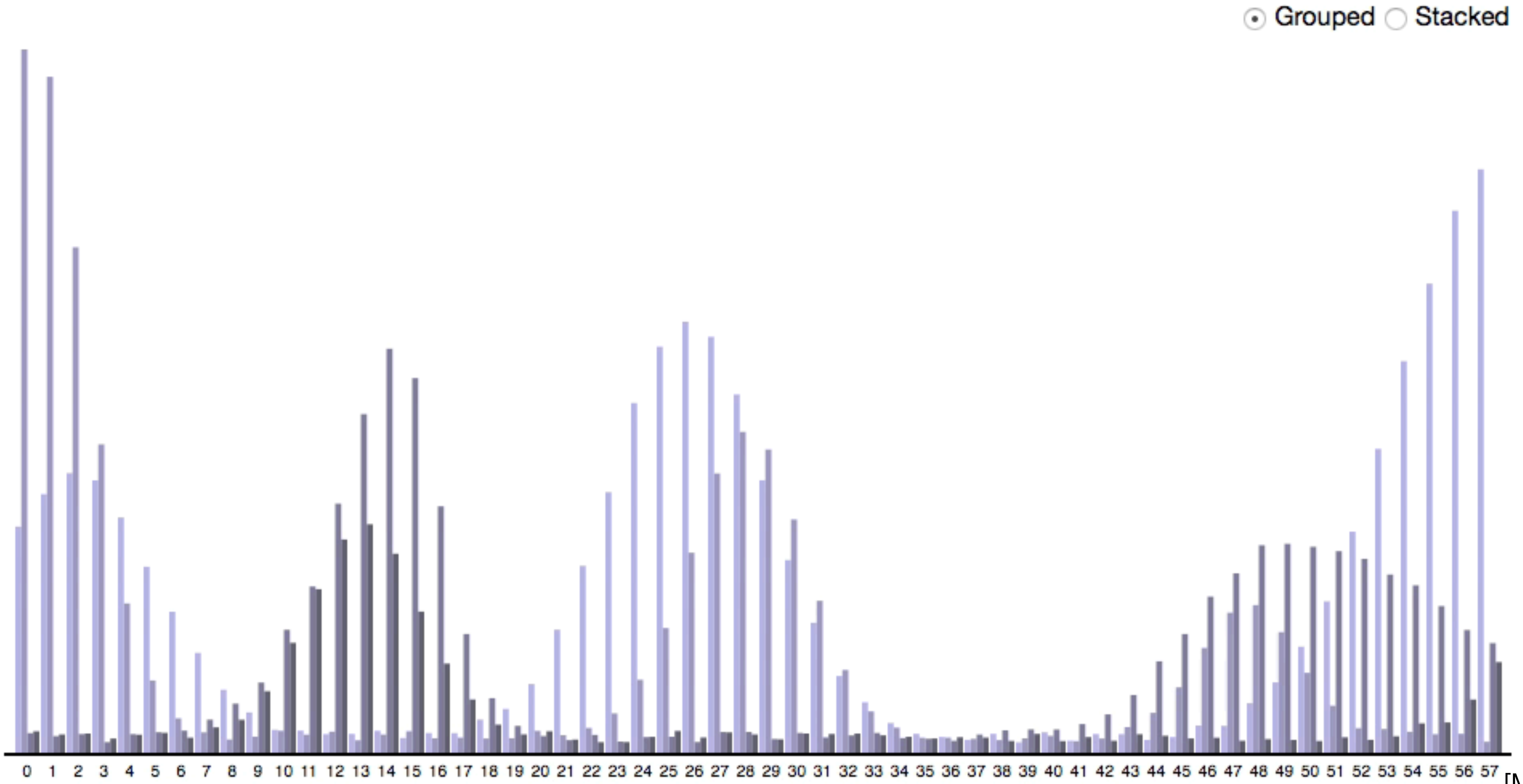
[Munzner (ill. Maguire), 2014]

Staged Animated Transitions



[M. Bostock]

Staged Animated Transitions



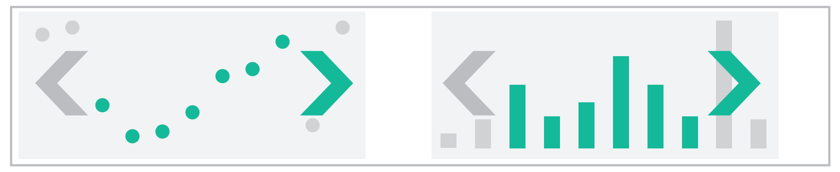
[M. Bostock]

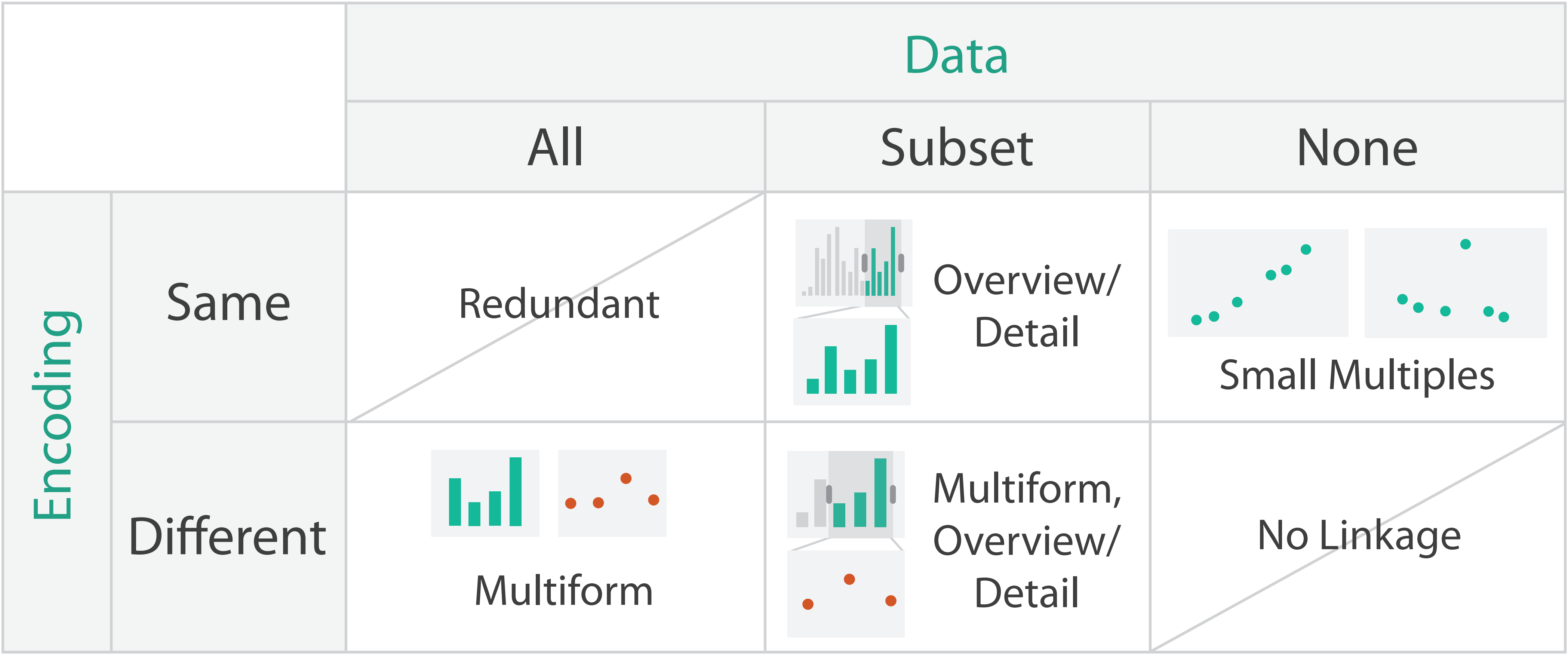
Multiple Views

- **Juxtapose and Coordinate Multiple Side-by-Side Views**
  - Share Encoding: Same/Different
    - *Linked Highlighting*

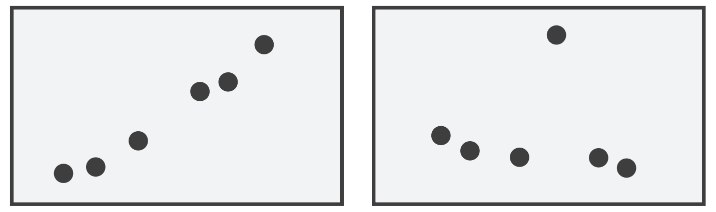
  - Share Data: All/Subset/None

  - Share Navigation

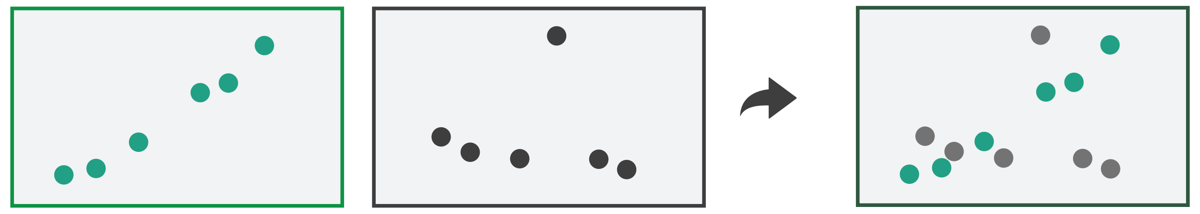




- **Partition into Side-by-Side Views**

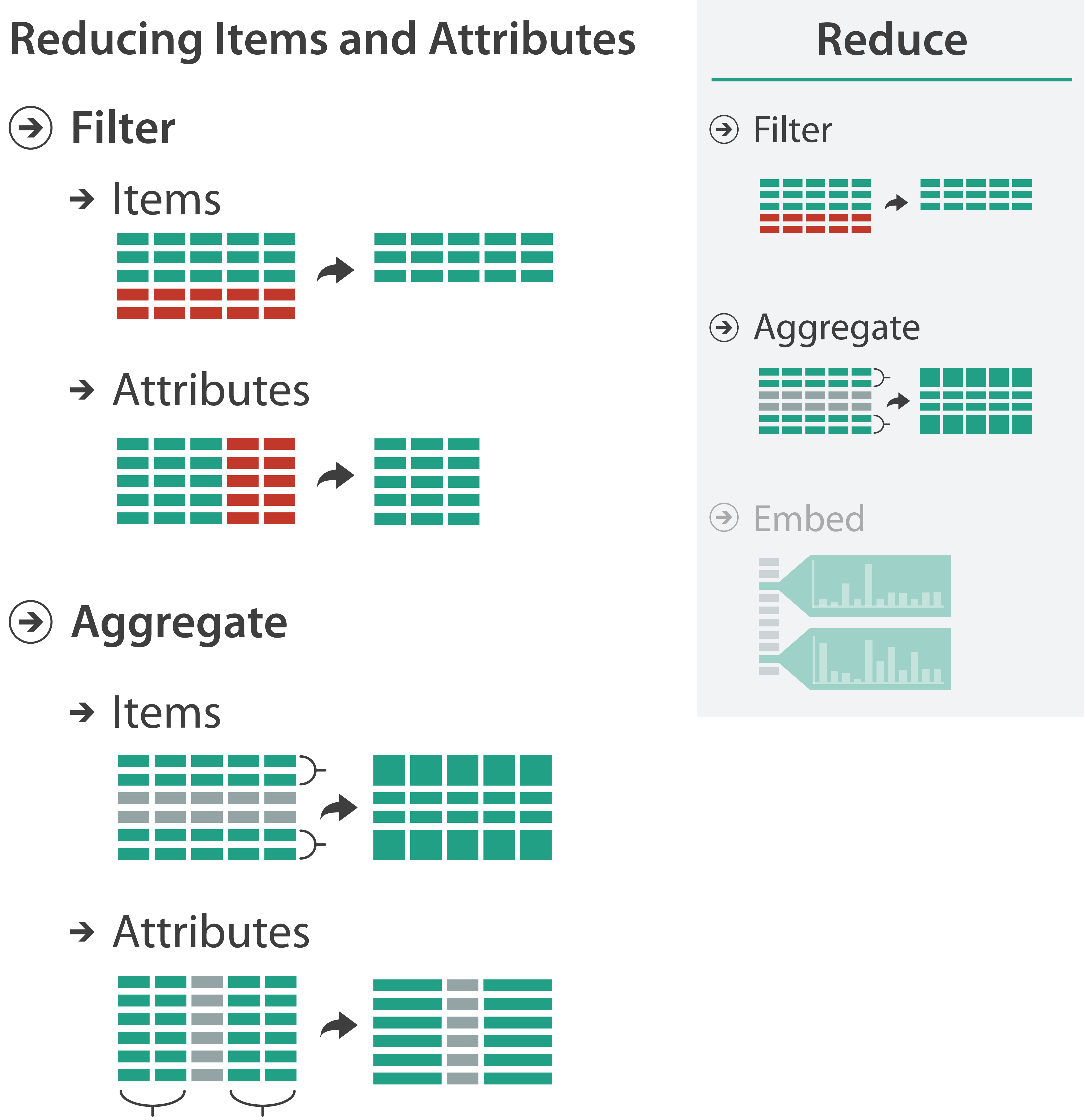


- **Superimpose Layers**



[Munzner (ill. Maguire), 2014]

Filtering and Aggregation



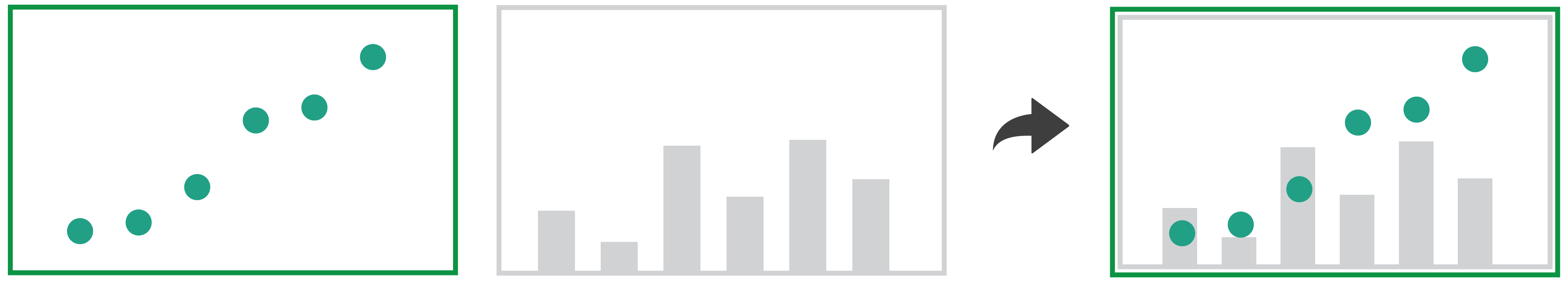
[Munzner (ill. Maguire), 2014]

Focus+Content

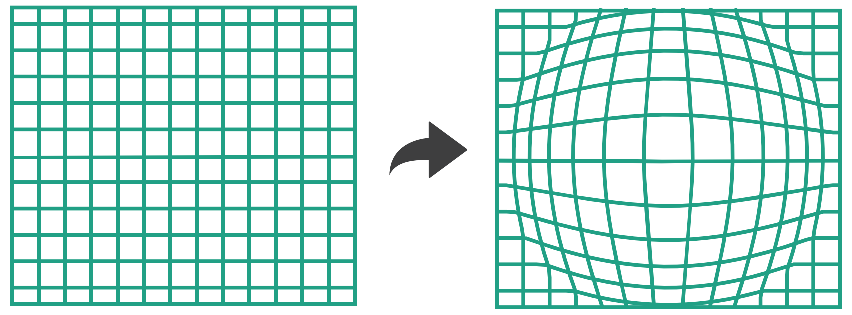
Embed

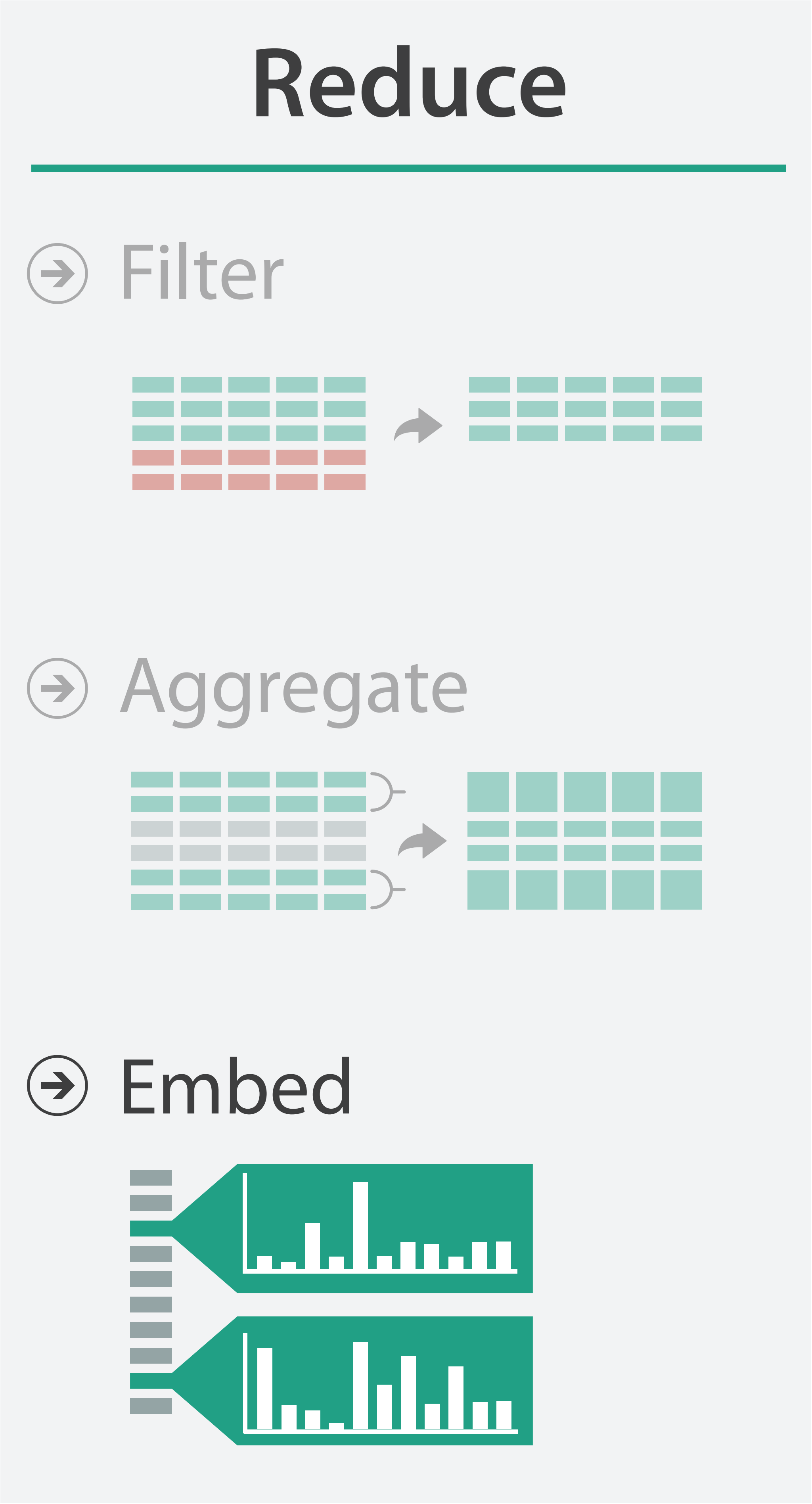
- Elide Data

- Superimpose Layer



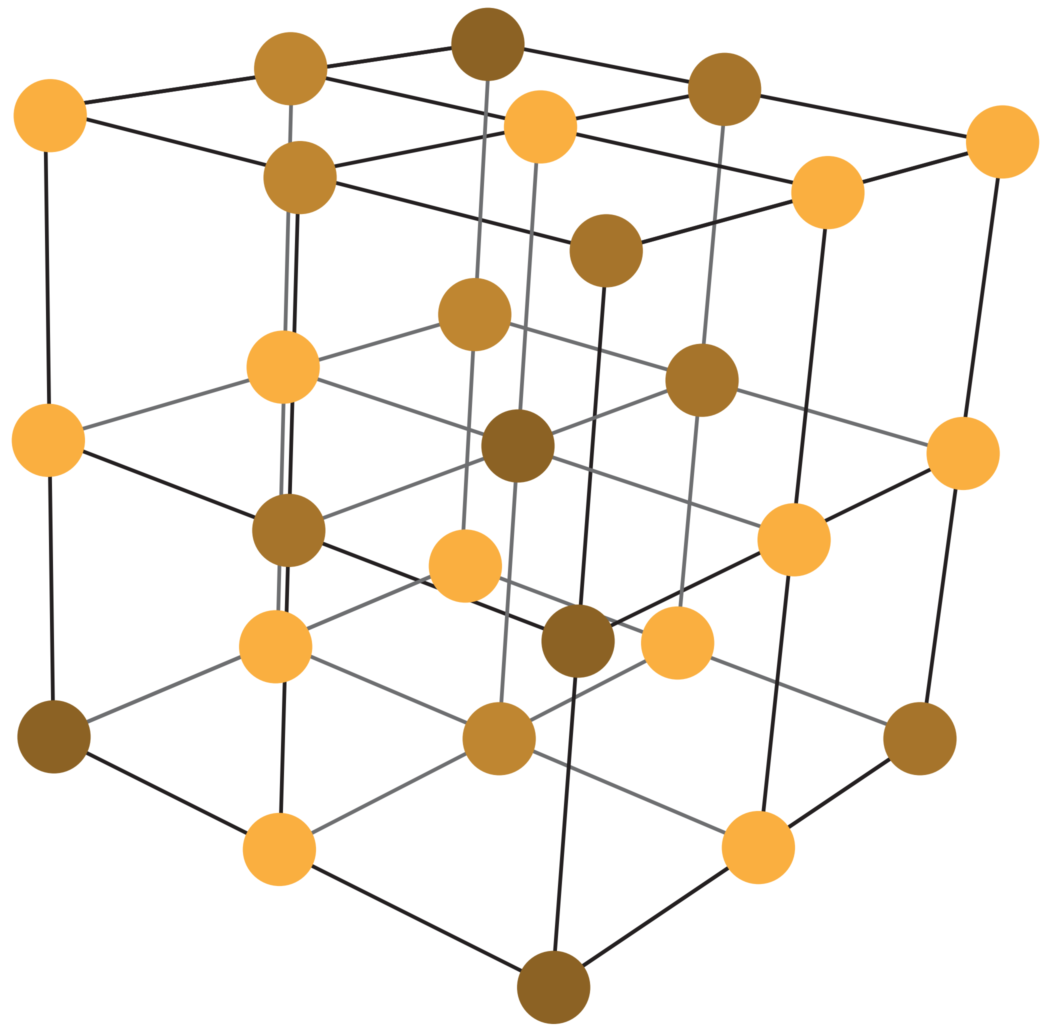
- Distort Geometry



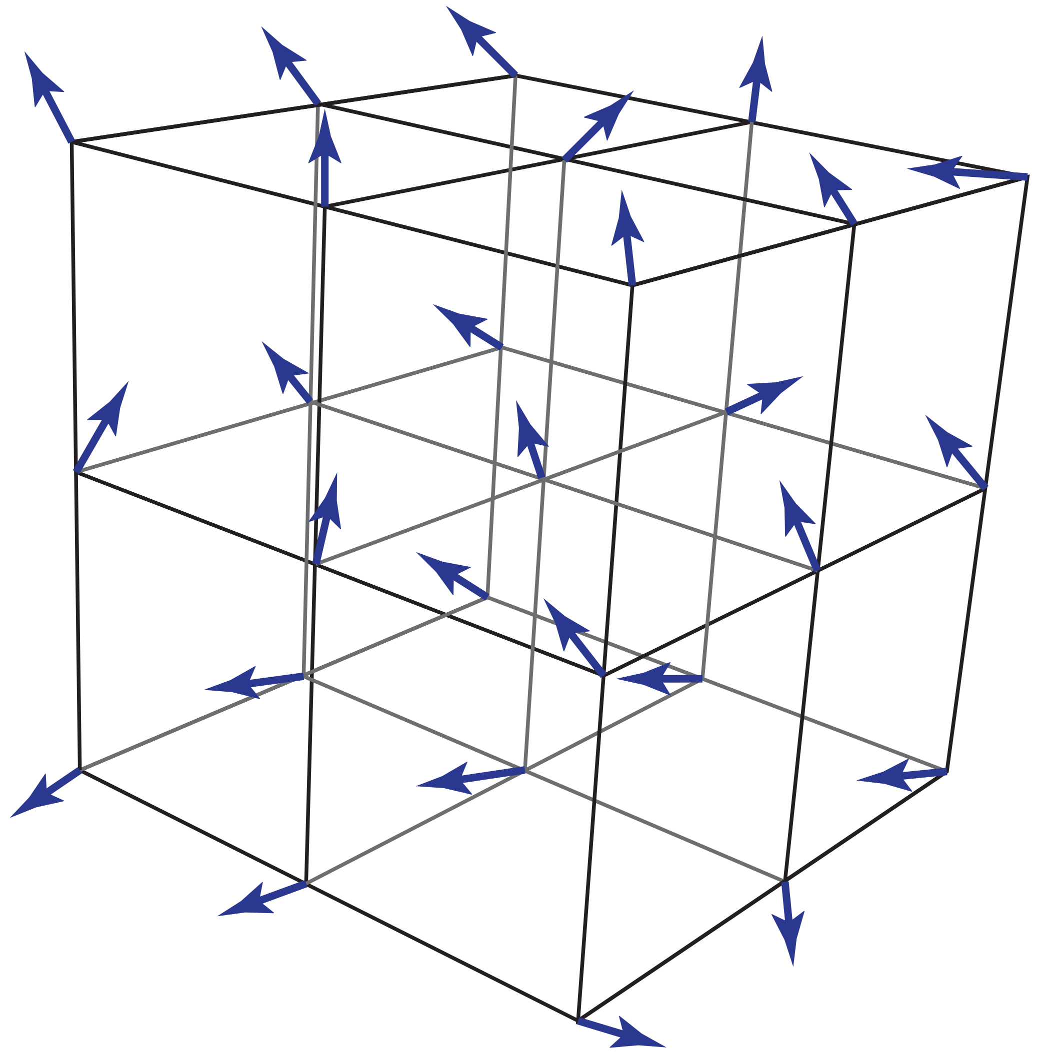


[Munzner (ill. Maguire), 2014]

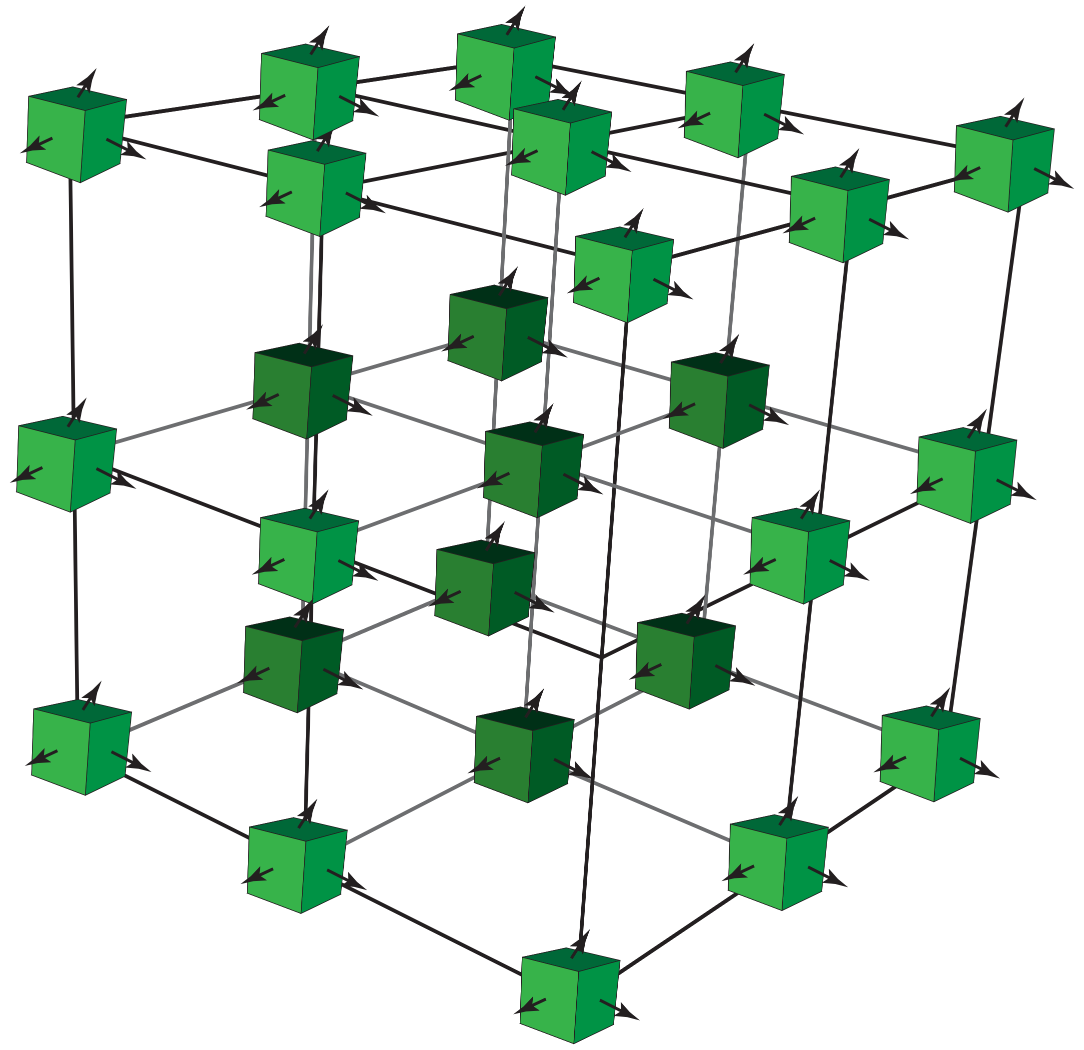
Fields in Visualization



Scalar Fields



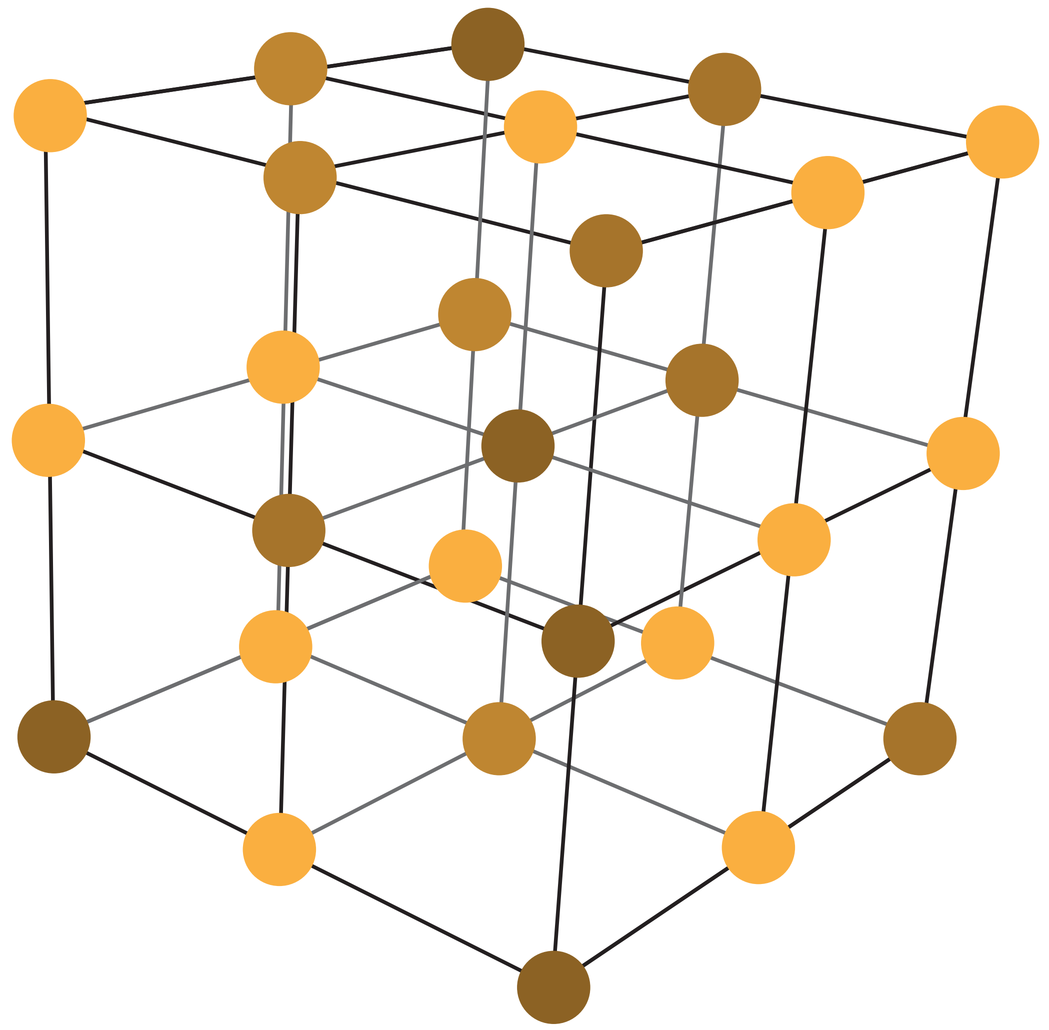
Vector Fields



Tensor Fields

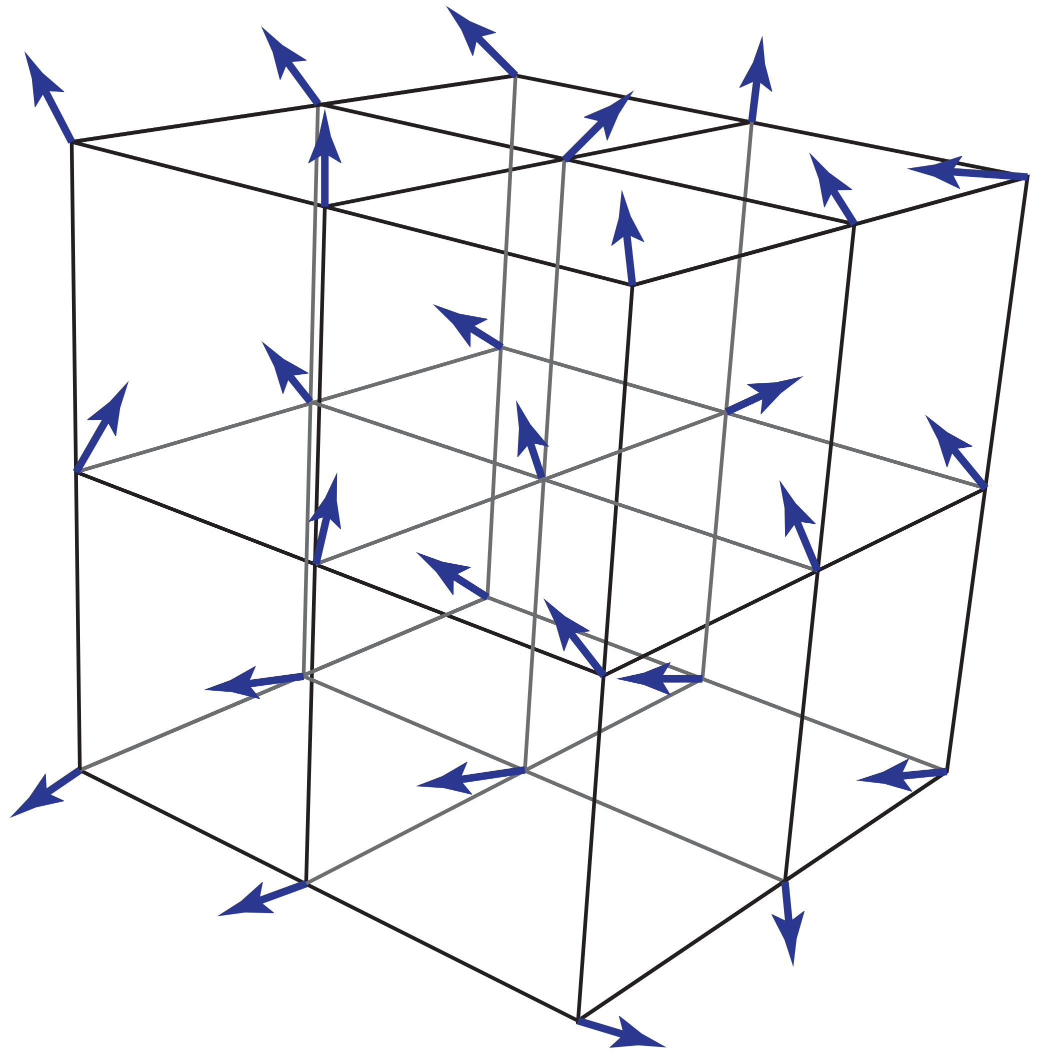
Each point in space has an associated...

Fields in Visualization



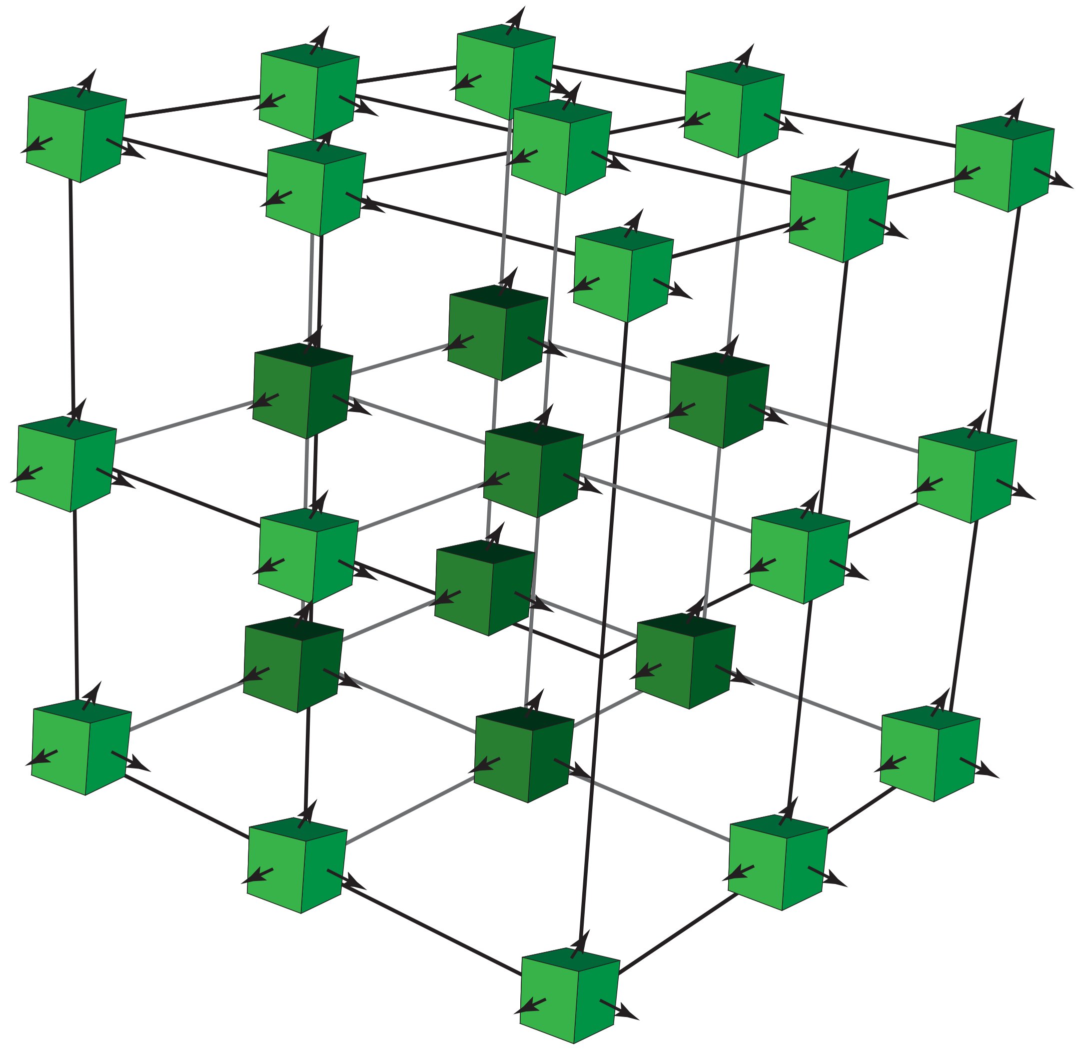
Scalar Fields

(Order-0 Tensor Fields)



Vector Fields

(Order-1 Tensor Fields)



Tensor Fields

(Order-2+)

Each point in space has an associated...

$$s_0$$

Scalar

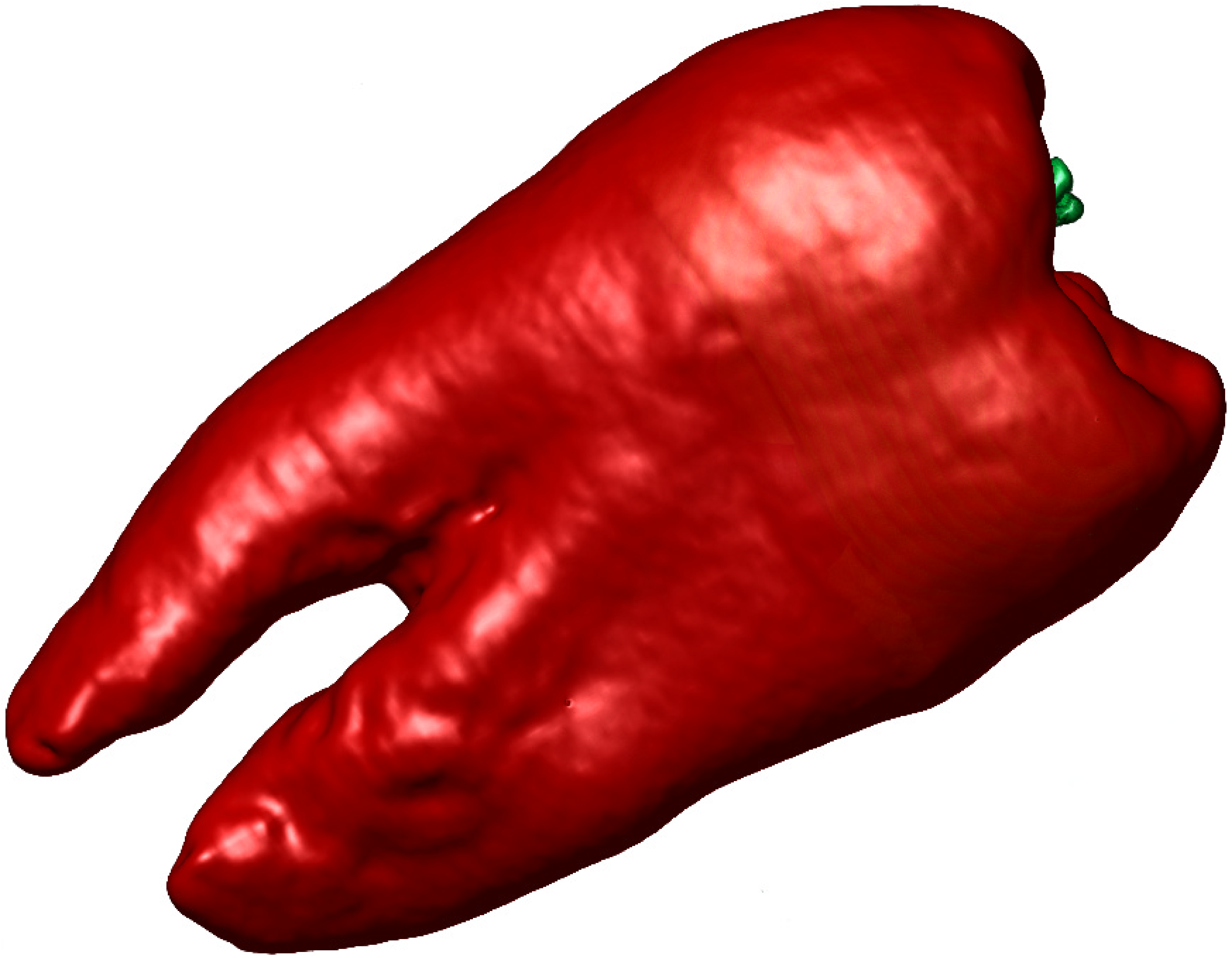
$$\begin{bmatrix} v_0 \\ v_1 \\ v_2 \end{bmatrix}$$

Vector

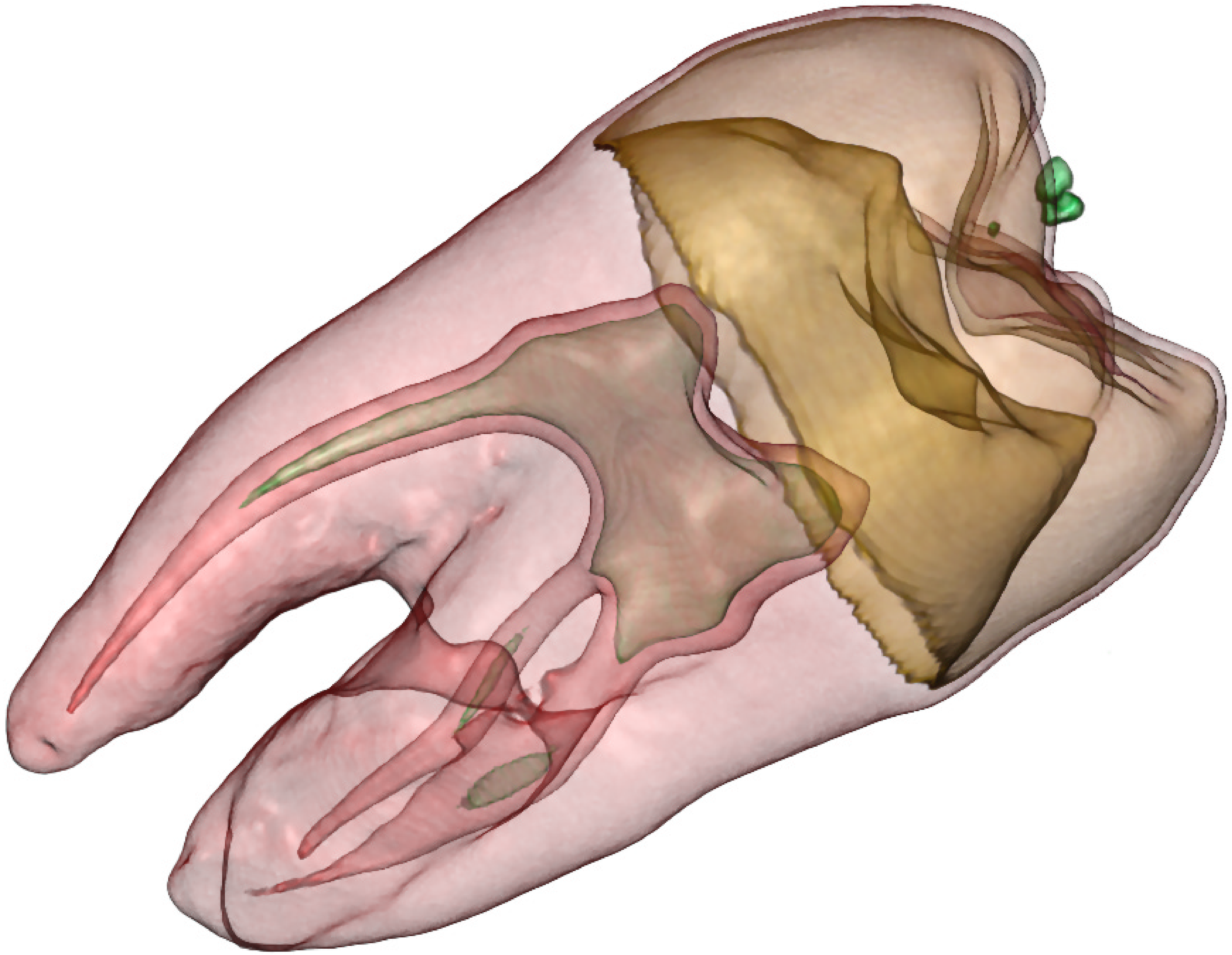
$$\begin{bmatrix} \sigma_{00} & \sigma_{01} & \sigma_{02} \\ \sigma_{10} & \sigma_{11} & \sigma_{12} \\ \sigma_{20} & \sigma_{21} & \sigma_{22} \end{bmatrix}$$

Tensor

Isosurfacing



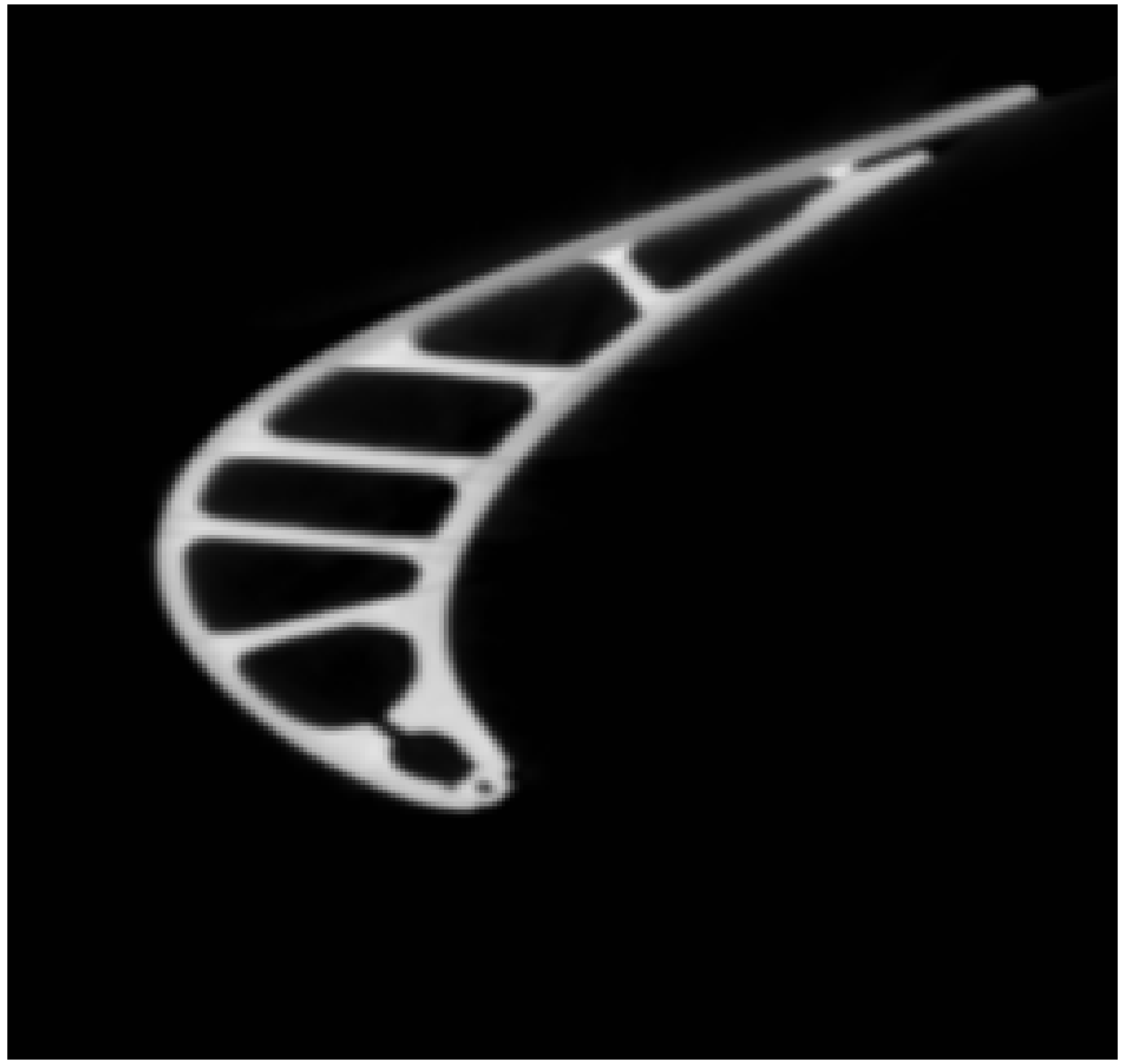
(a) An isosurfaced tooth.

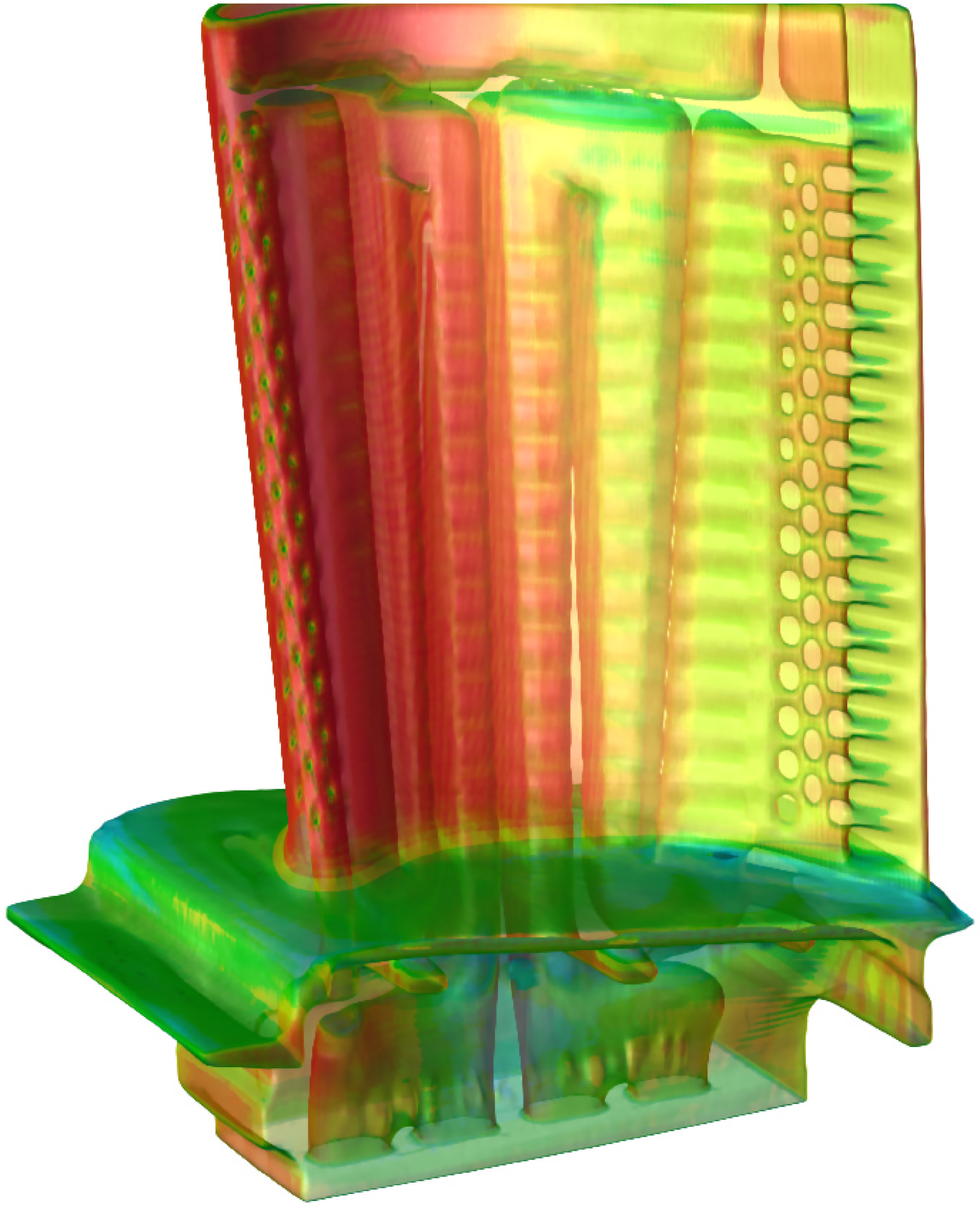


(b) Multiple isosurfaces.

[J. Kniss, 2002]

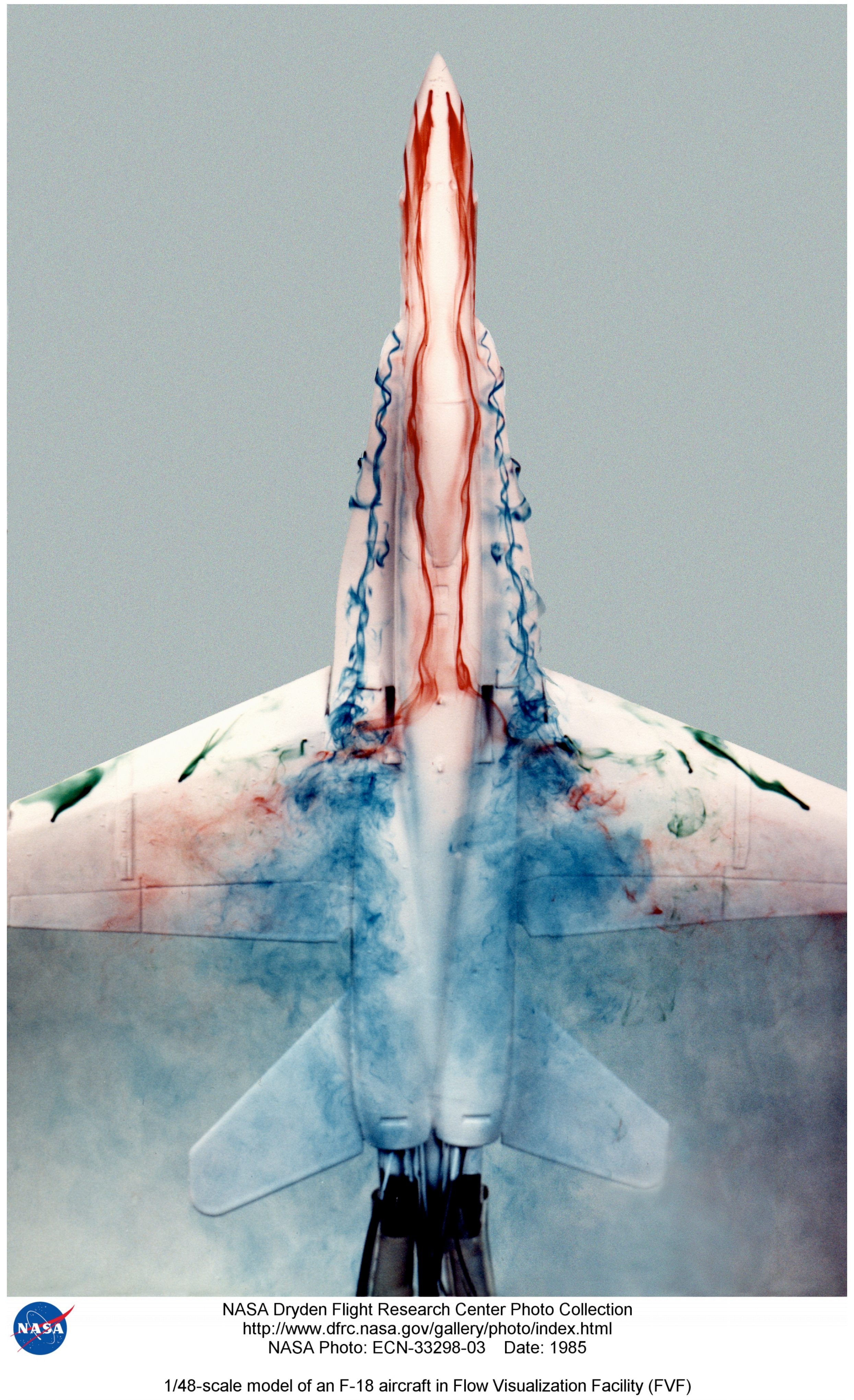
Volume Rendering



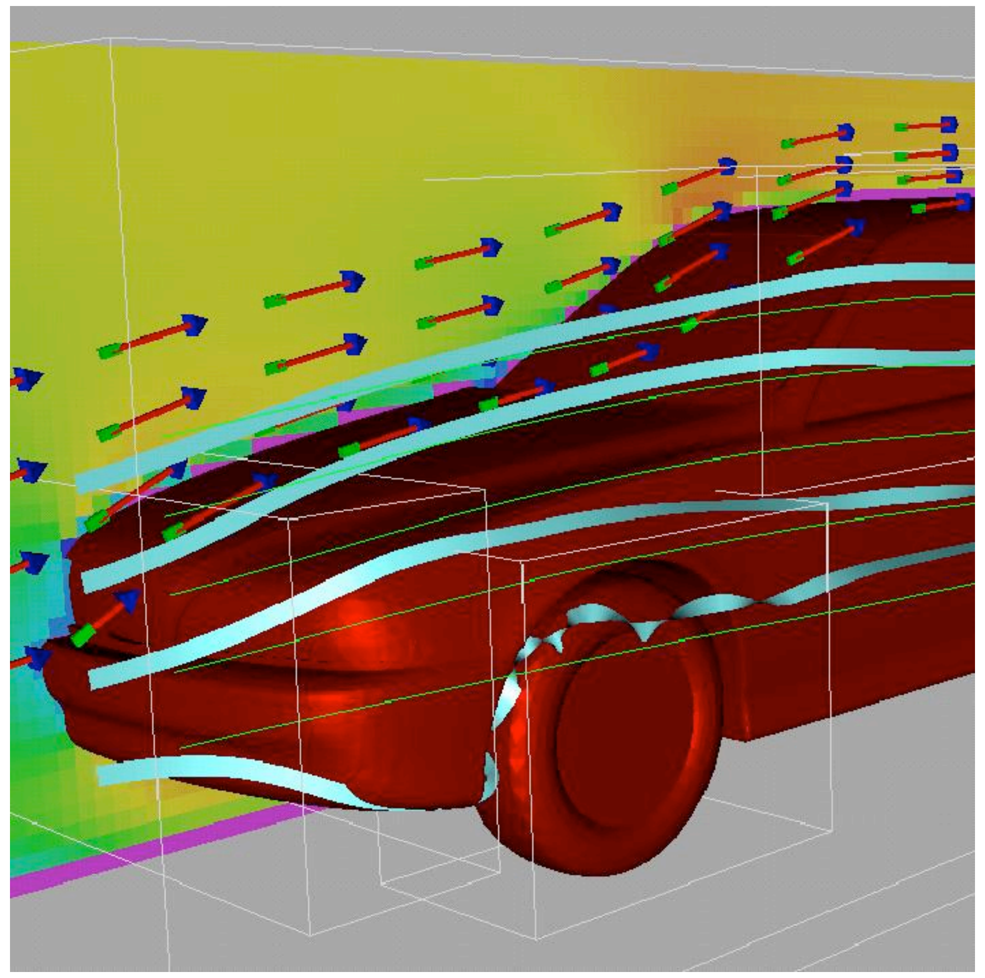


[J. Kniss, 2002]

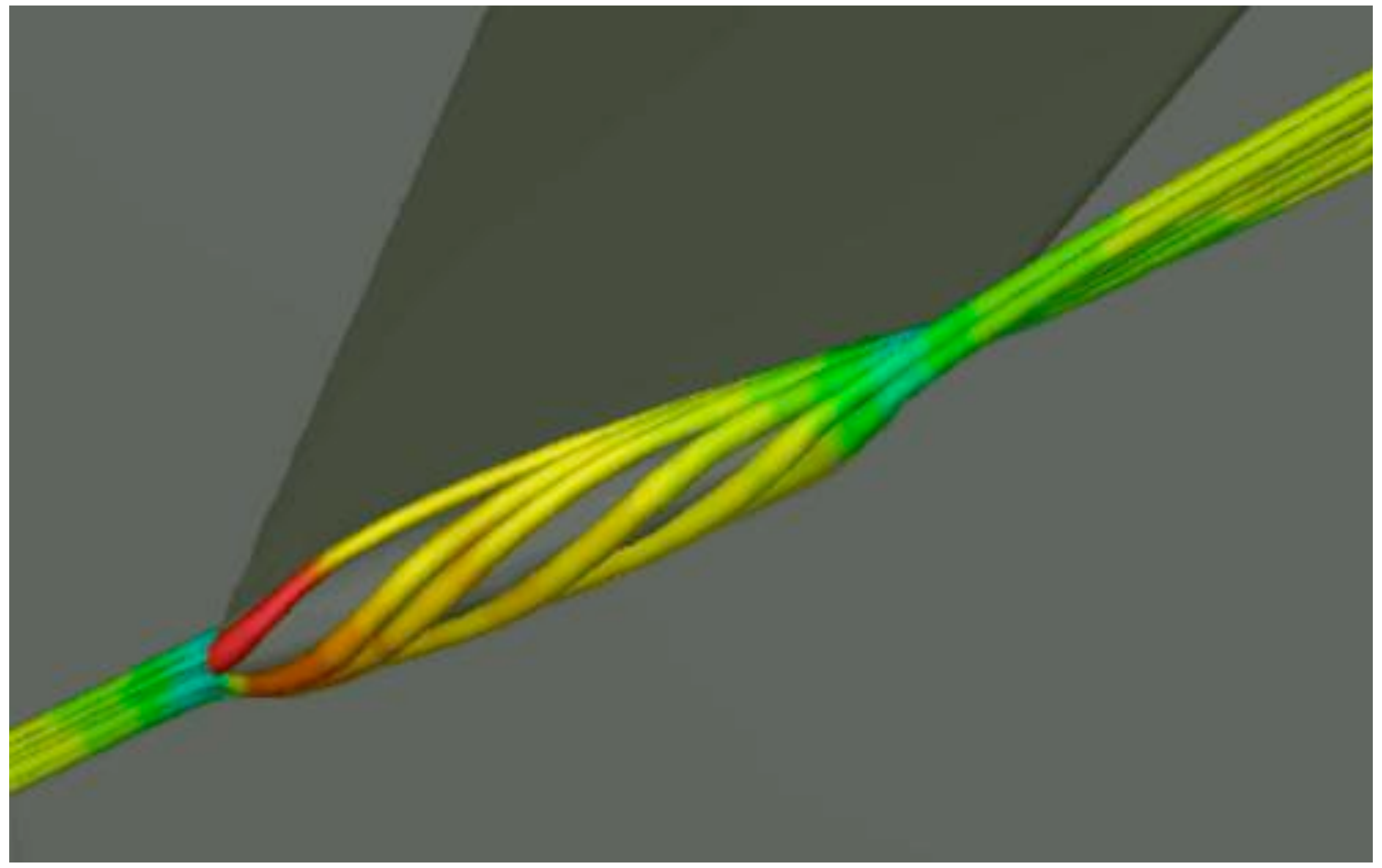
Vector Fields



Streaklines [NASA]



Stream Ribbons [Weiskopf/Machiraju/Möller]



Stream Tubes [Weiskopf/Machiraju/Möller]

The purpose of computing is about insight, not numbers

– R. W. Hamming

The purpose of **visualization** is about insight, not **pictures**

– Card, Mackinlay, Schneiderman

Projects Thursday