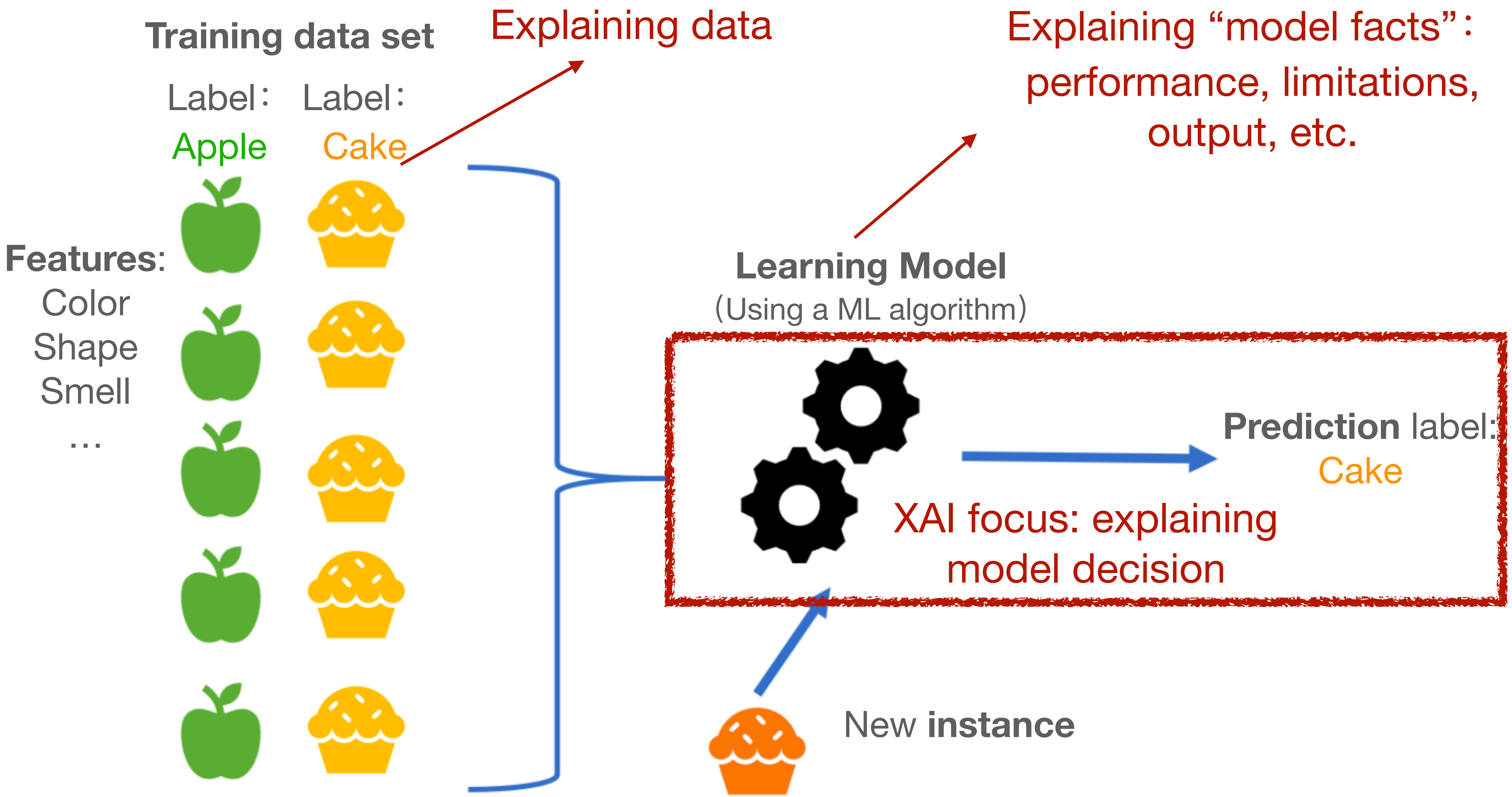
Information Visualization

Multiple Views

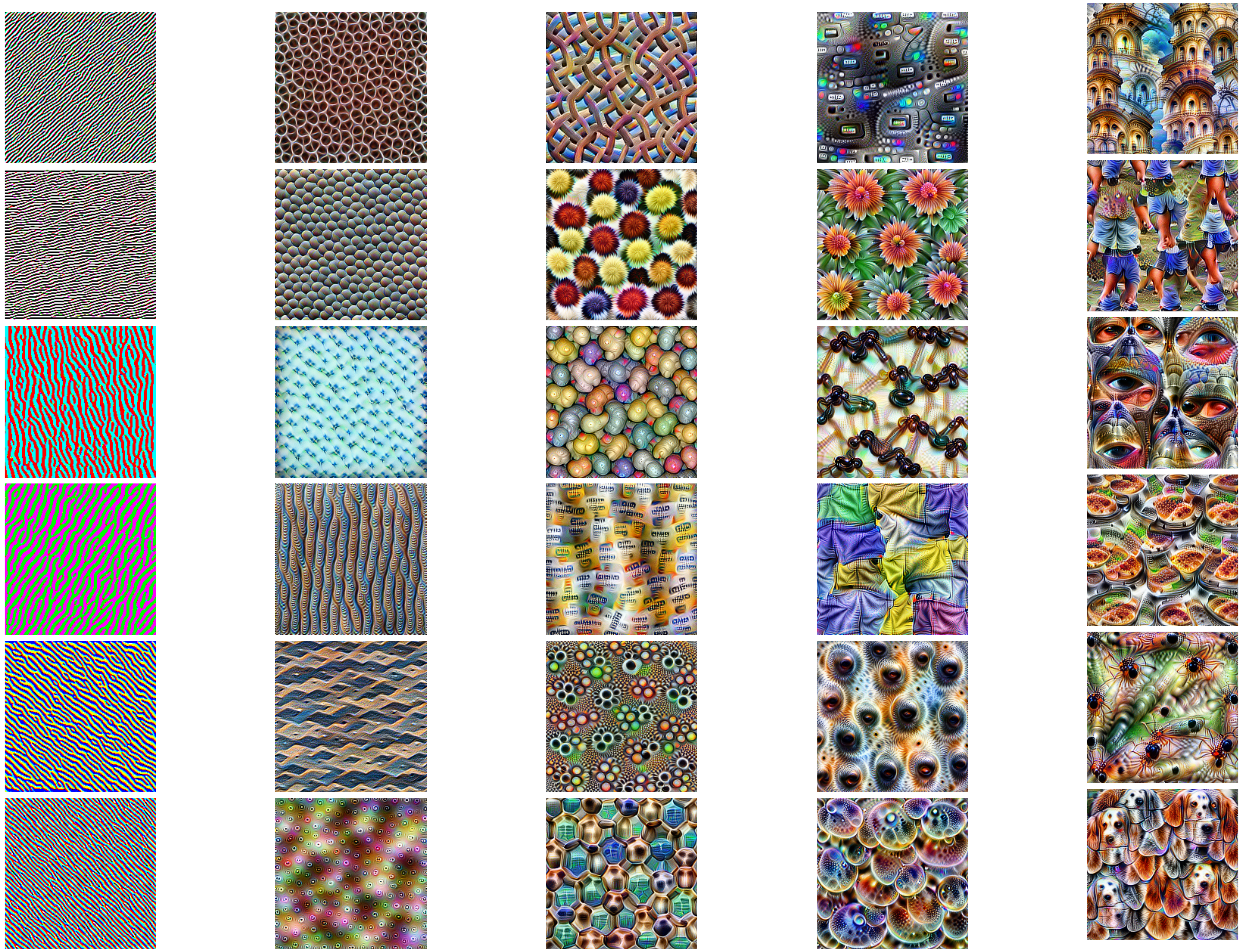
Dr. David Koop

eXplainable Artificial Intelligence



[Liao et al.]

Feature Visualization

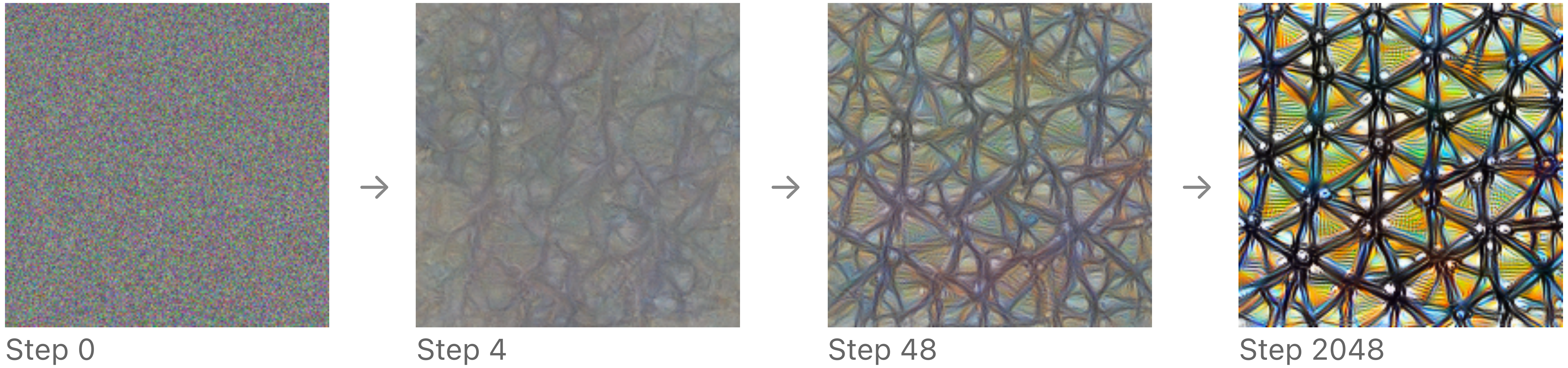


Edges (layer conv2d0) **Textures** (layer mixed3a) **Patterns** (layer mixed4a) **Parts** (layers mixed4b & mixed4c) **Objects** (layers mixed4d & mixed4e)

[C. Olah et al., 2017]

Feature Vis by Optimization

- "[W]hat kind of input would cause a certain behavior"
- Start from random noise and iteratively tweak (using derivatives)



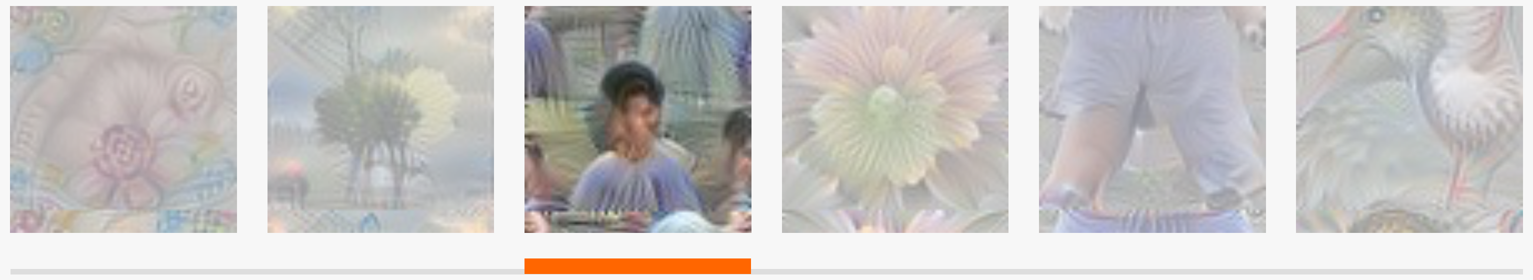
- What are the objectives? (Where are we going?)
  - Neuron, channel, layer (has DeepDream "interesting" objective

[C. Olah et al., 2017]

Naive Optimization Doesn't Work

Even if you carefully tune learning rate, you'll get noise.

Optimization results are enlarged to show detail and artifacts.



Learning Rate (0.05)

REPRODUCE IN A CO NOTEBOOK

Step 1 Step 32 Step 128 Step 256 Step 2048

[C. Olah et al., 2017]

The Building Blocks of Interpretability

The Building Blocks of Interpretability

Interpretability techniques are normally studied in isolation.
We explore the powerful interfaces that arise when you combine them—
and the rich structure of this combinatorial space.

CHOOSE AN INPUT IMAGE

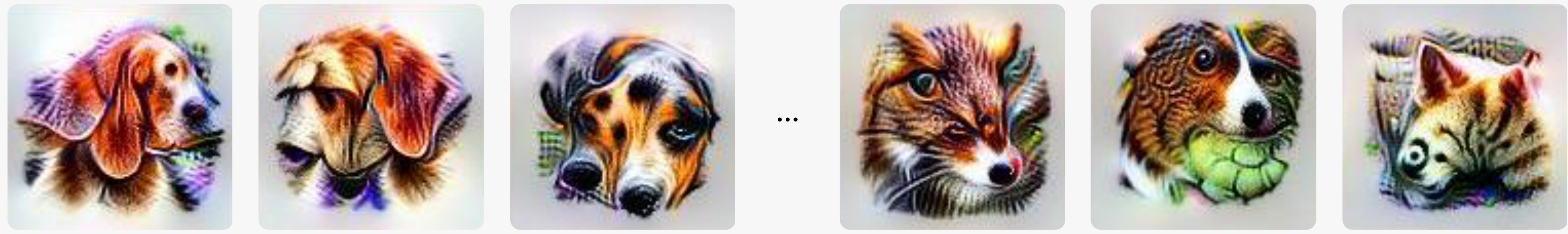
For instance, by combining feature visualization (*what is a neuron looking for?*) with attribution (*how does it affect the output?*), we can explore how the network decides between labels like **Labrador retriever** and **tiger cat**.

Several floppy ear detectors seem to be important when distinguishing dogs, whereas pointy ears are used to classify "tiger cat".

CHANNELS THAT MOST SUPPORT ... LABRADOR RETRIEVER | TIGER CAT

feature visualization of channel

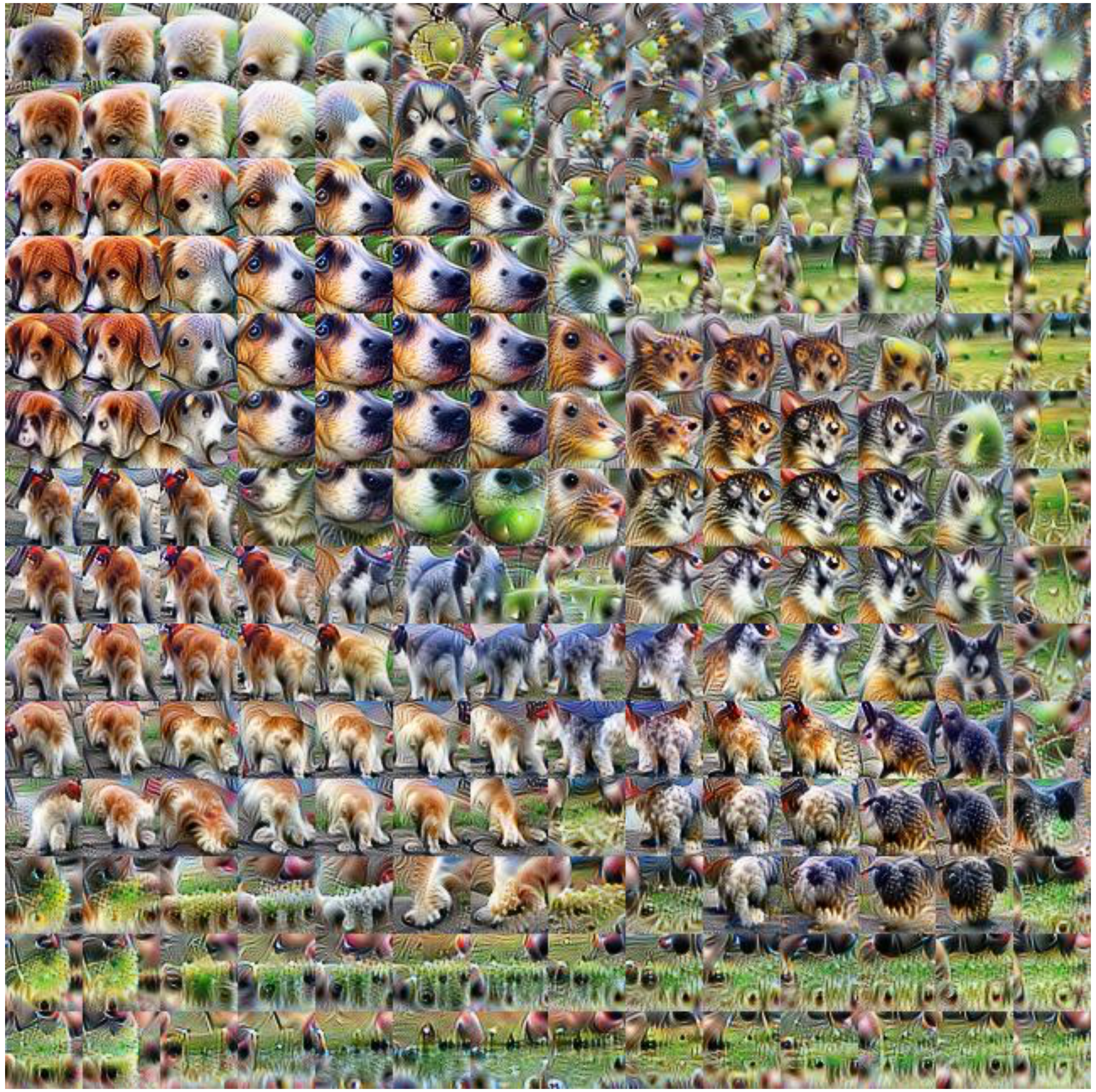
hover for attribution maps →



net evidence	1.63	1.51	1.19	...	1.32	1.54	1.72
for "Labrador retriever"	1.22	1.24	1.32		-0.70	-1.24	-0.43
for "tiger cat"	-0.40	-0.27	0.13		0.62	0.30	1.29

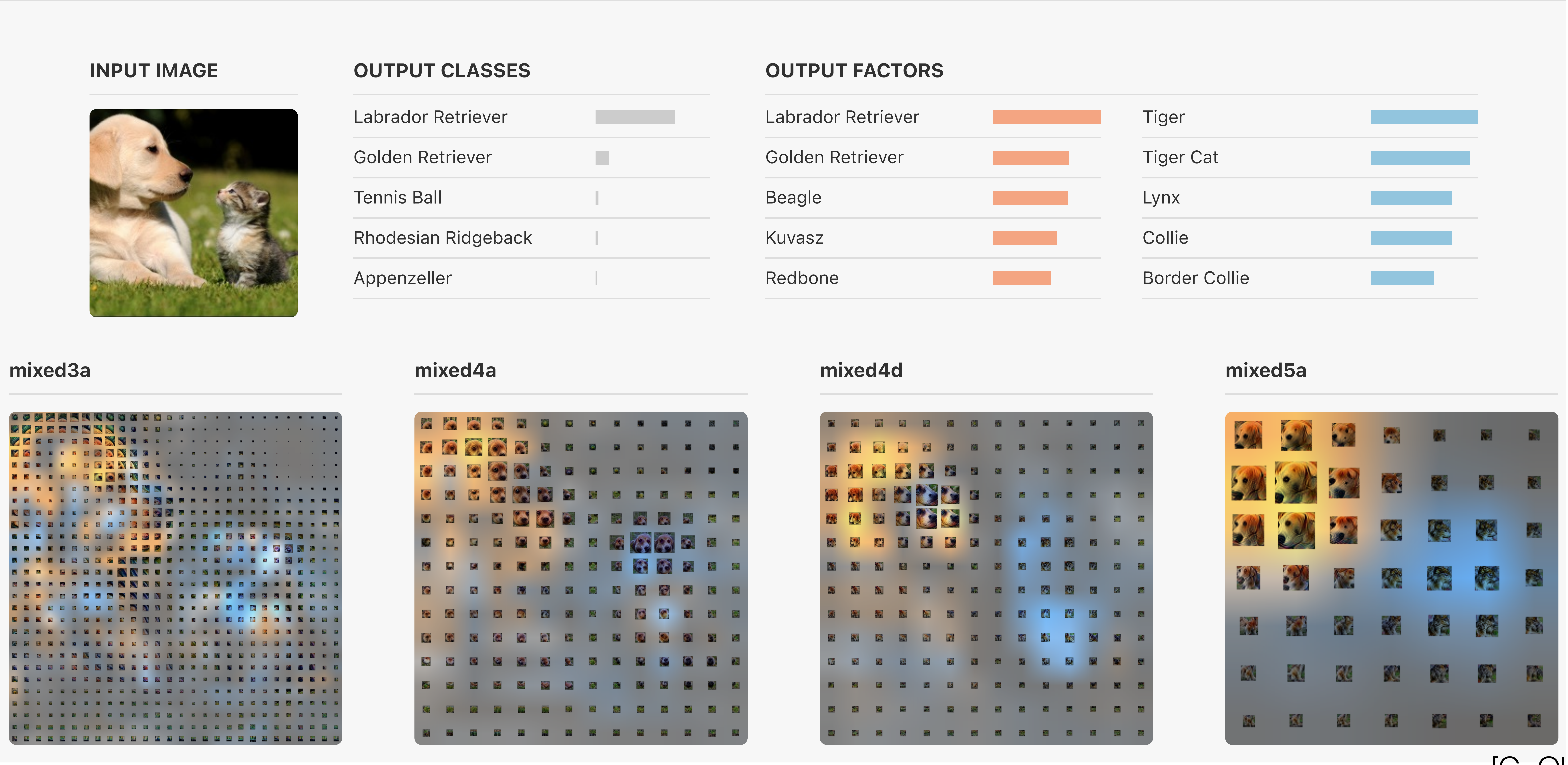
[C. Olah et al.]

Feature Vis + Attribution



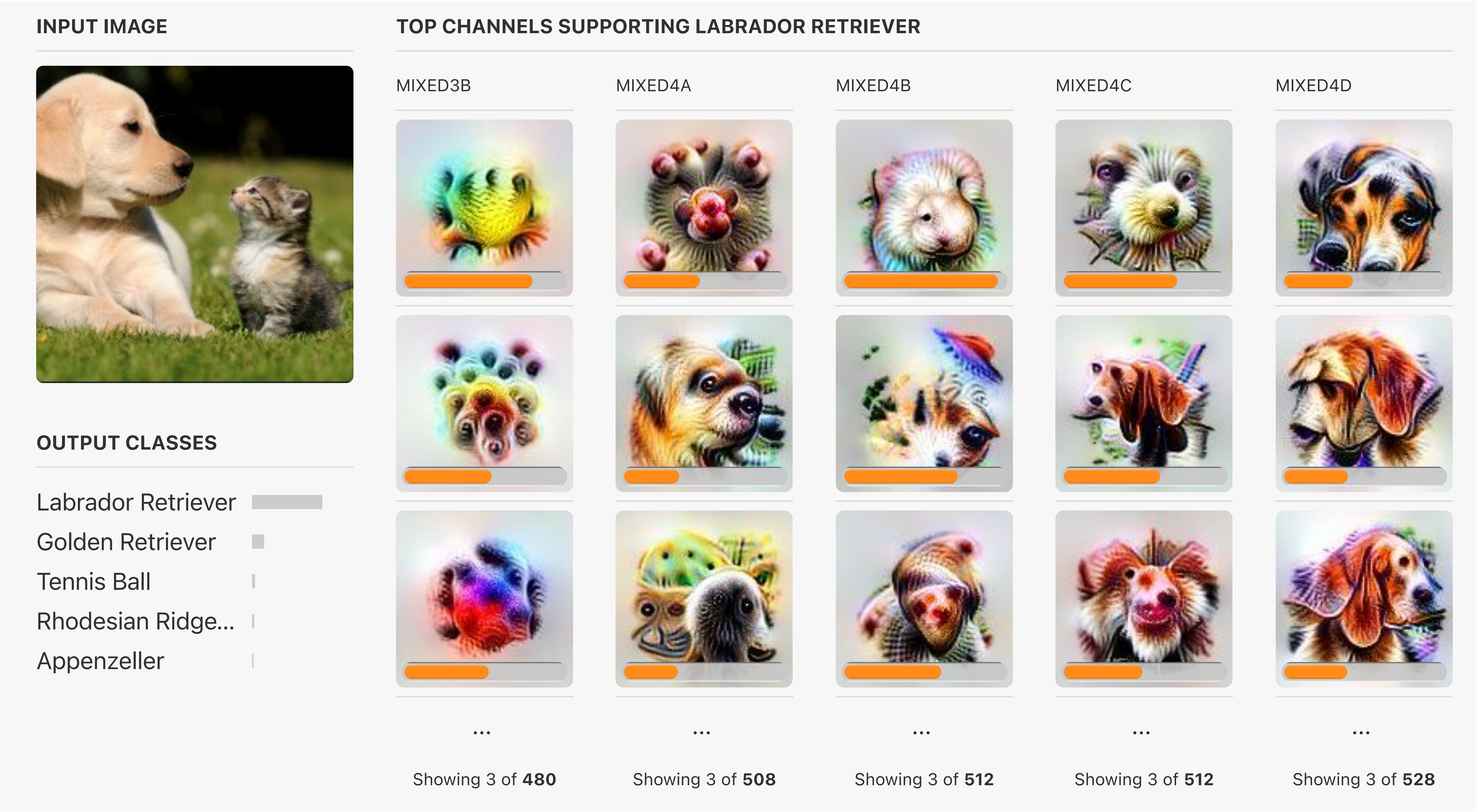
[C. Olah et al.]

Spatial Attribution with Saliency Maps



[C. Olah et al.]

Channel Attribution



[C. Olah et al.]

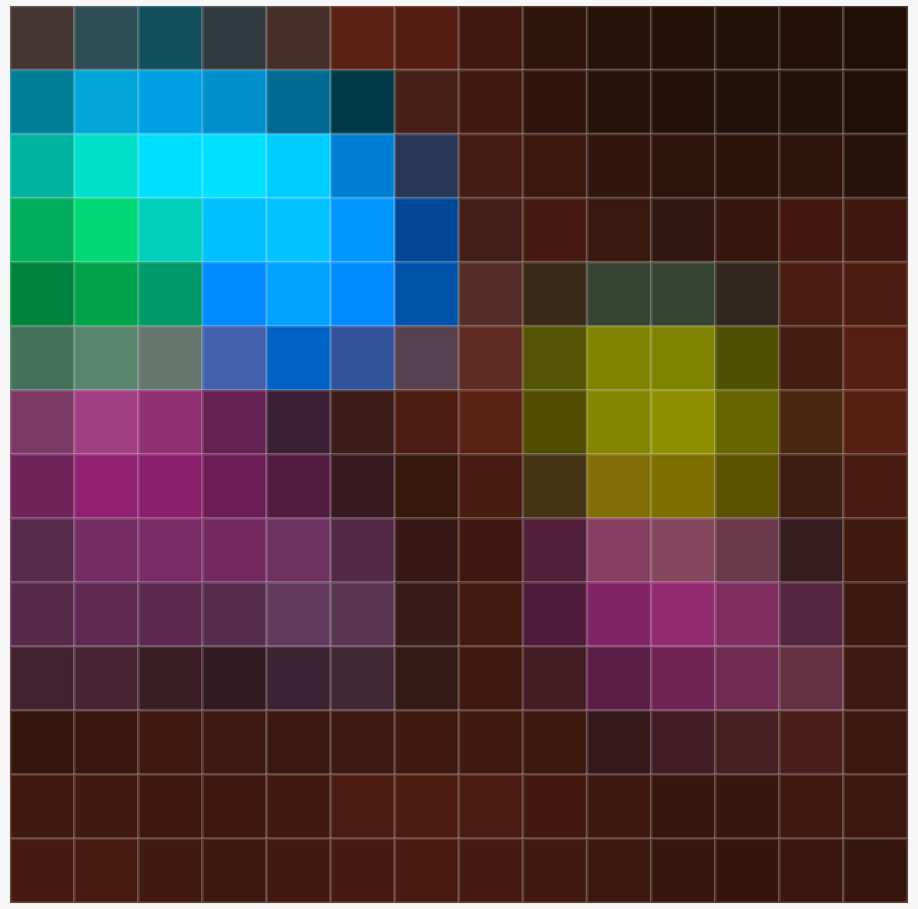
Factoring into Neuron Groups

By using non-negative matrix factorization we can reduce the large number of neurons to a small set of groups that concisely summarize the story of the network.

REPRODUCE IN A NOTEBOOK

INPUT IMAGE

ACTIVATIONS of neuron groups



NEURON GROUPS based on matrix factorization of mixed4d layer

6 groups

color key

feature visualization of each group

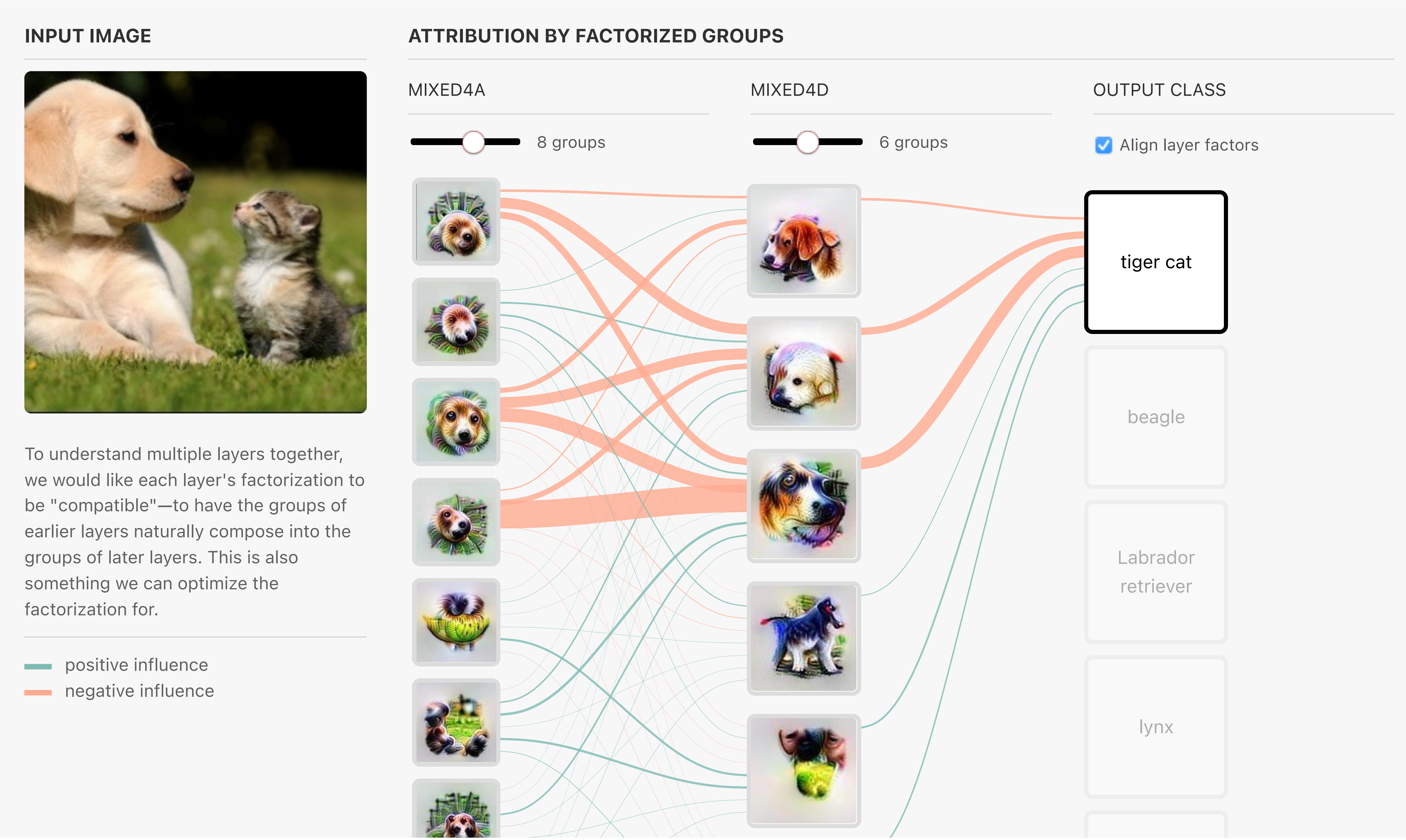
hover to isolate →

EFFECT of neuron groups on output classes

Labrador retriever	2.249	3.755	-1.193	-1.141	1.117	-1.892
beagle	3.298	0.599	-0.110	-0.356	-0.133	-2.618
tiger cat	-0.350	-0.994	-1.607	0.116	0.248	0.205
lynx	0.111	-0.642	-0.057	0.117	1.120	0.152
tennis ball	0.920	1.336	0.152	-0.885	1.227	-0.480

[C. Olah et al.]

Adding InfoVis



[C. Olah et al.]

Schedule

- Critique for Thursday
- Progress Reports next Tuesday

Multiple Views

Multiple Views

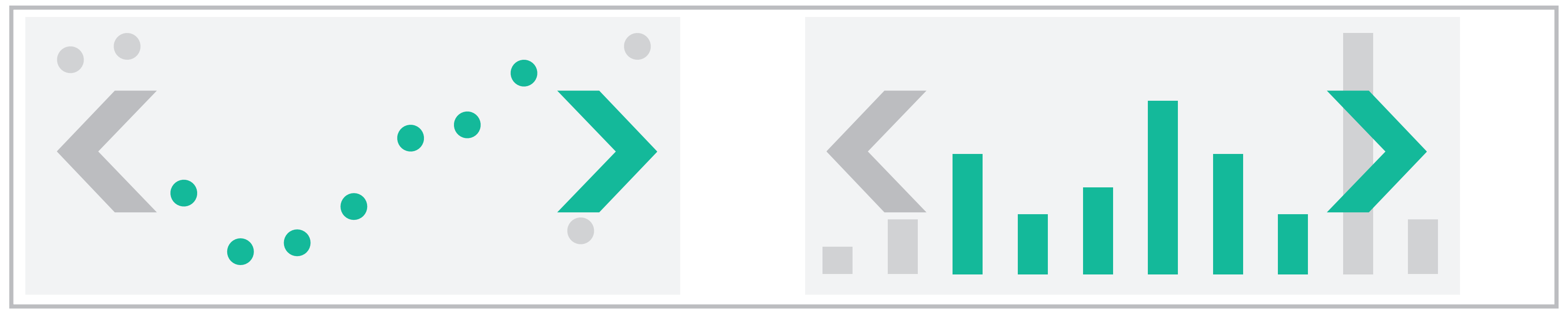
- Facet (noun and verb)
  - particular aspect or feature of something
  - to split
- Partition visualization into views/layers
  - Either juxtapose (side-by-side), superimpose (layer), nest, etc.
  - Depends on data and encoding
  - Generally, superimposing does not scale as well
  - Multiple views eats display space (either large screens or small visualizations)

Multiple Views

- Share Encoding: Same/Different
  - *Linked Highlighting*

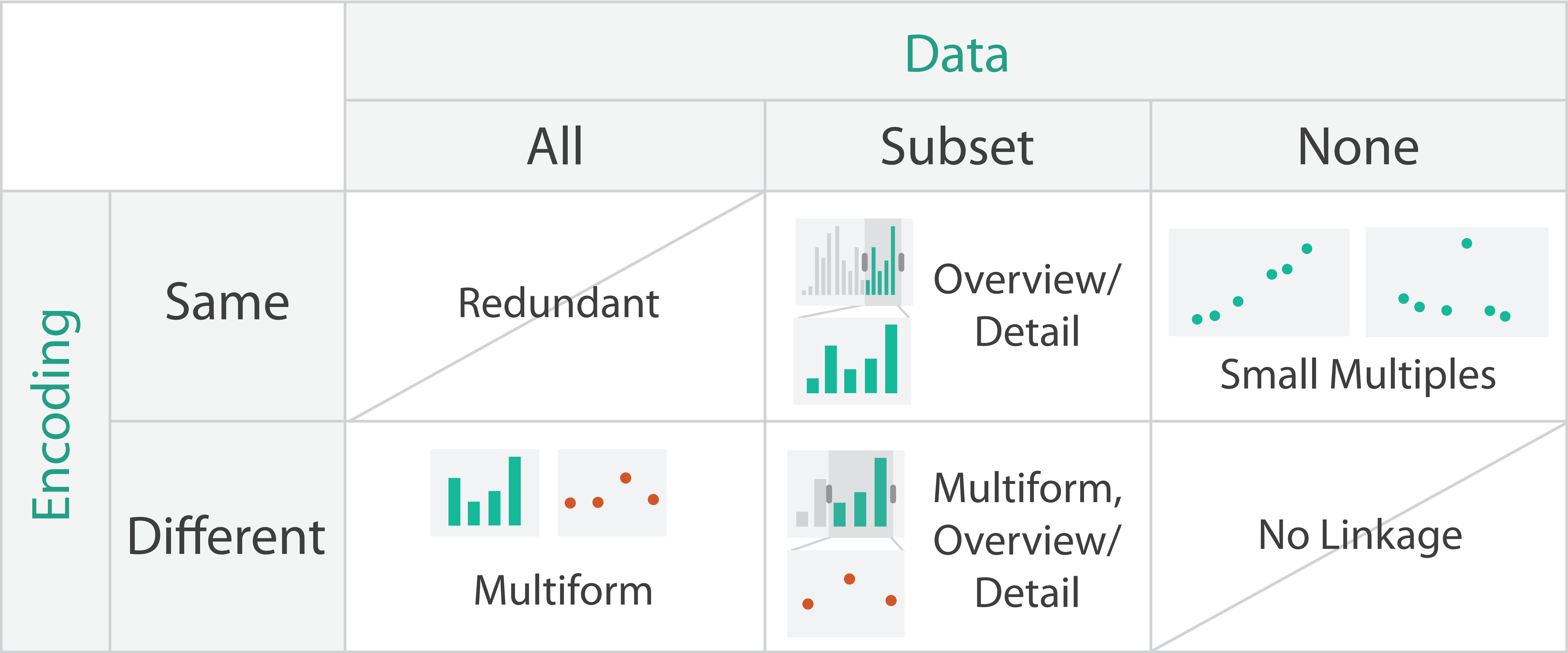
- Share Data: All/Subset/None

- Share Navigation



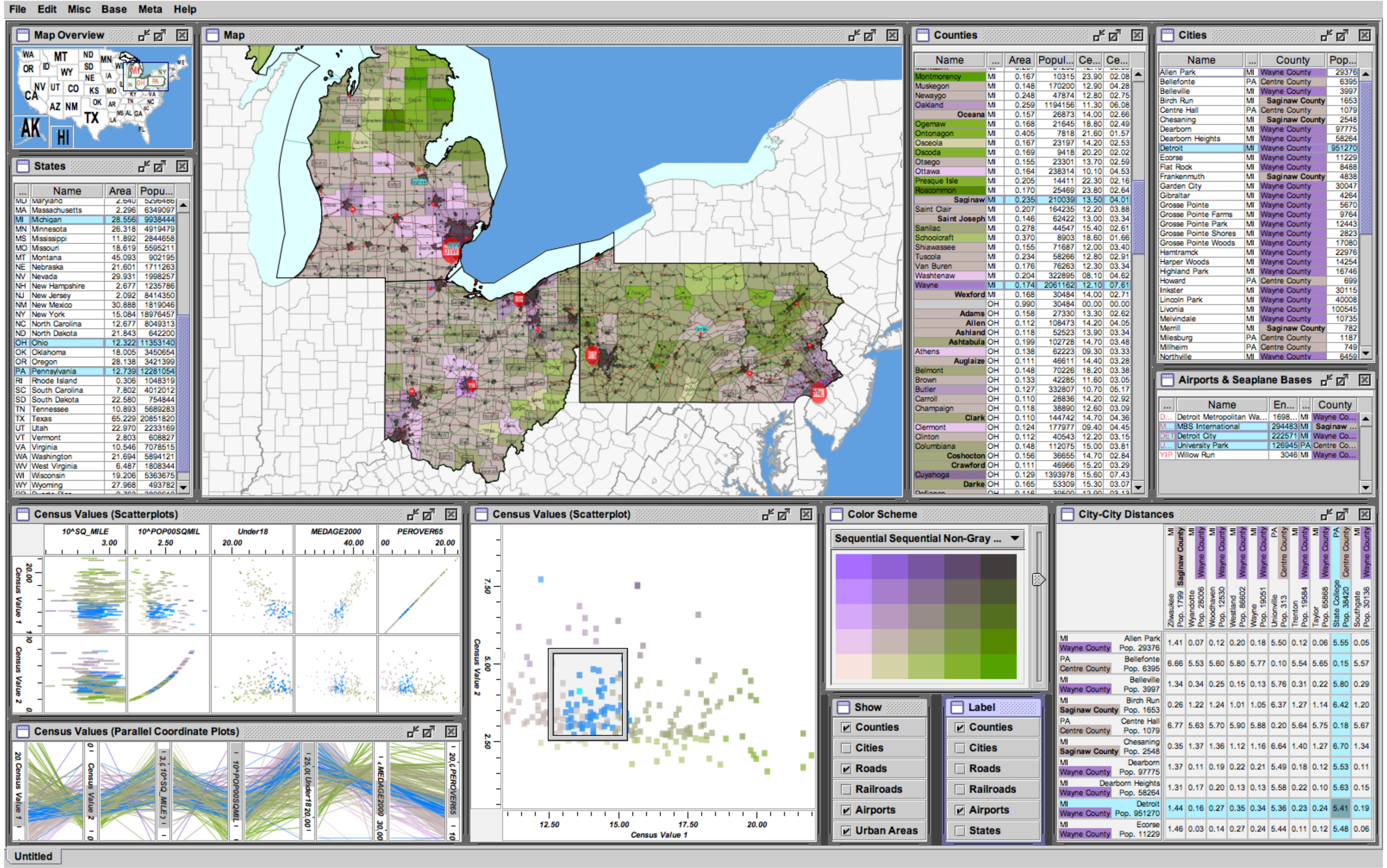
[Munzner (ill. Maguire), 2014]

Multiple Views



[Munzner (ill. Maguire), 2014]

Multiform



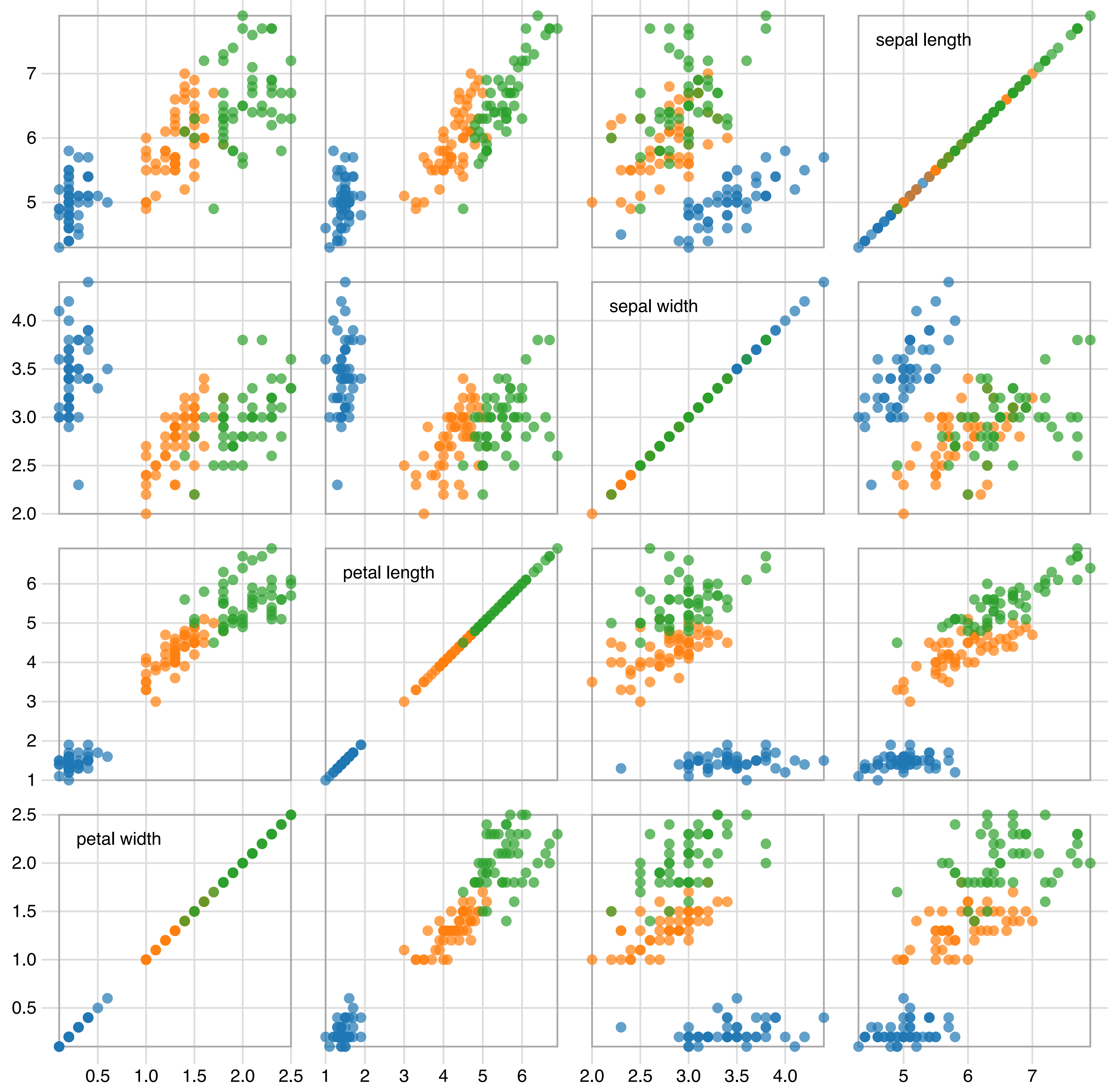
[Improvise, Weaver, 2004]

Multiform Views

- The same data visualized in different ways
- Does not need to be a totally different encoding (all choices need not be disjoint), e.g. horizontal positions could be the same
- One view becomes cluttered with too many attributes
- Consumes more screen space
- Allows greater separability between channels

Small Multiples

- Same encoding, but different data in each view (e.g. SPLOM)

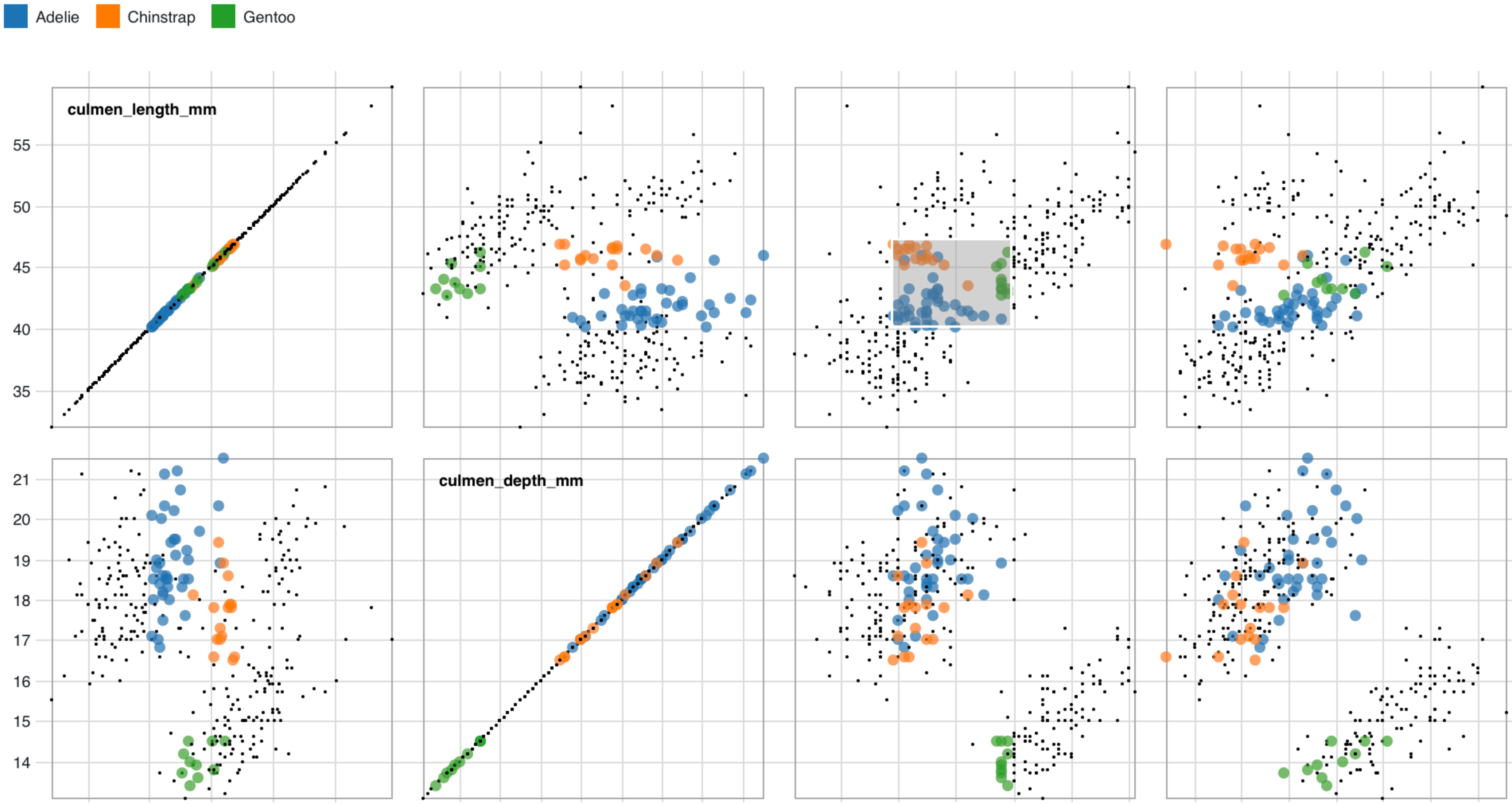


[M. Bostock]

Interaction with Multiform & Small Multiples

- Key interaction with multiform and small multiples: **brushing**
  - also called linked highlighting
- Want to understand correspondences between representation in the different views

Brushing

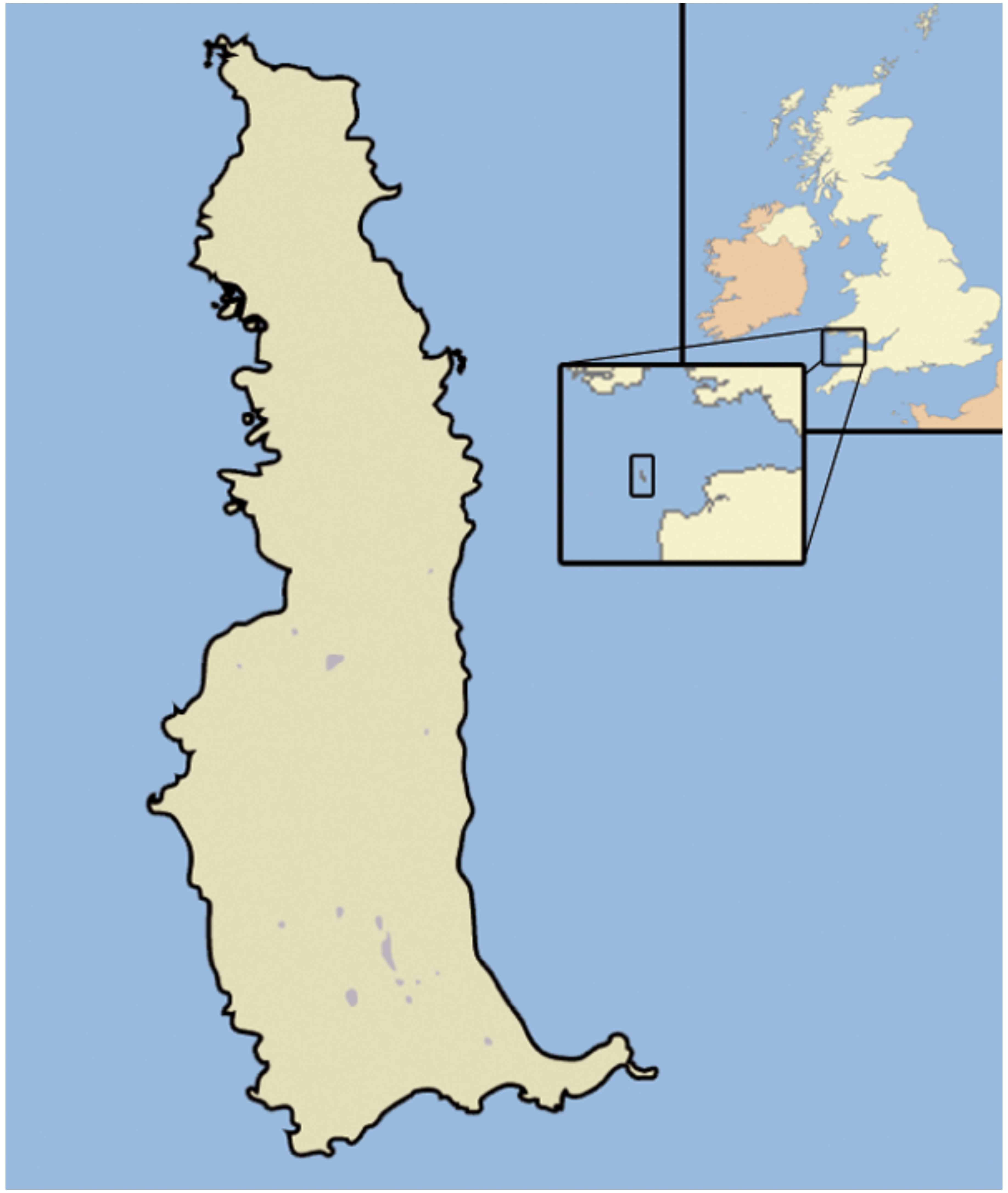


[M. Bostock]

Shneiderman's Mantra

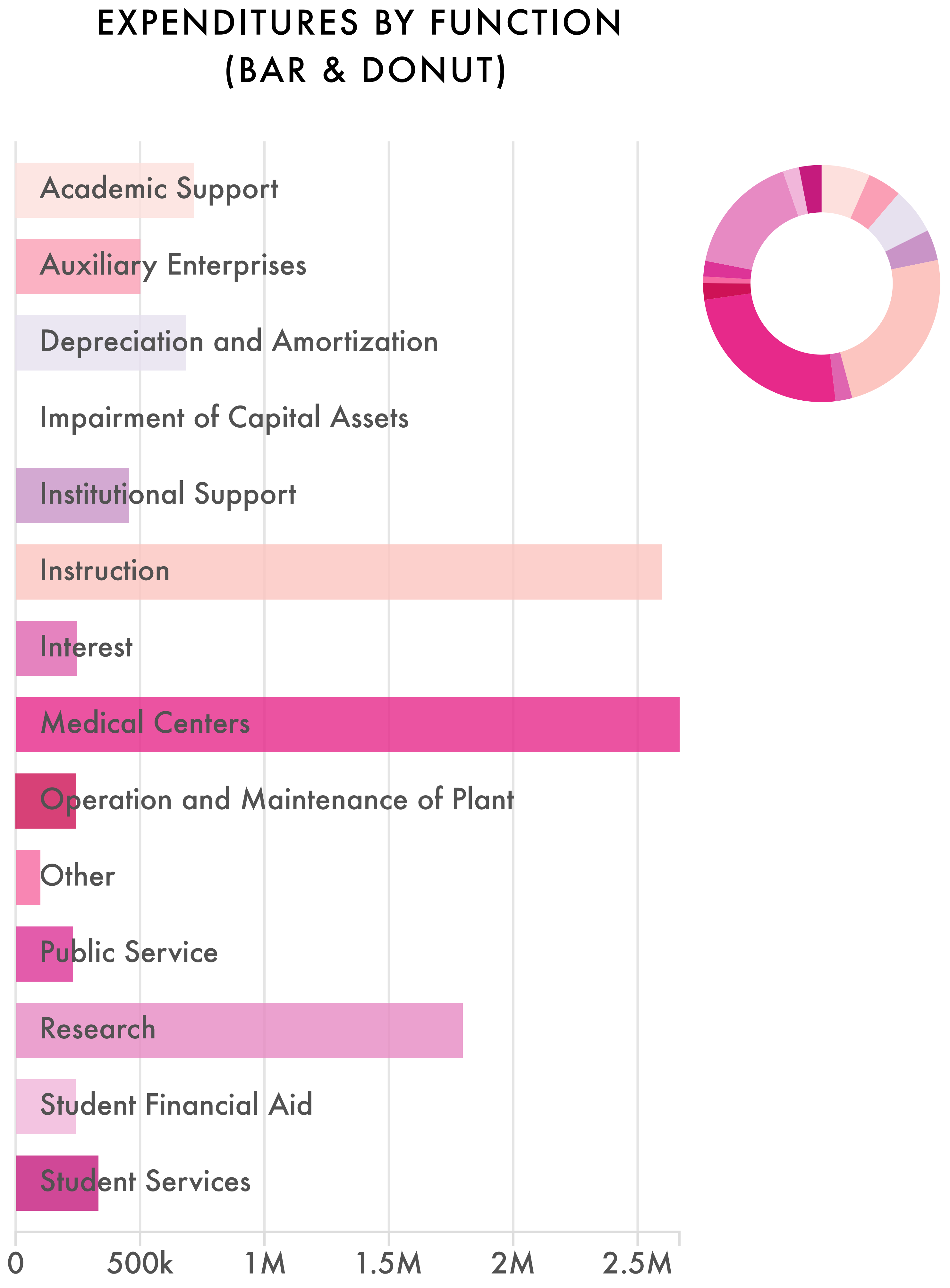
- Visual Information-Seeking Mantra [B. Shneiderman, 1996]:
  - Overview first
  - Zoom and filter (Chapter 13)
  - Details on demand
- Goal of the overview is to **summarize** all of the data
- Want specific **details** about some aspect(s) of the data, need another view/layer
  - May be permanent: side-by-side
  - May be a popup layer: often opaque or separated
- (see textbook Ch. 6.7)

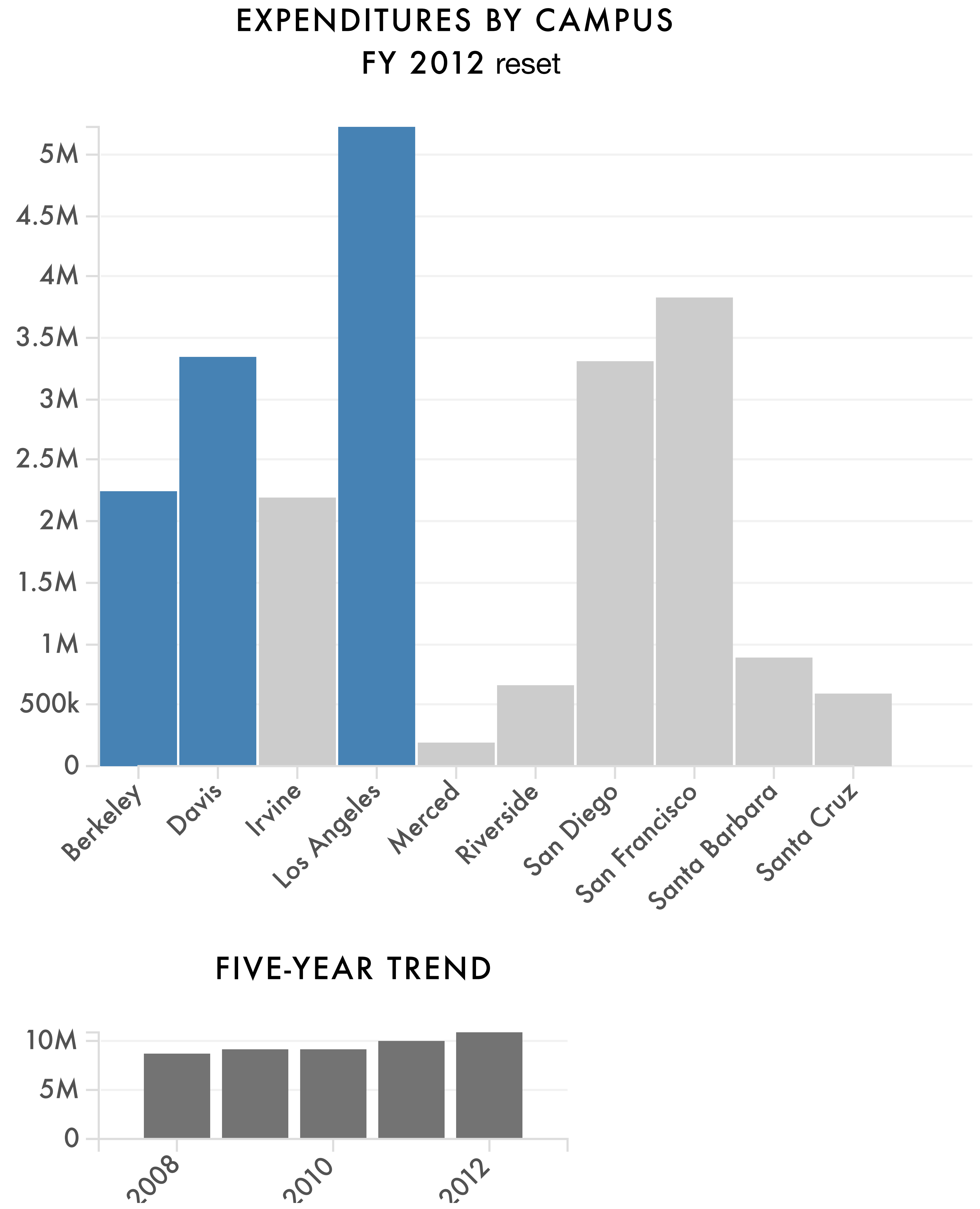
Overview-Detail View



[Wikipedia]

Overview-Detail (Different Encoding)





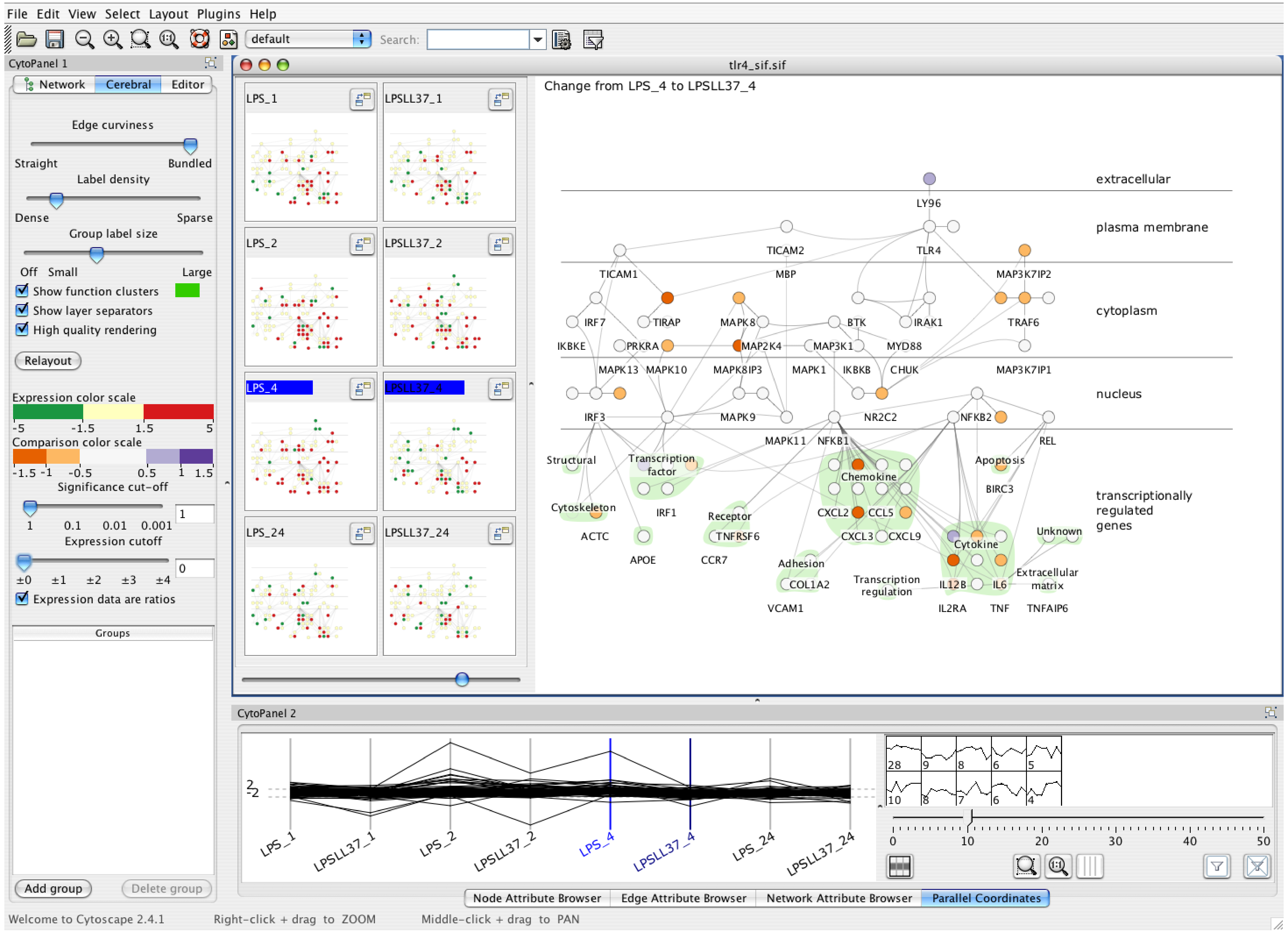
[S. Quigley]

Overview-Detail (with Zoom-Filter)

- Detail involves some subset of the full dataset
- Involves user selection or filtering of some type

- How question: includes facet
- Examples:
  - Maps: partition into two views with same encoding, overview-detail
  - UC Trends: partition into multiple views, coordinated with linked highlighting, overview+detail of expenditures

Multiform & Small Multiples (Cerebral)



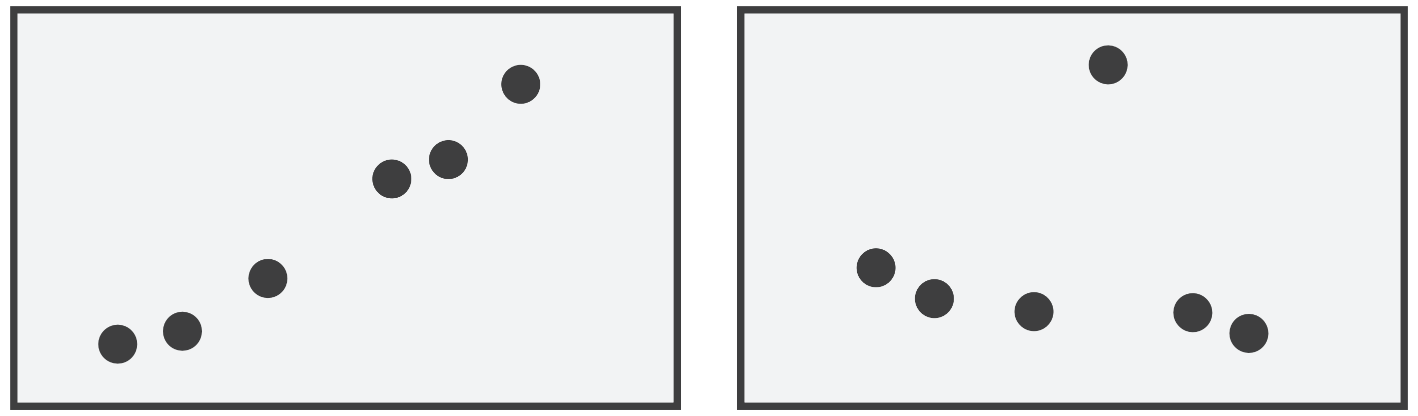
[Barsky et al., 2008]

Navigation across multiple views

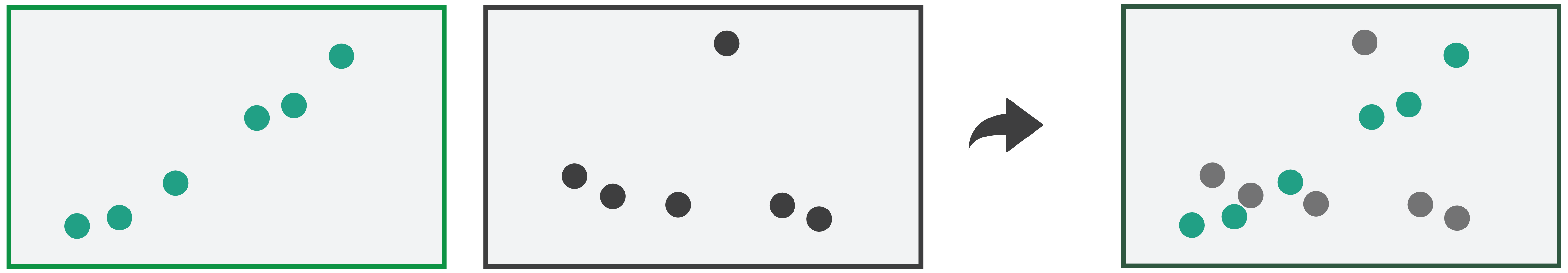
- Often navigation in one view updates navigation in another
- Example: Maps: overview shifts as you move around in detail view
- Selections in one view may trigger selections in another

Multiple Views

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



- **Superimpose Layers**



[Munzner (ill. Maguire), 2014]

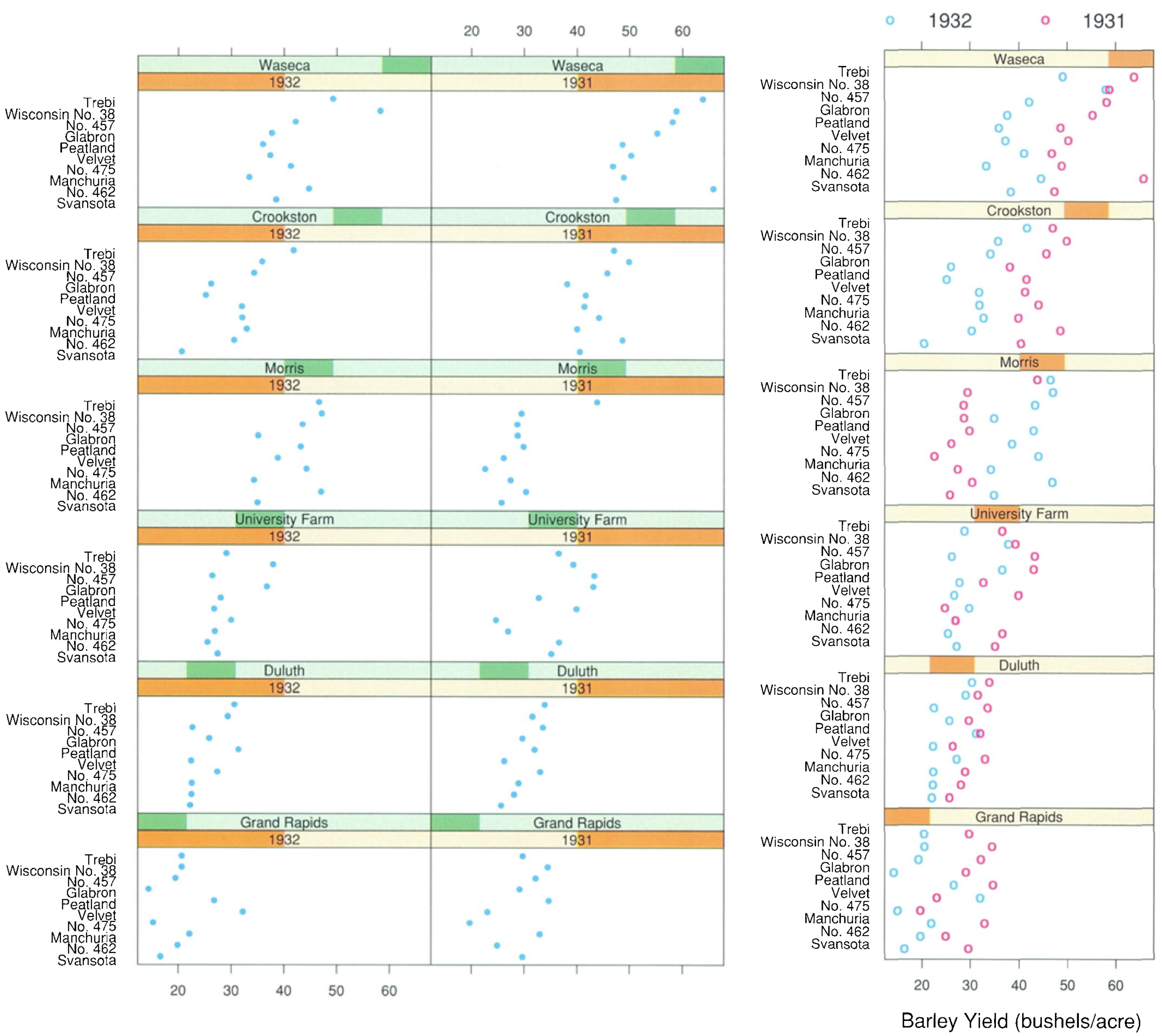
Partitioned Views

- Split dataset into groups and visualize each group
- Extremes: one item per group, one group for all items
- Can be a hierarchy
  - Order: which splits are more "related"?
  - Which attributes are used to split? usually categorical

Matrix Alignment & Recursive Subdivision

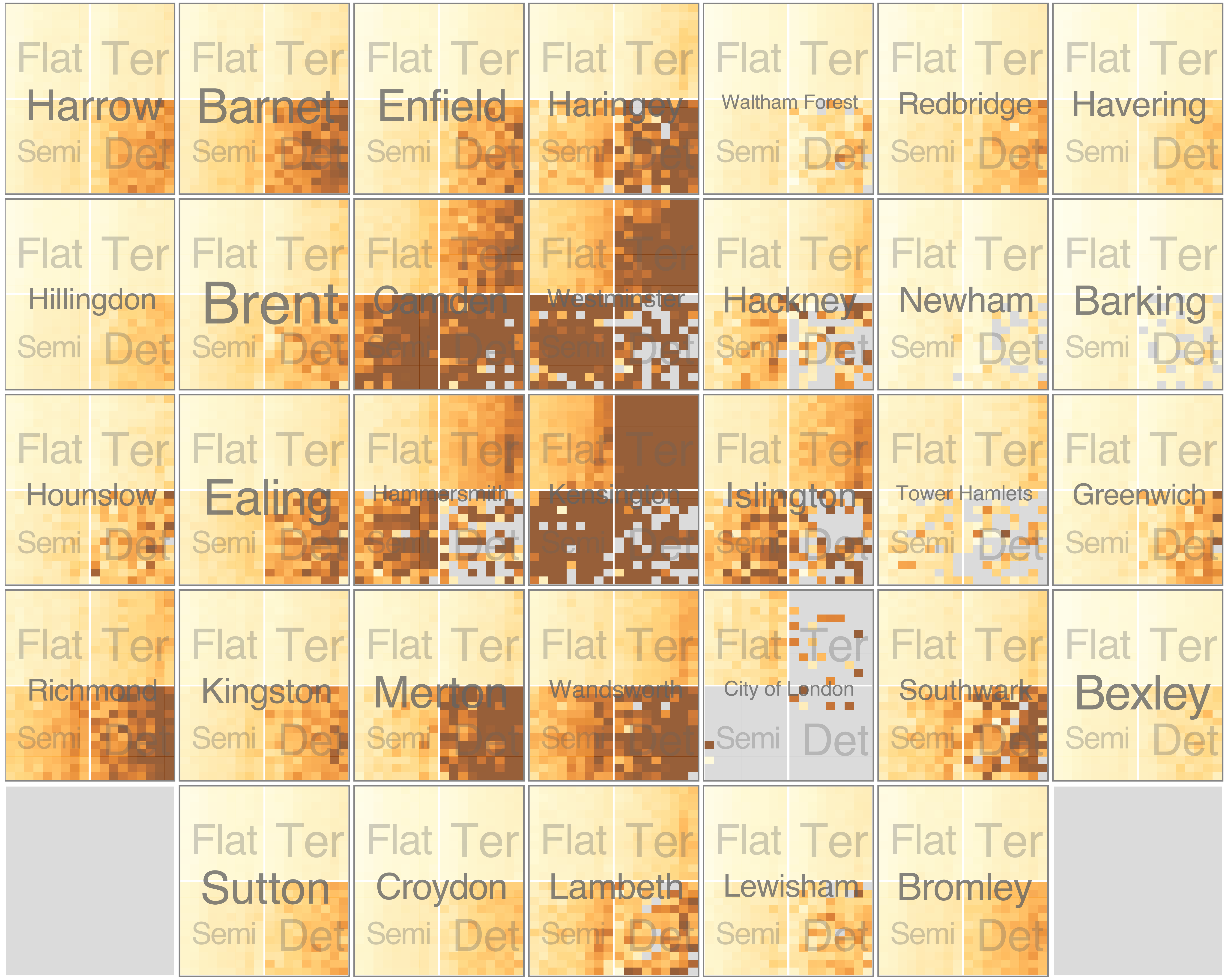
- Matrix Alignment:
  - regions are placed in a matrix alignment
  - splits go to rows and columns
  - main-effects ordering: use summary statistic to determine order of categorical attribute
- Recursive subdivision:
  - Designed for exploration
  - Involves hierarchy
  - User drives the ways data is broken down in recursive manner

Example: Trellis Matrix Alignment



[Becker et al., 1996]

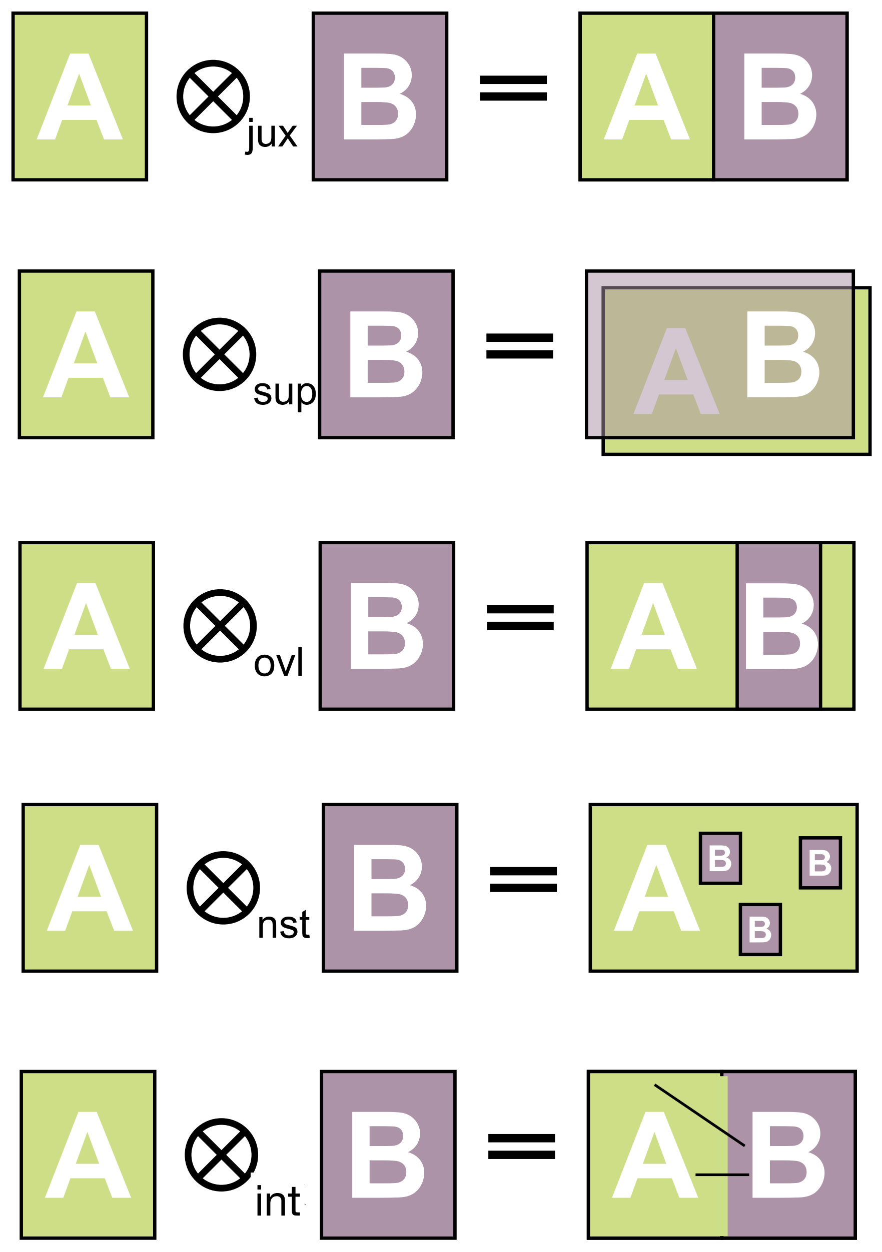
Example: HiVE System



[Slingsby et al., 2009]

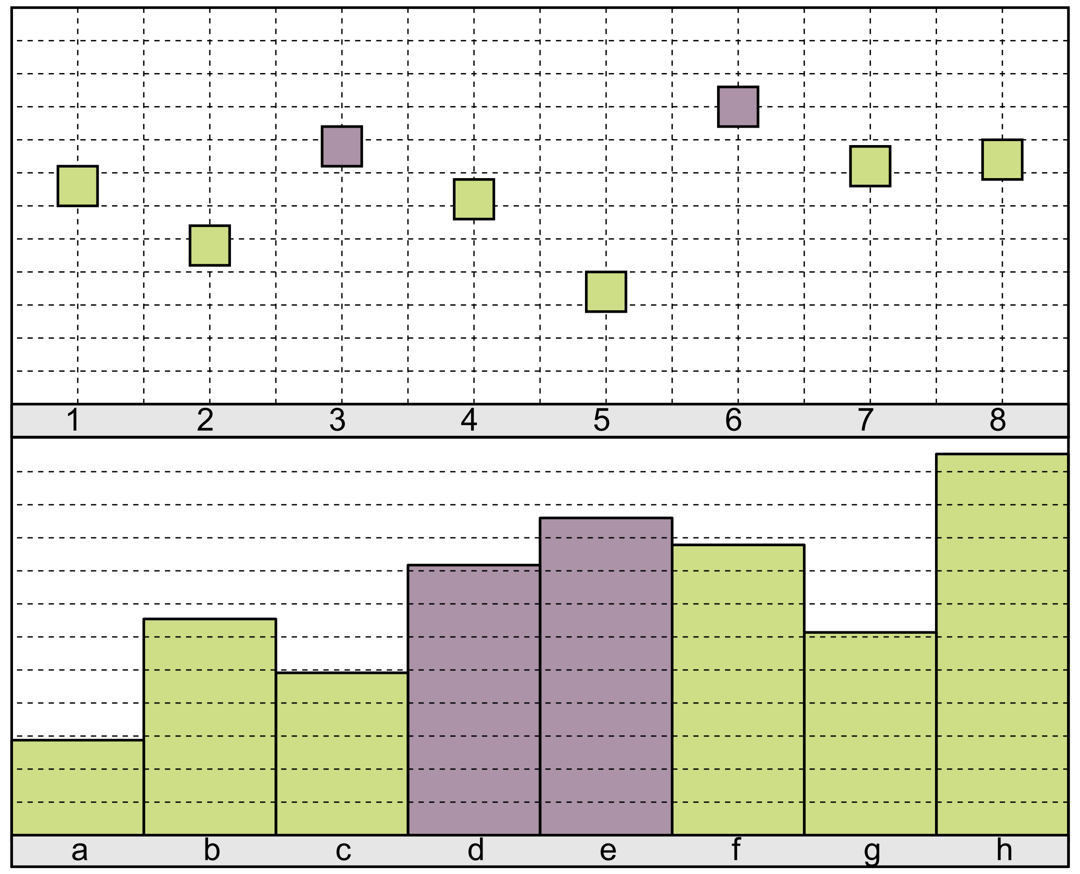
Design Space of Composite Visualization

- Composite visualization views (CVVs)
  - Includes Coordinated multiple views (CMV)
  - + More!
- Design Patterns:
  - Juxtaposition: side-by-side
  - Superimposition: layers
  - Overloading: vis meshed with another
  - Nesting: vis inside a vis (recursive vis)
  - Integration: "merge" views + links

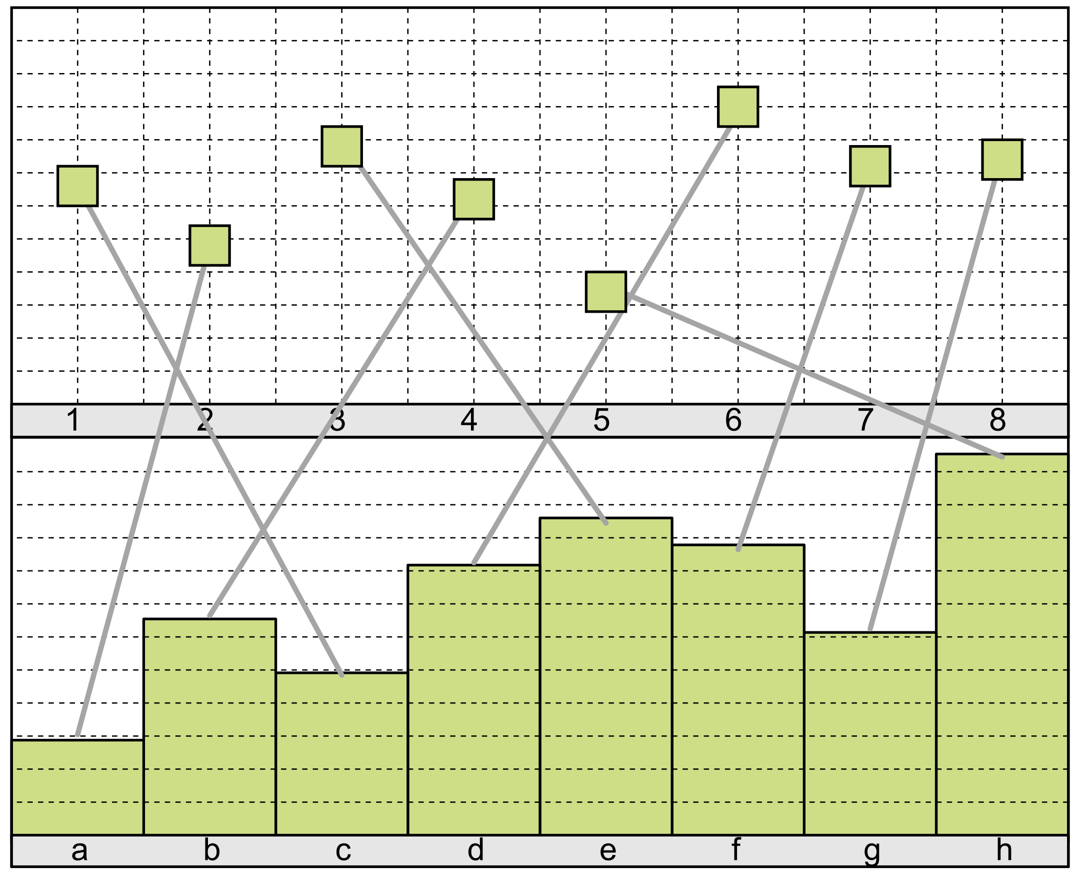


[W. Javed and N. Elmqvist, 2012]

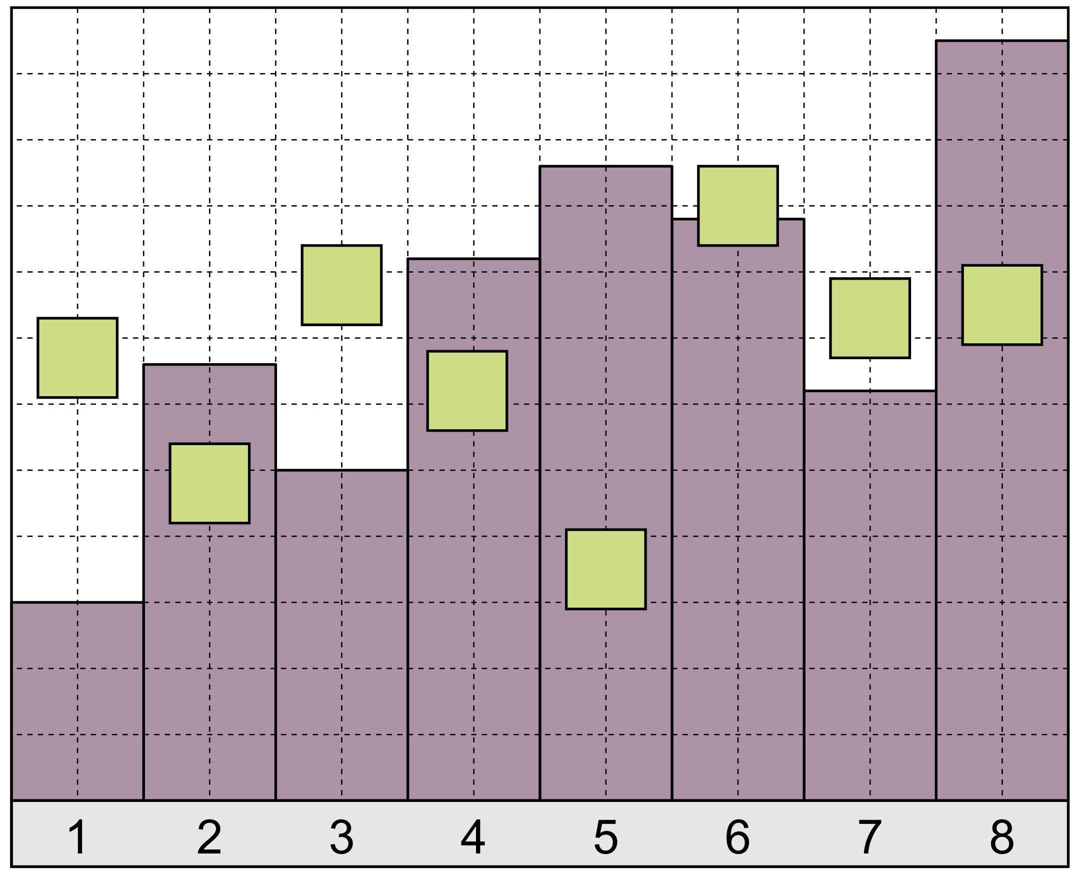
Composite Visualization Techniques



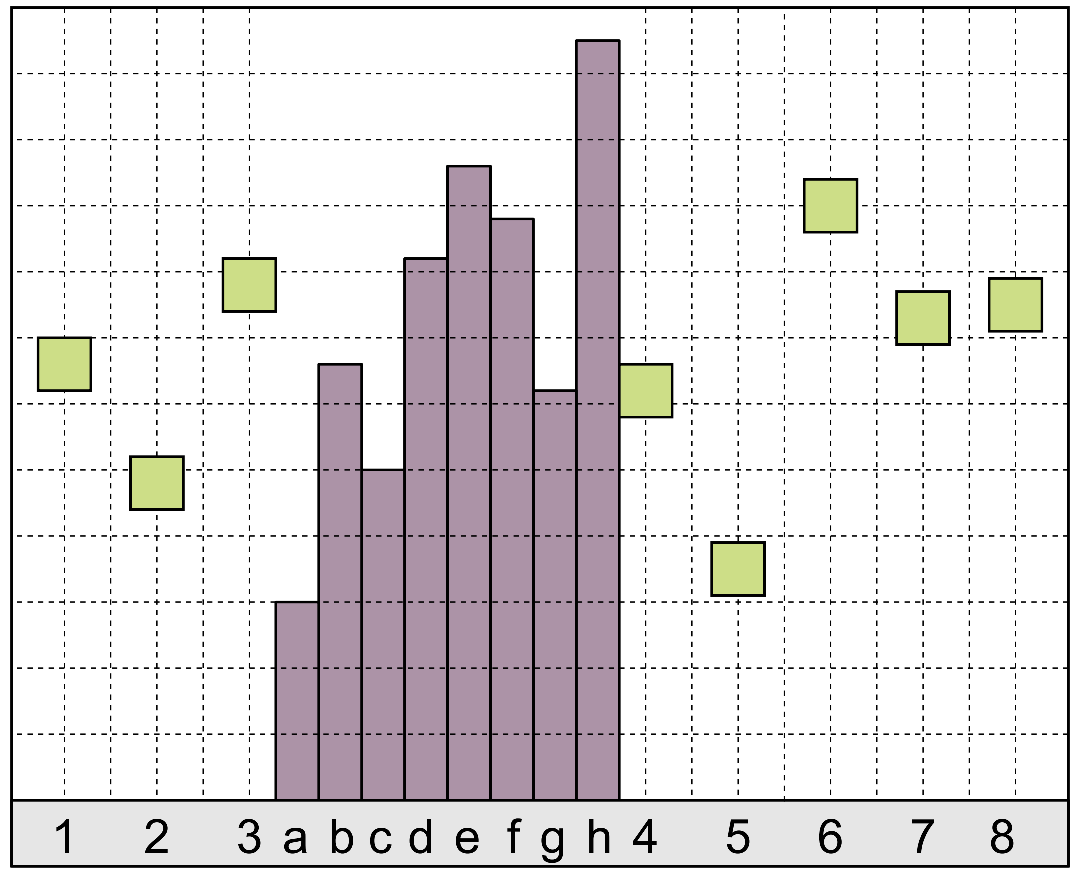
(a) Juxtaposed views.



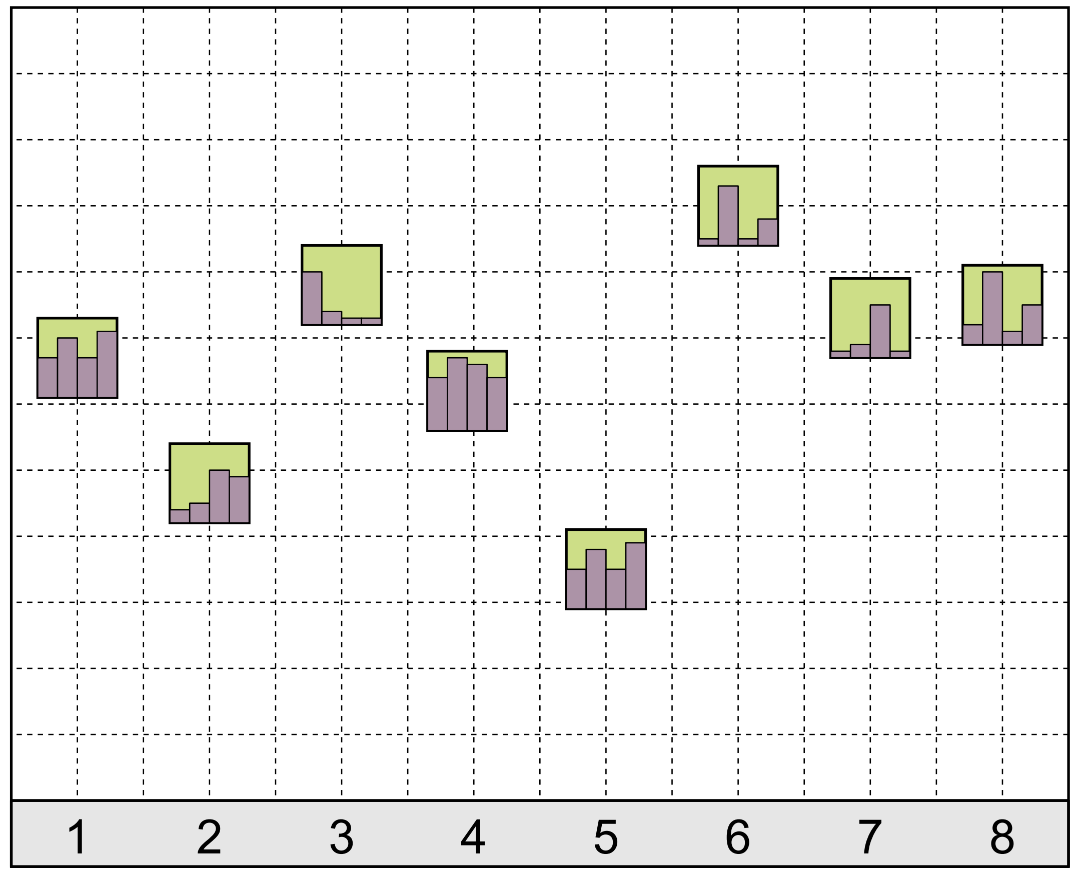
(b) Integrated views.



(c) Superimposed views.



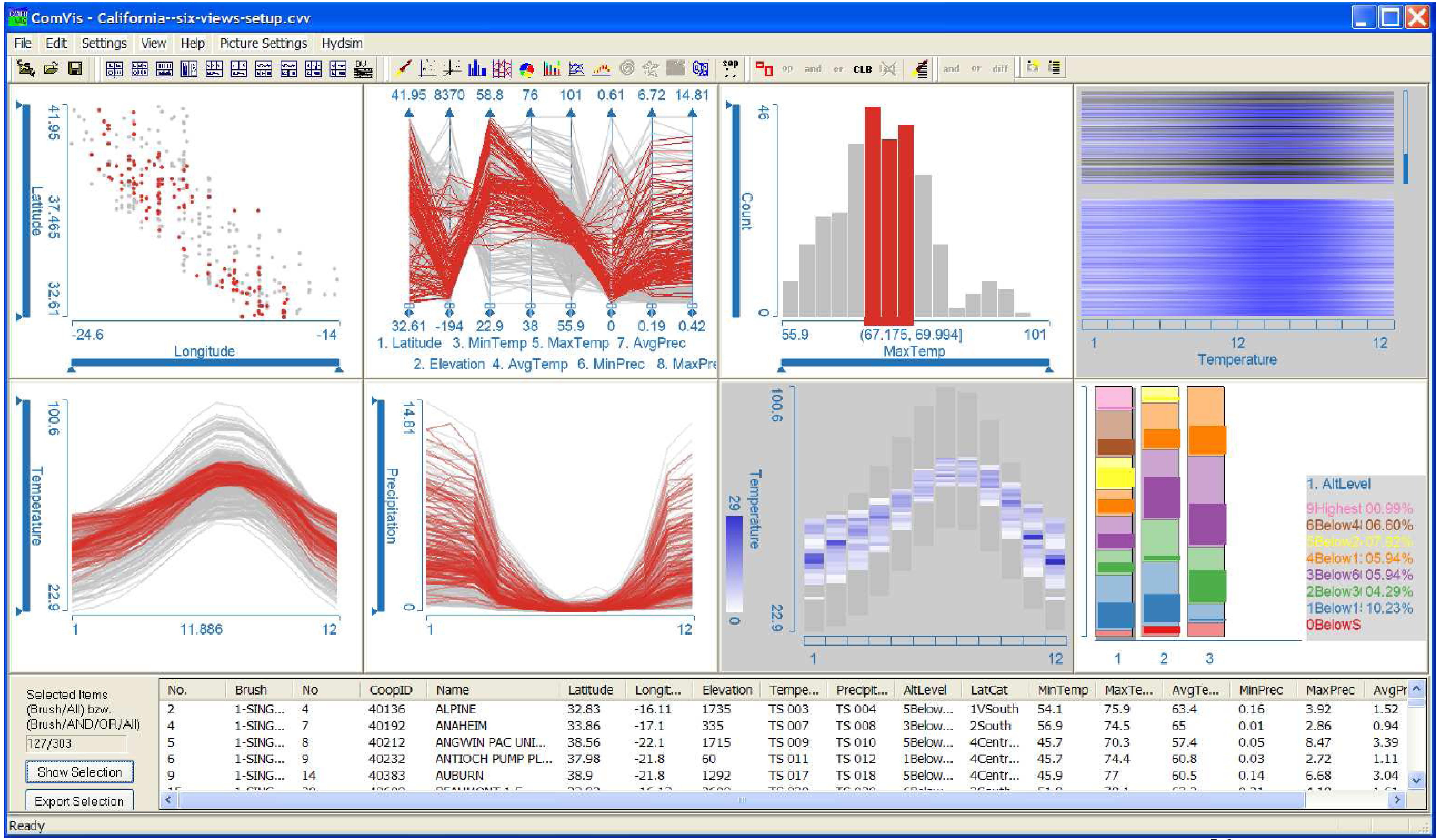
(d) Overloaded views.



(e) Nested views.

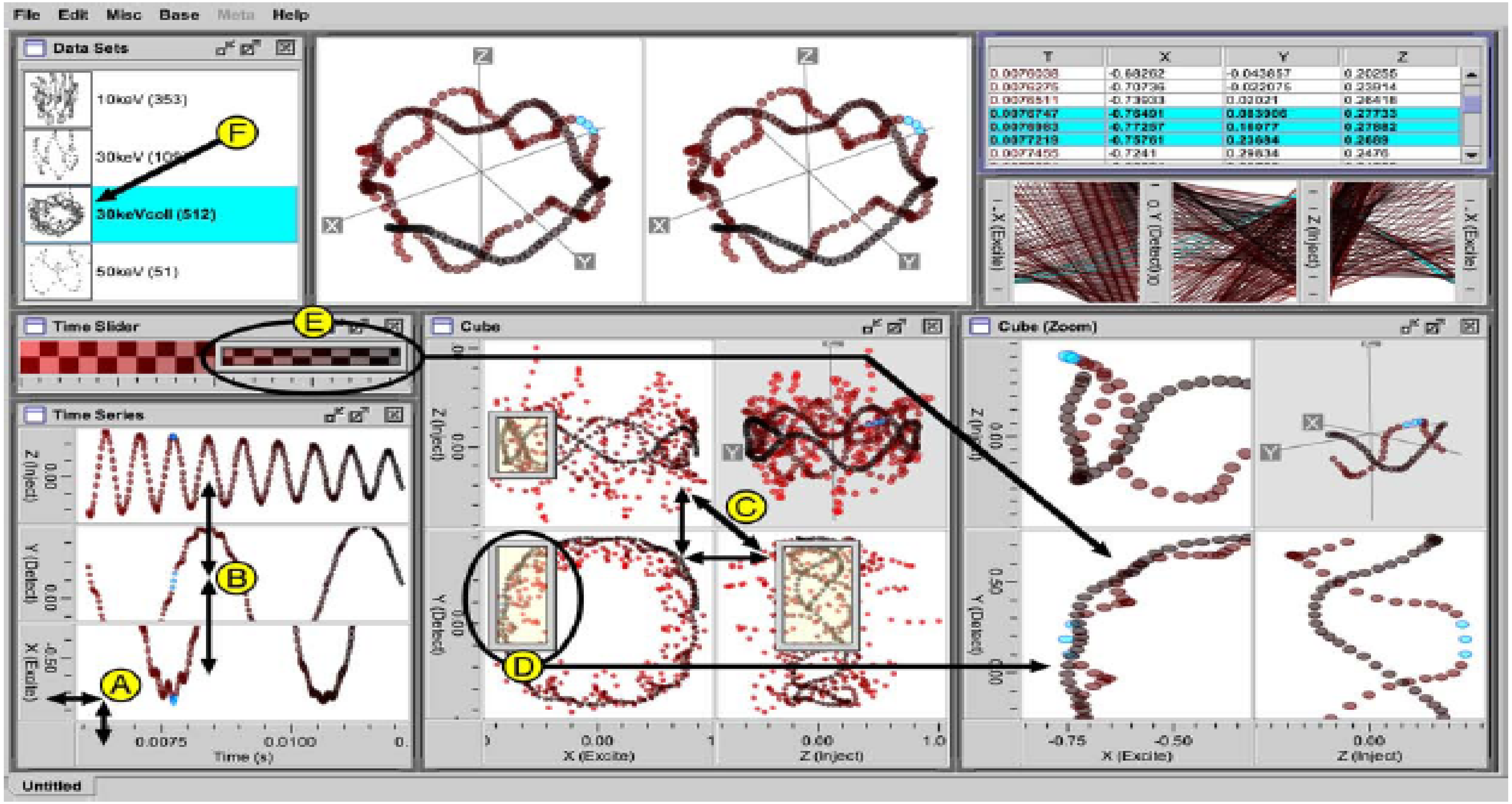
[W. Javed and N. Elmqvist, 2012]

Juxtaposition



[ComVis, K. Matkovic et al., 2008]

Juxtaposition



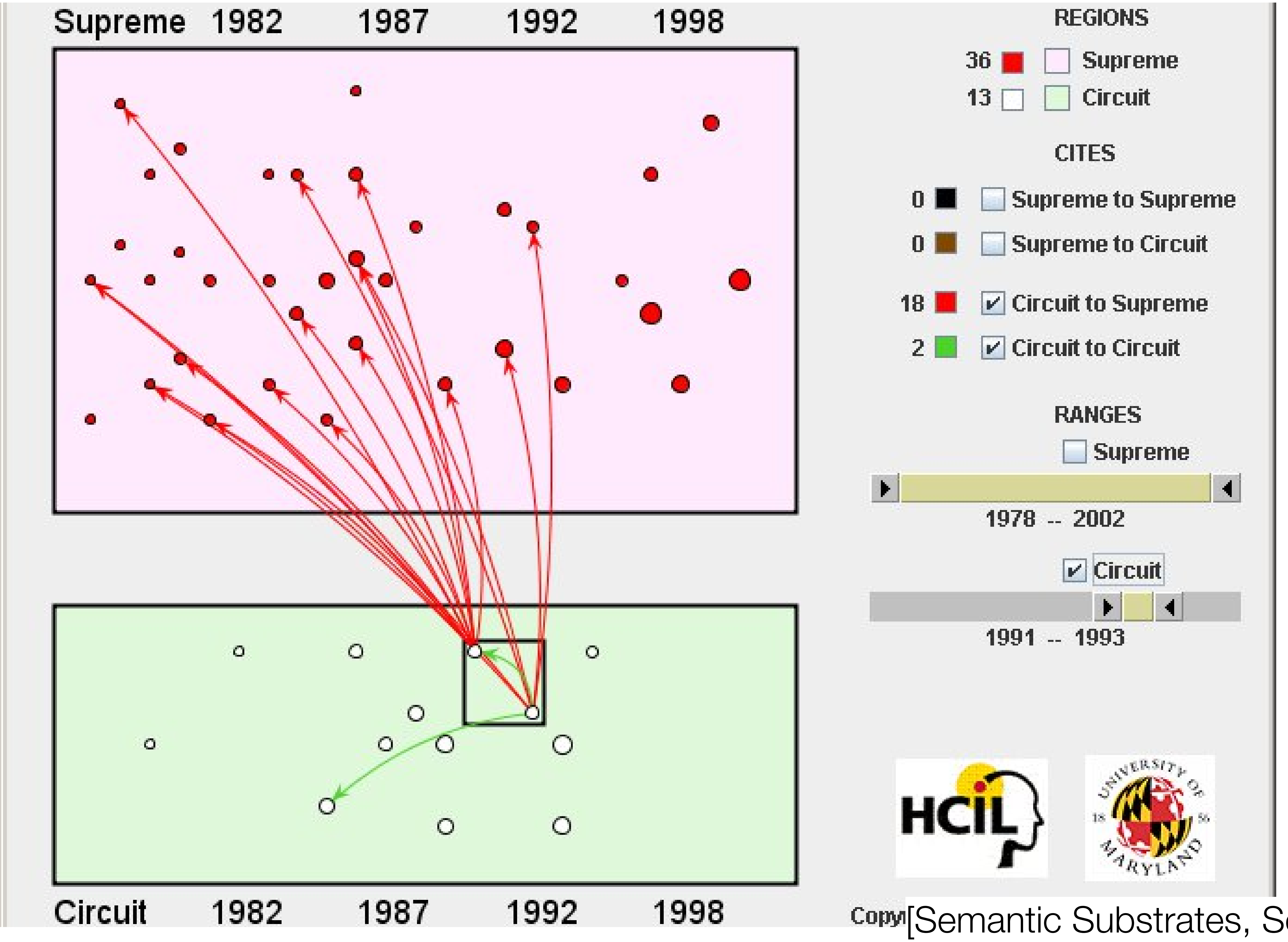
[Improvise, C. Weaver, 2004]

Juxtaposition Guidelines

- Benefits:
  - The component visualizations are independent and can be composed without interference
  - Easy to implement
- Drawbacks:
  - Implicit visual linking is not always easy to see, particularly when multiple objects are selected
  - Space is divided between the views, yielding less space for each view
- Applications: Use for heterogeneous datasets consisting of many different types of data, or for where different independent visualizations need to be combined.

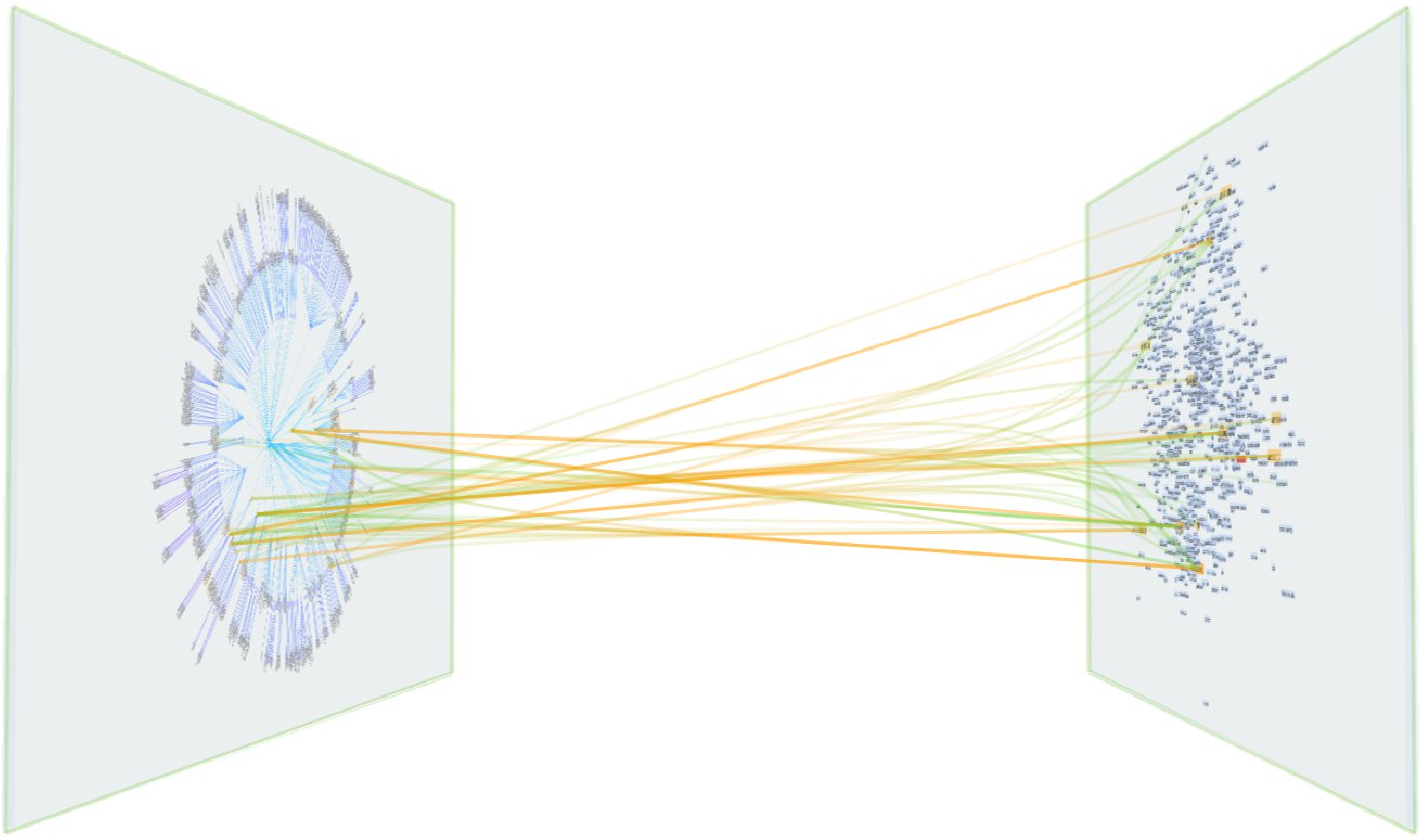
[W. Javed and N. Elmqvist, 2012]

Integration



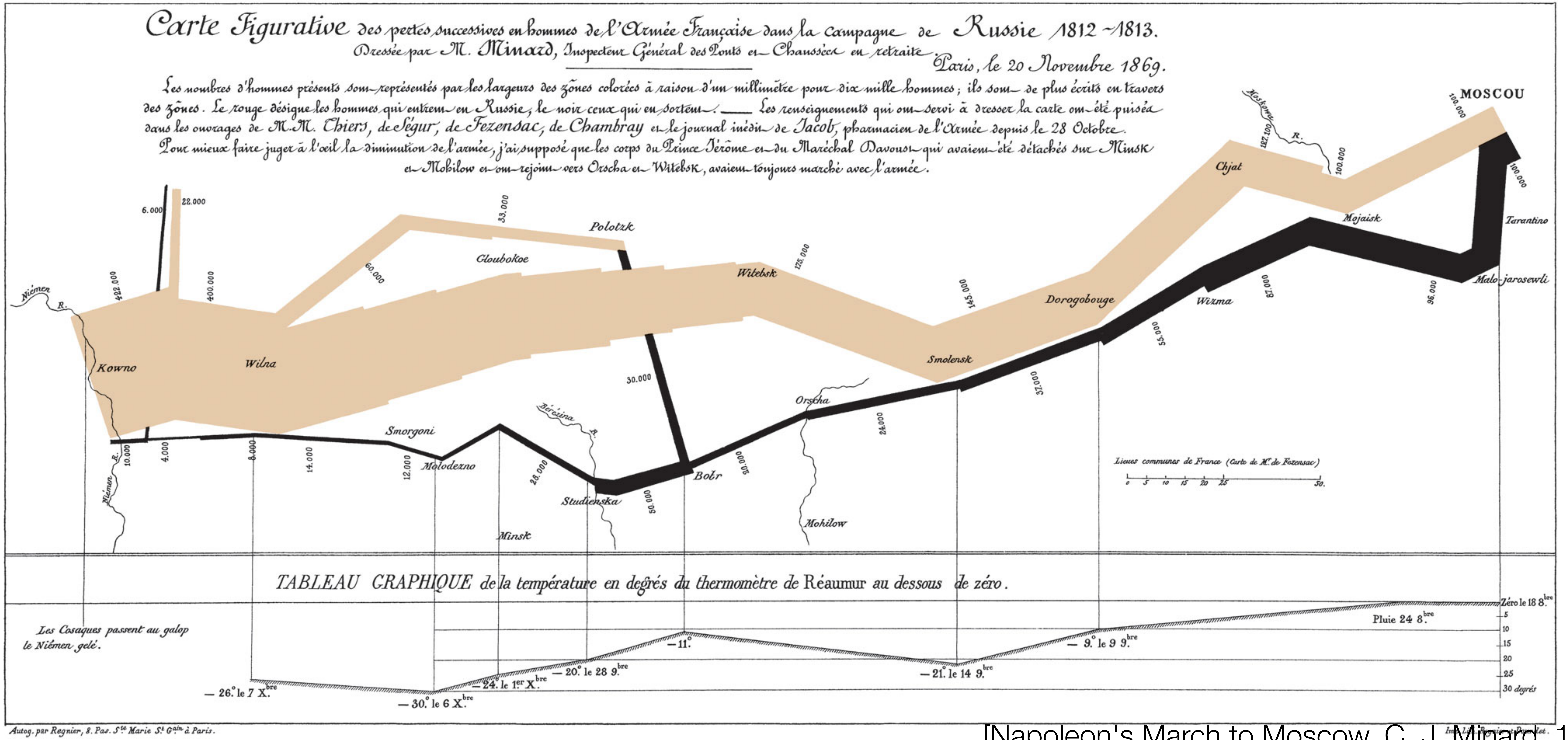
[Semantic Substrates, Schneiderin and Aris, 2006]

Integration



[VisLink, Collins and Carpendale, 2007]

Integration



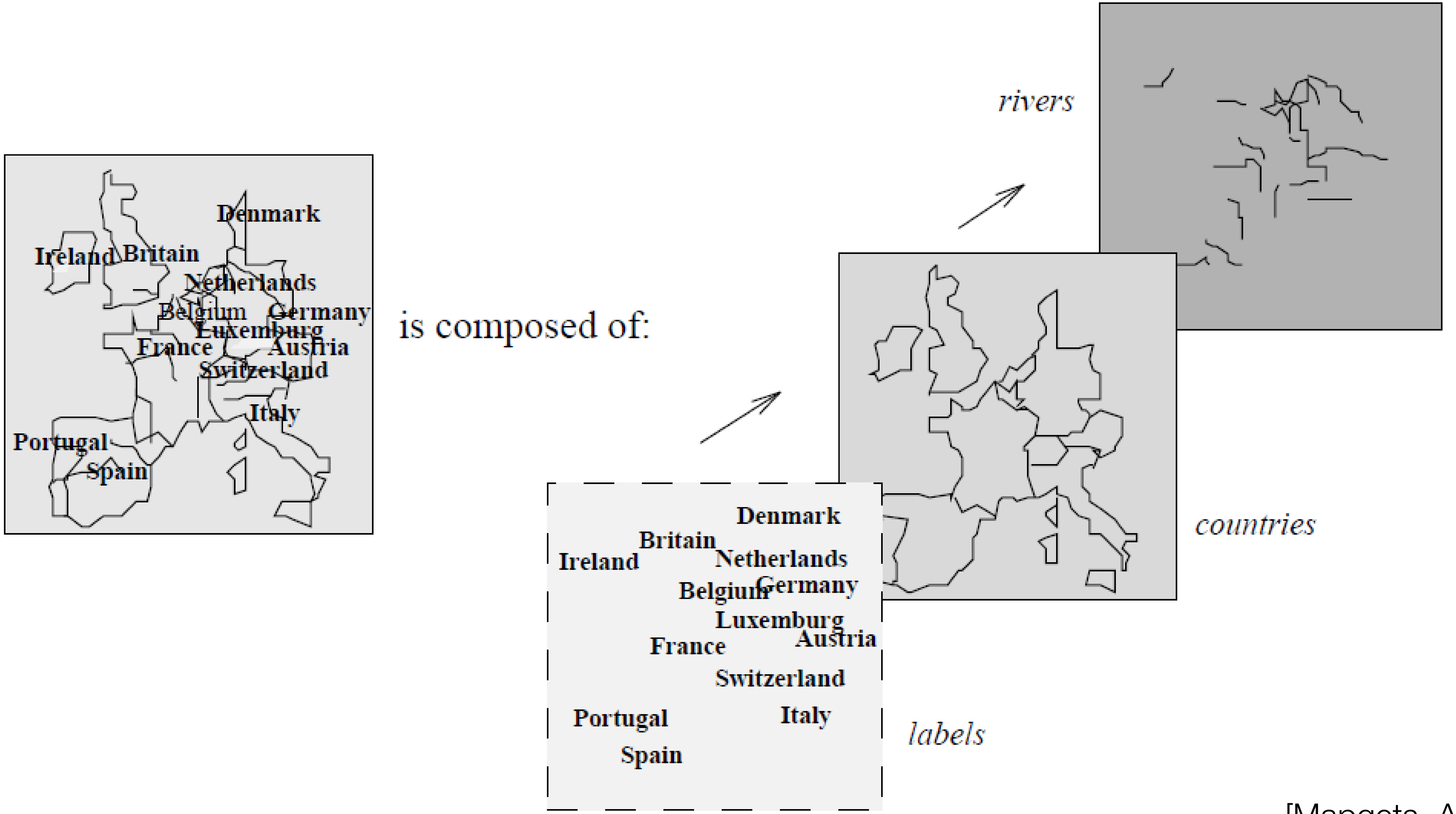
[Napoleon's March to Moscow, C. J. Minard, 1869]

Integration Guidelines

- Benefits:
  - Easy to perceive one-to-one and one-to-many relations between items in components
  - Visualizations are less independent compared to juxtaposed views, but still separate
- Drawbacks:
  - Extra visual clutter added to the overall view
  - Display space is split between the views
  - Some dependencies exist between views to allow for the visual linking
- Applications: Use for heterogeneous datasets where correlation and comparisons between views is particularly important.

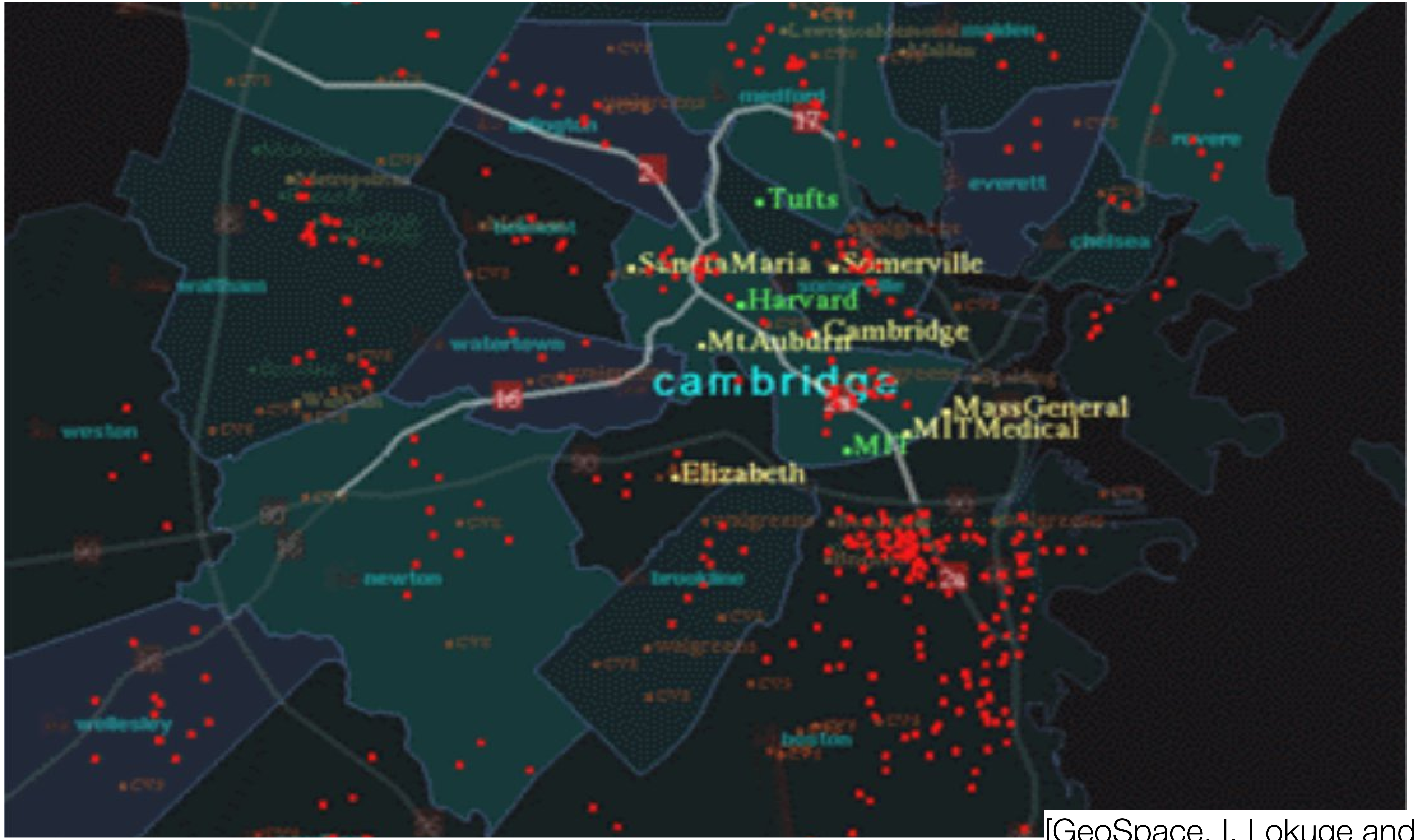
[W. Javed and N. Elmqvist, 2012]

Superimposition



[Mapgets, A. Voisard, 1995]

Superimposition



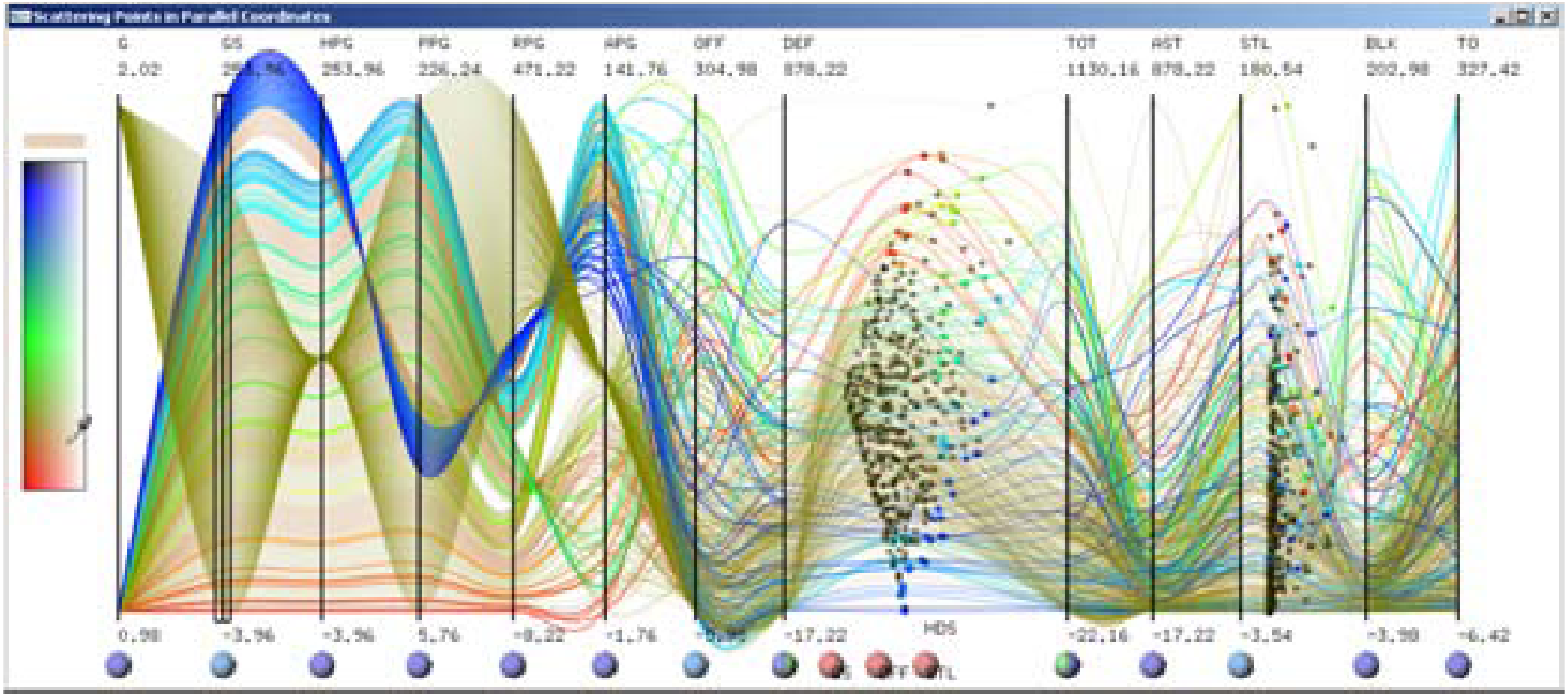
[GeoSpace, I. Lokuge and S. Ishizaki, 1995]

Superimposition Guidelines

- Benefits:
  - Allows direct comparison in the same visual space.
- Drawbacks:
  - May cause occlusion and high visual clutter.
  - The client visualization must share the same spatial mapping as the host visualization.
- Applications: In settings where comparison is common, or where the component visualization views need to be as large as possible (potentially the entire available space).

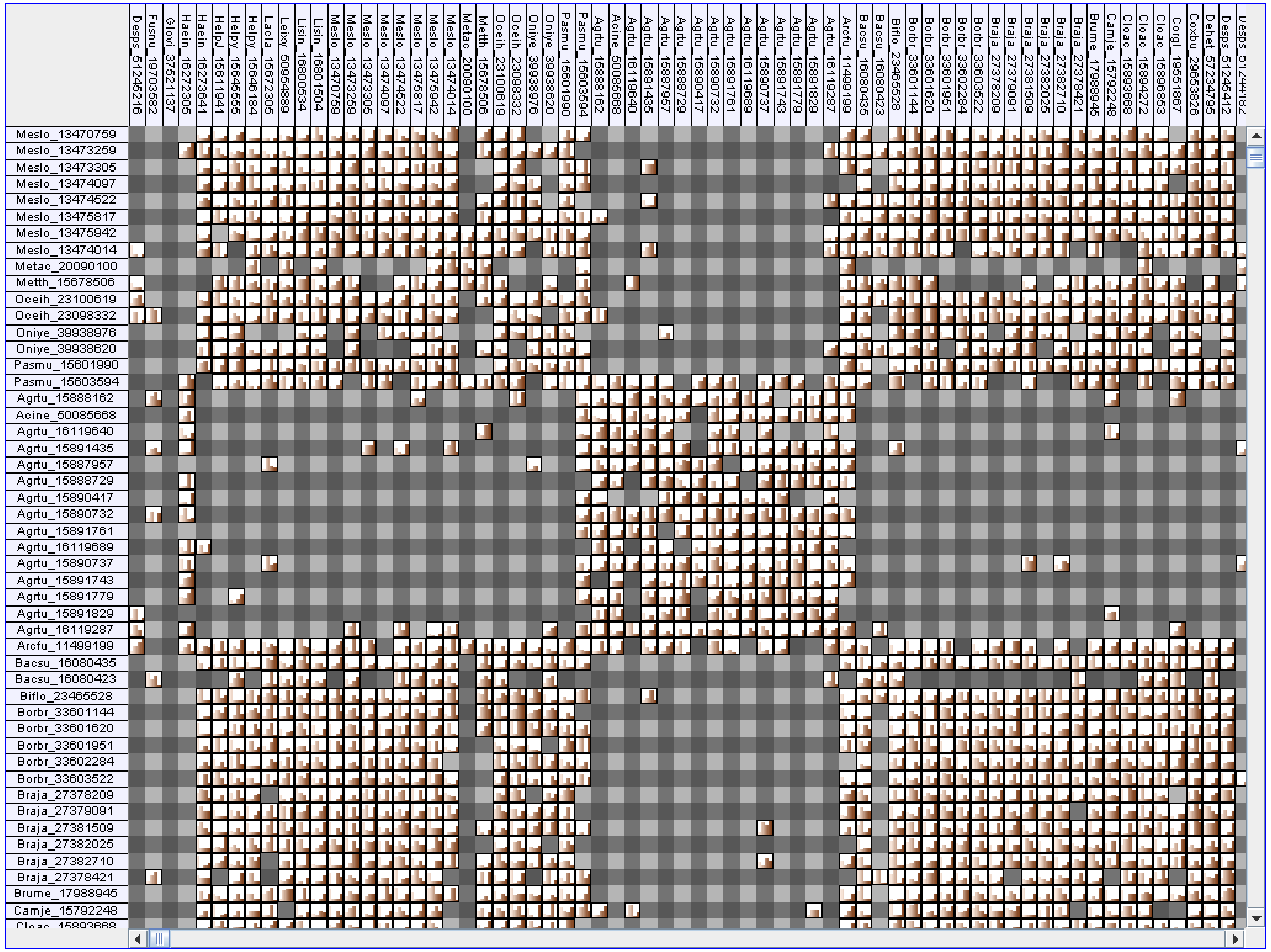
[W. Javed and N. Elmqvist, 2012]

Overloading



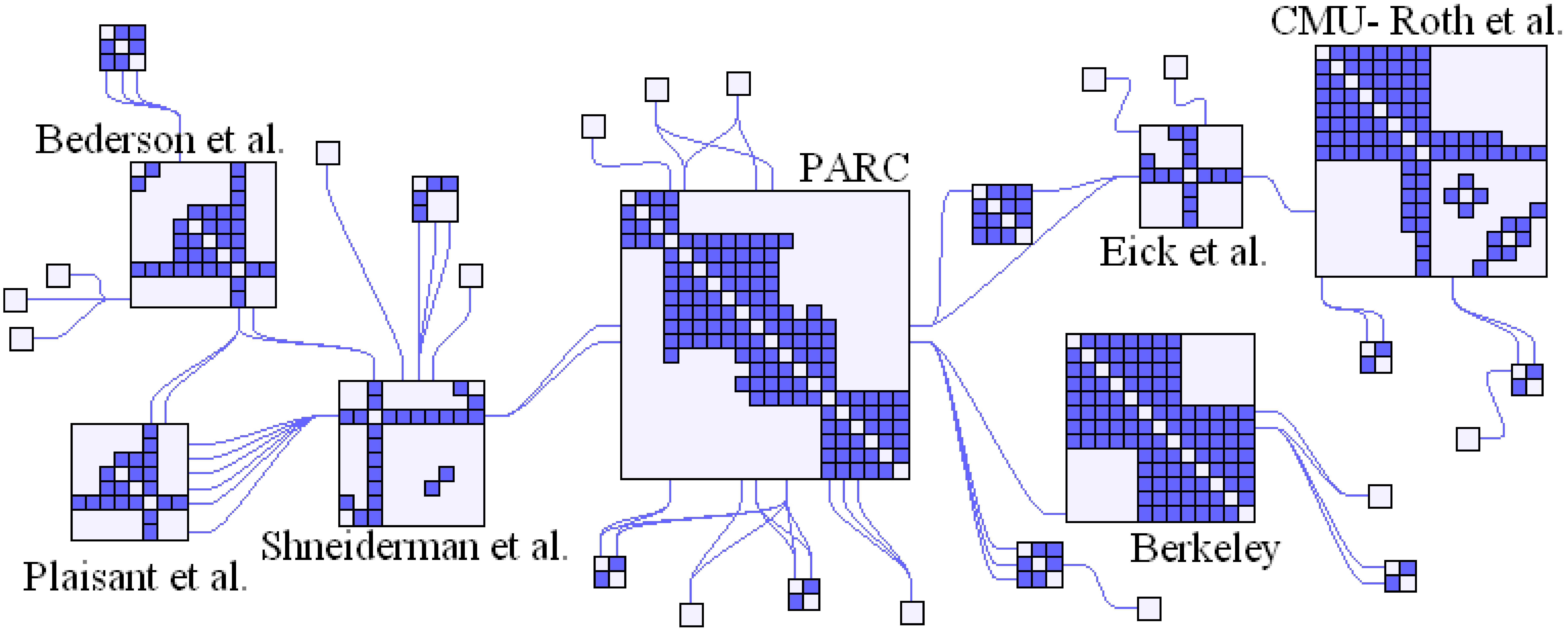
[SPCC, X. Yuan et al., 2009]

Nesting



[ZAME, N. Elmqvist et al., 2008]

Nesting



[NodeTrix, N. Henry et al., 2007]

Nesting Guidlines

- Benefits:
  - Very compact representation
  - Easy correlation
- Drawbacks:
  - Limited space for the client visualizations
  - Clutter is high
  - Visual design dependencies are high
- Applications: Situations that call for augmenting a particular visual representation with additional mapping

[W. Javed and N. Elmqvist, 2012]

Design Space

- Visualizations: the techniques or idioms used
- Spatial relation: relationship between visual structures in display space
- Data relation: visual relationship between items in different views
  - None: No relation
  - Item-item: One-to-one
  - Item-group: One-to-many
  - Item-dimension: Item in one view is a **scale** in another

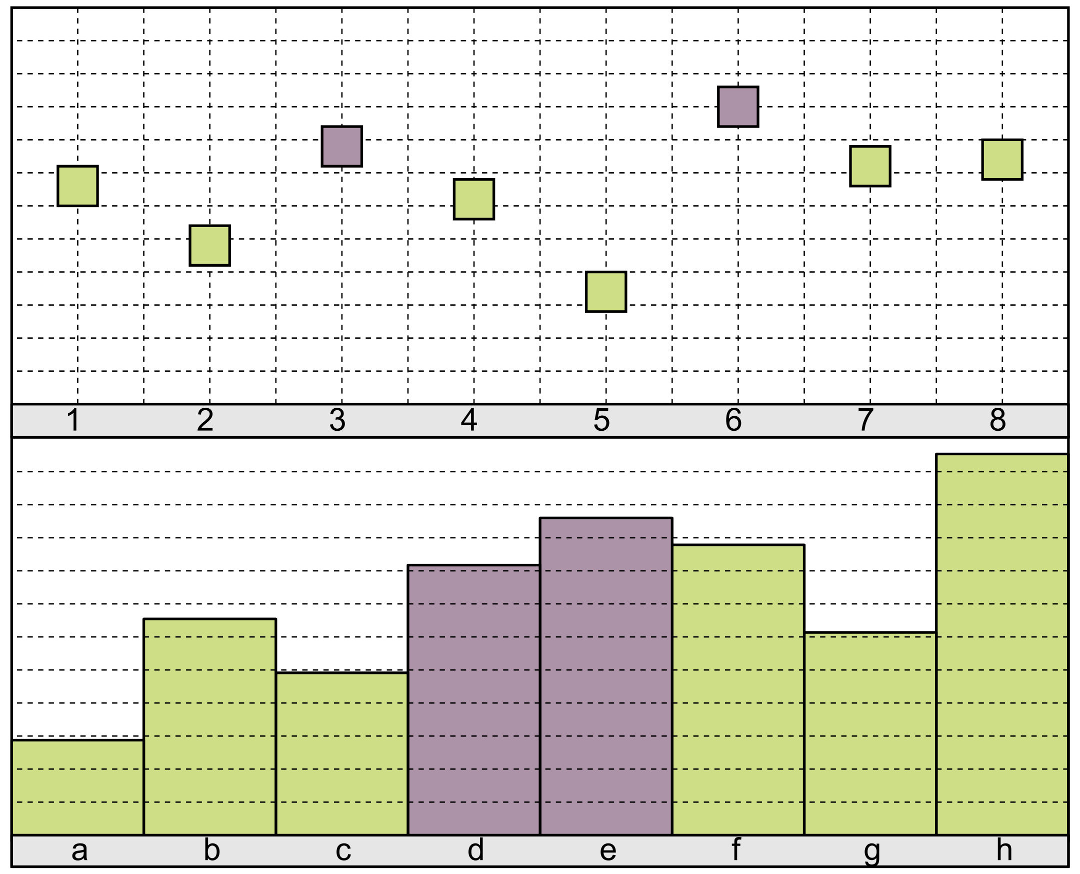
[W. Javed and N. Elmqvist, 2012]

Summary

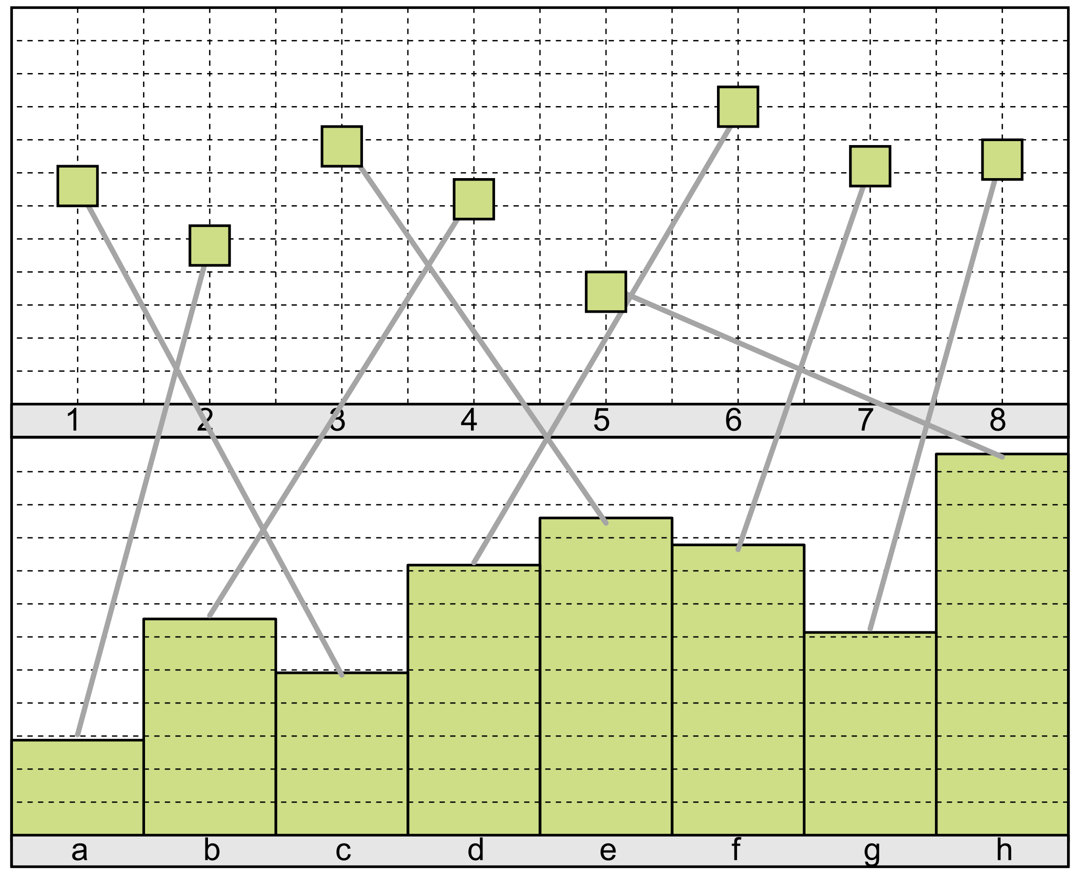
Technique	Visualization A	Visualization B	Spatial Relation	Data Relation
ComVis [24] (Figure 2)	any	any	juxtapose	none
Improvise [39] (Figure 3)	any	any	juxtapose	none
Jigsaw [36]	any	any	juxtapose	none
Snap-Together [30]	any	any	juxtapose	none
semantic substrates [34] (Figure 4)	node-link	node-link	juxtapose	item-item
VisLink [11] (Figure 5)	radial graph	node-link	juxtapose	item-item
Napoleon's March on Moscow [37]	time line view	area visualization	juxtapose	item-item
Mapgets [38] (Figure 6)	map	text	superimpose	item-item
GeoSpace [22] (Figure 7)	map	bar graph	superimpose	item-item
3D GIS [8]	map	glyphs	superimpose	item-item
Scatter Plots in Parallel Coordinates [45] (Figure 8)	parallel coordinate	scatterplot	overload	item-dimension
Graph links on treemaps [14] (Figure 9)	treemap	node-link	overload	item-item
SparkClouds [21]	tag cloud	line graph	overload	item-item
ZAME [13] (Figure 10)	matrix	glyphs	nested	item-group
NodeTrix [17] (Figure 11)	node-link	matrix	nested	item-group
TimeMatrix [44]	matrix	glyphs	nested	item-group
GPUVis [25]	Scatterplot	glyphs	nested	item-group

[W. Javed and N. Elmqvist, 2012]

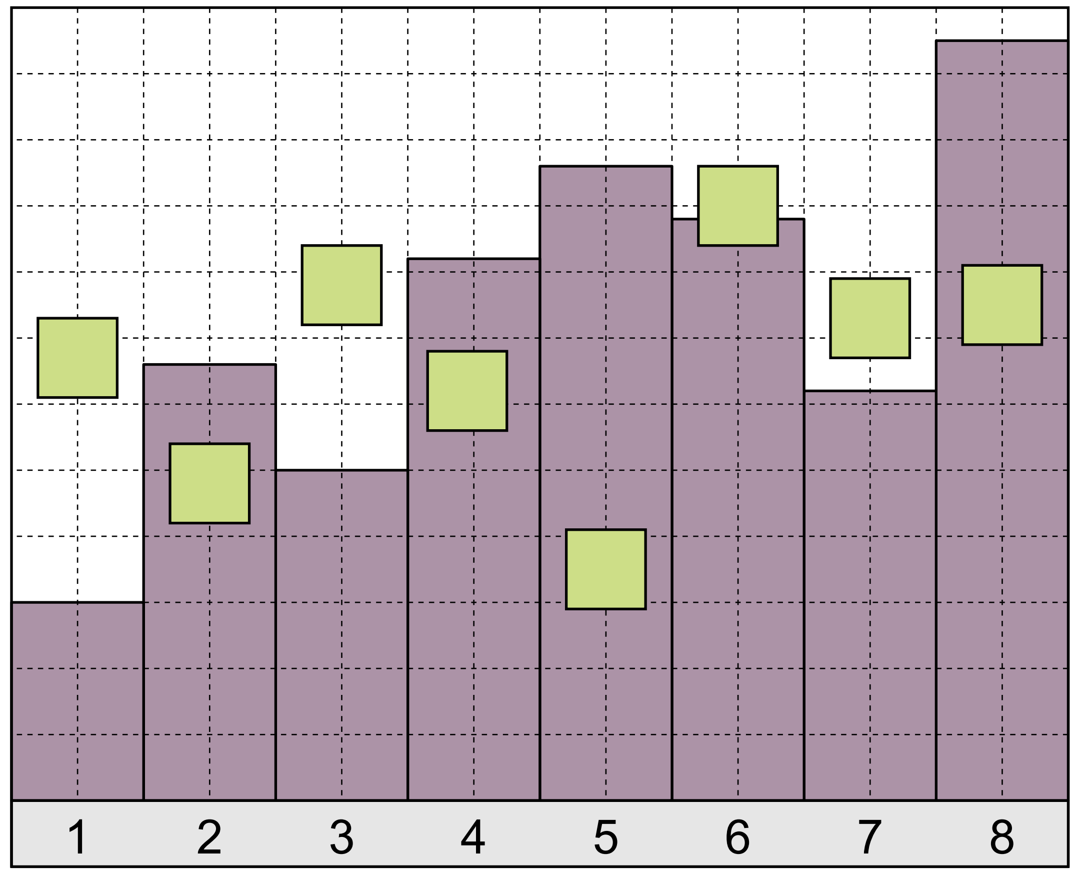
Summary (Scatterplot + Bar Chart)



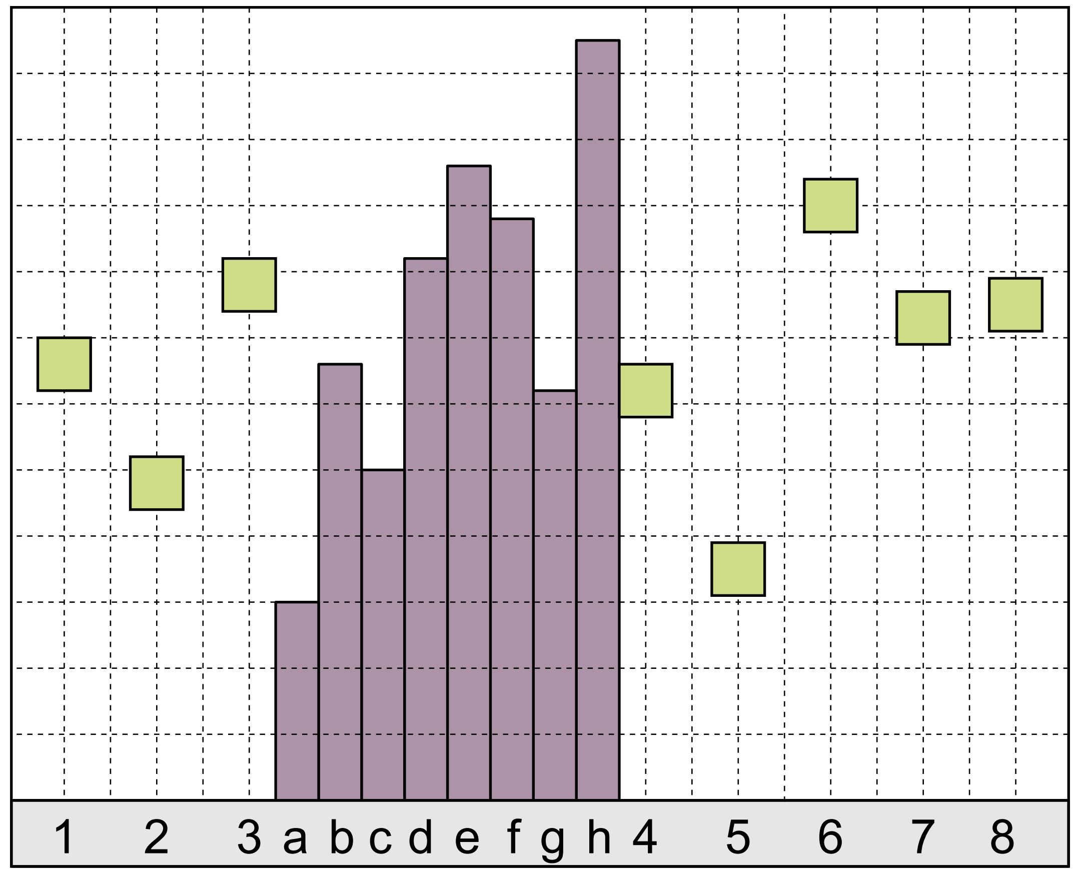
(a) Juxtaposed views.



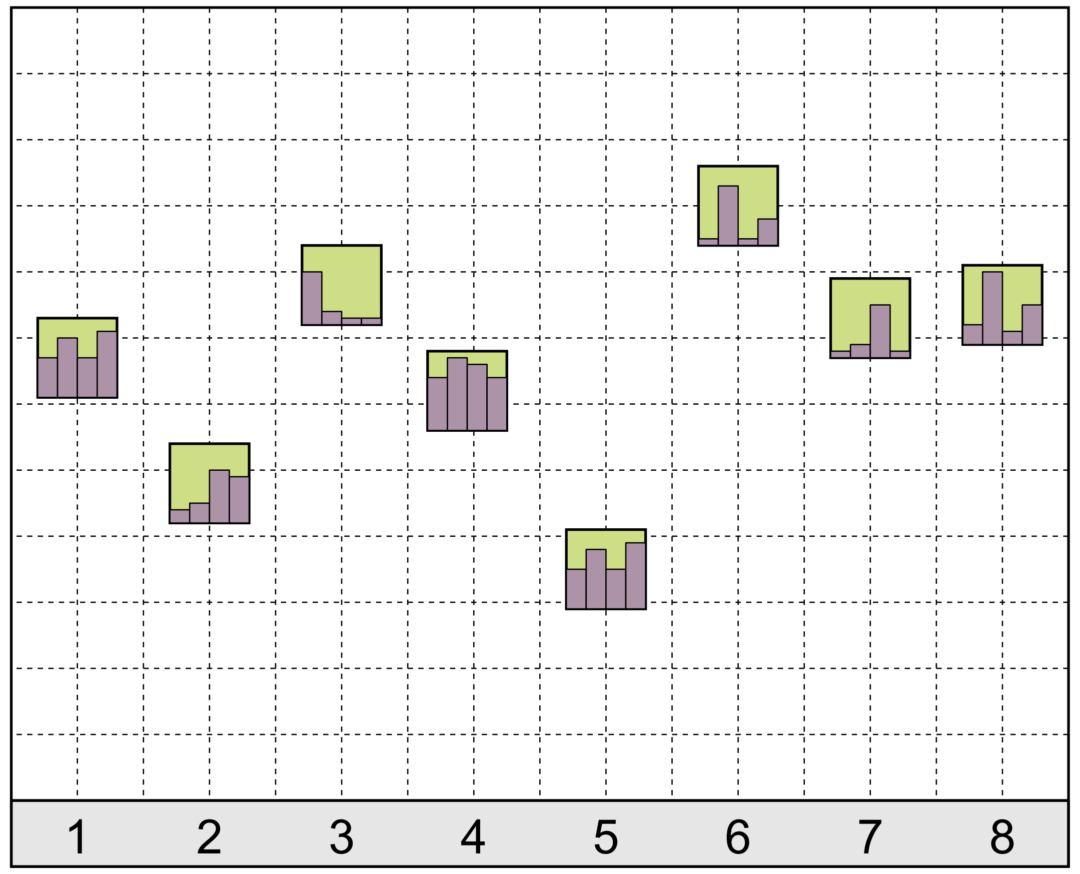
(b) Integrated views.



(c) Superimposed views.



(d) Overloaded views.



(e) Nested views.

[W. Javed and N. Elmqvist, 2012]

What about large displays, multiple devices, or virtual/augmented reality?

Visualization on Devices other than Personal Computers

VisTiles

[Langner, Horak, and Dachselt, VIS 2017]

David Meets Goliath

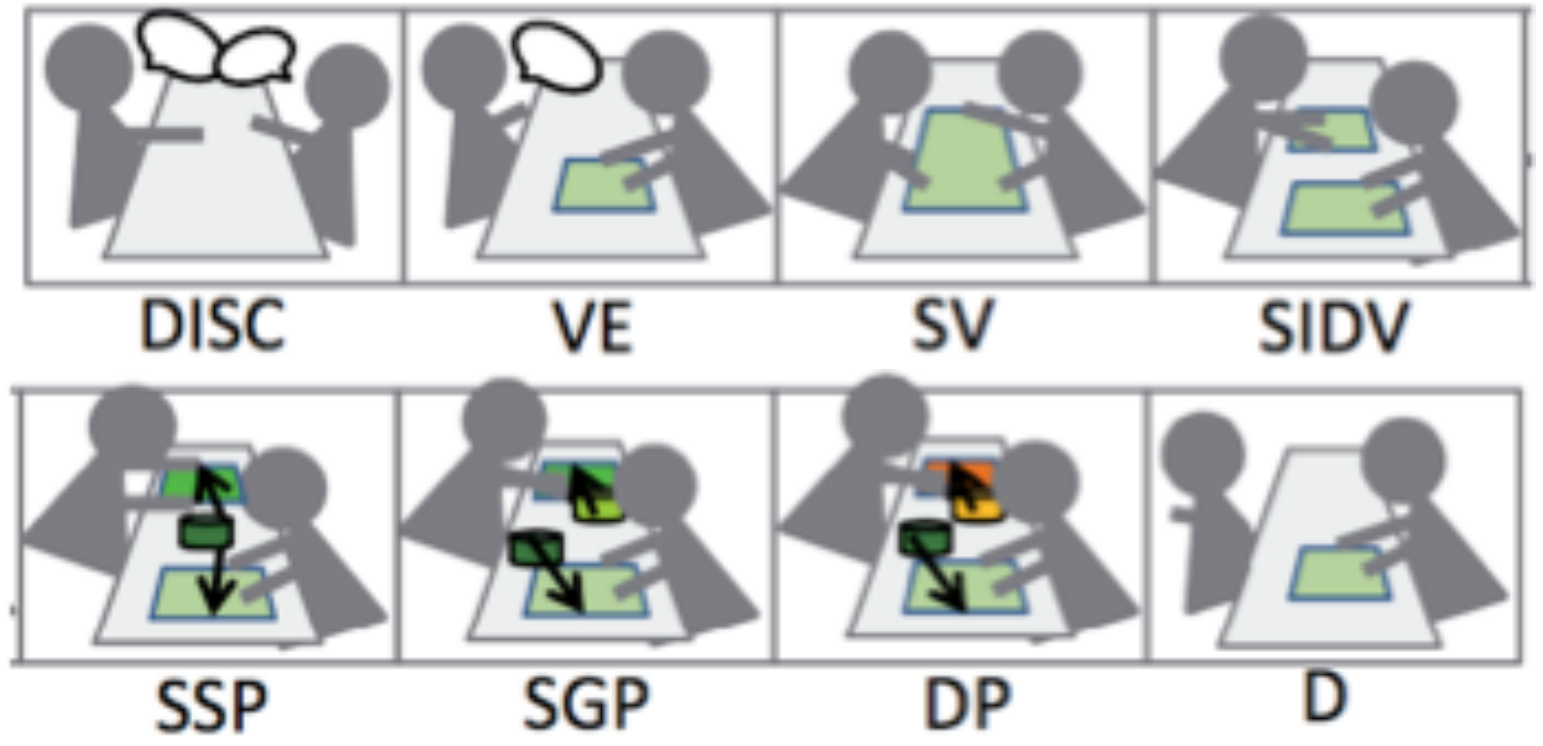
[Horak, Badam, Elmqvist, and Dachselt, CHI 2018]

Now: **Large Wall-sized Displays**

- More data
- More views
- More users

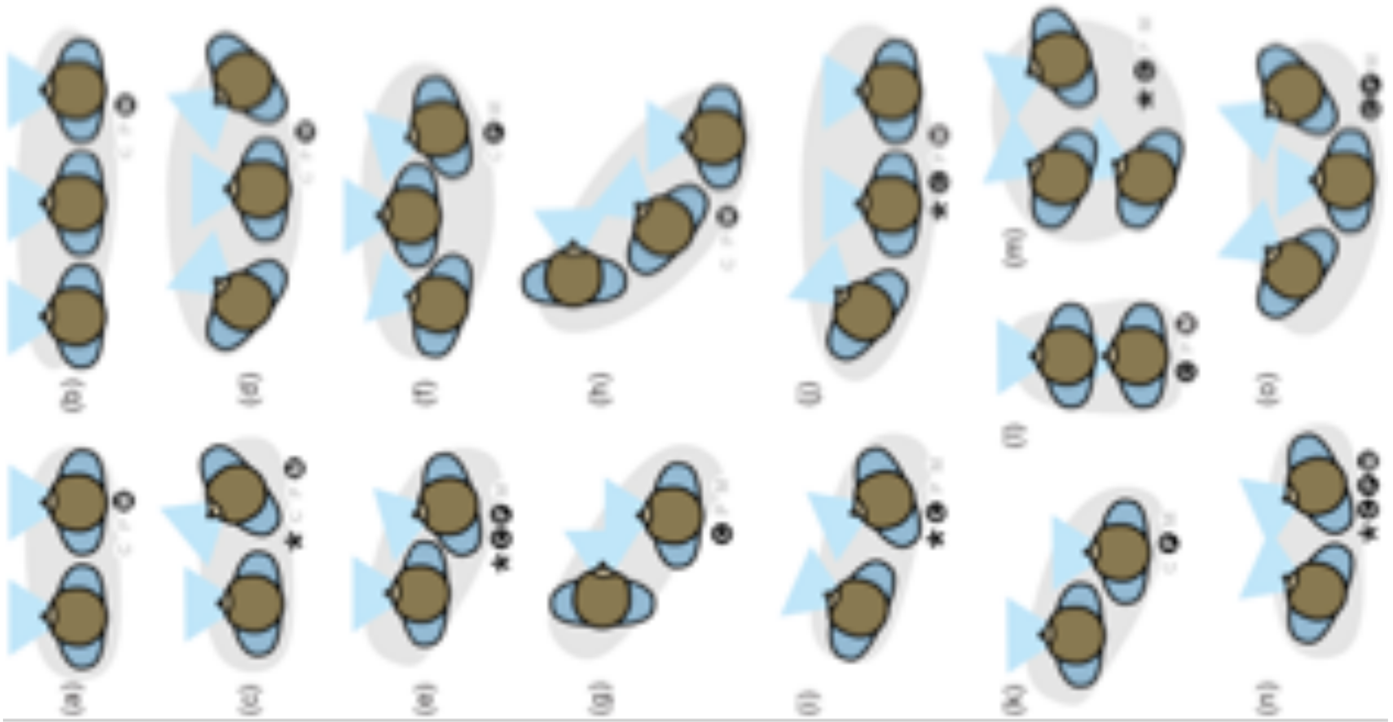
[R. Langner et al.]

Large Display Interactions and Movement



Collaboration Styles

[Isenberg, Fisher, Morris, Inkpen, Czerwinski, VAST 2010]



Territoriality and Formations

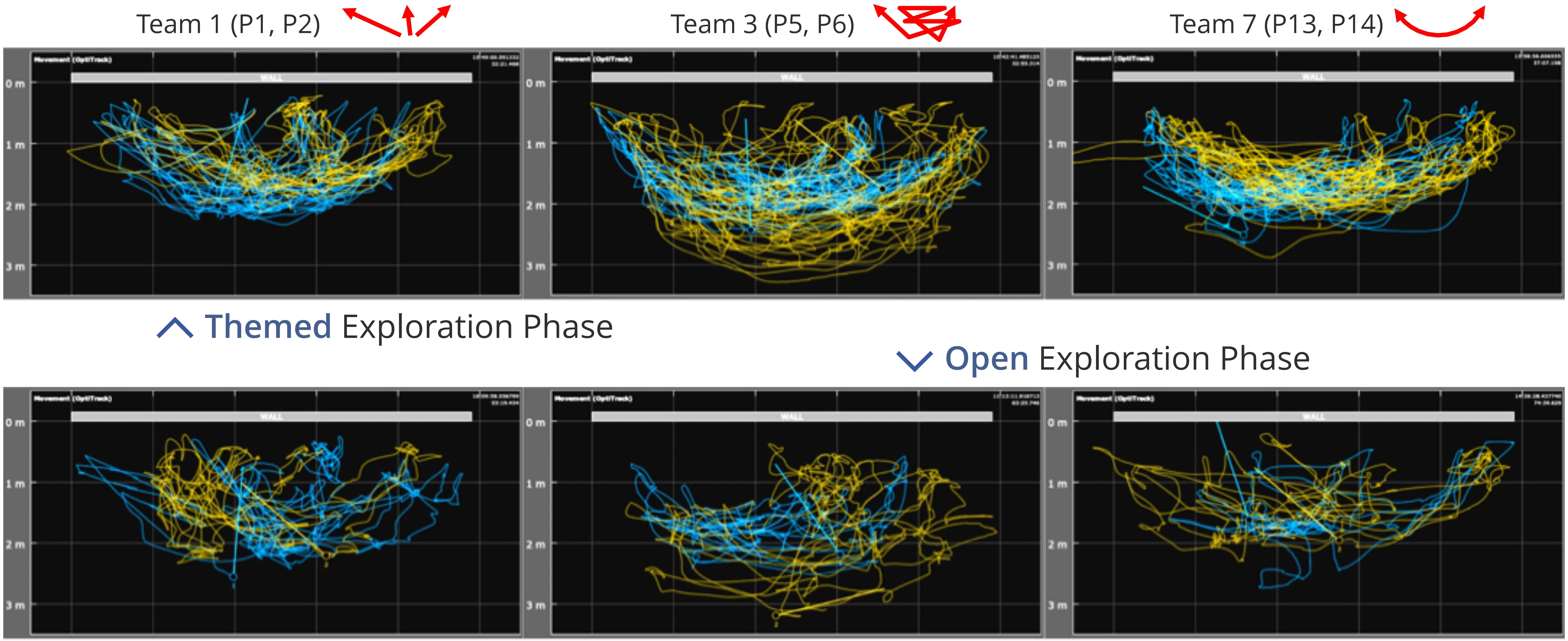
[Azad, Ruiz, Vogel, Hancock, and Lank, DIS 2012]

Proximity to the display

Up Close and Personal [Jakobsen and Hornbæk, TOCHI 2014]

[R. Langner et al.]

User Study on User Movement



[R. Langner et al.]

Vistribute

Vistribute:
Distributing Interactive Visualizations in Dynamic Multi-Device Setups

Tom Horak, Andreas Mathisen, Clemens N. Klokmose, Raimund Dachselt, Niklas Elmqvist

ACM CHI 2019
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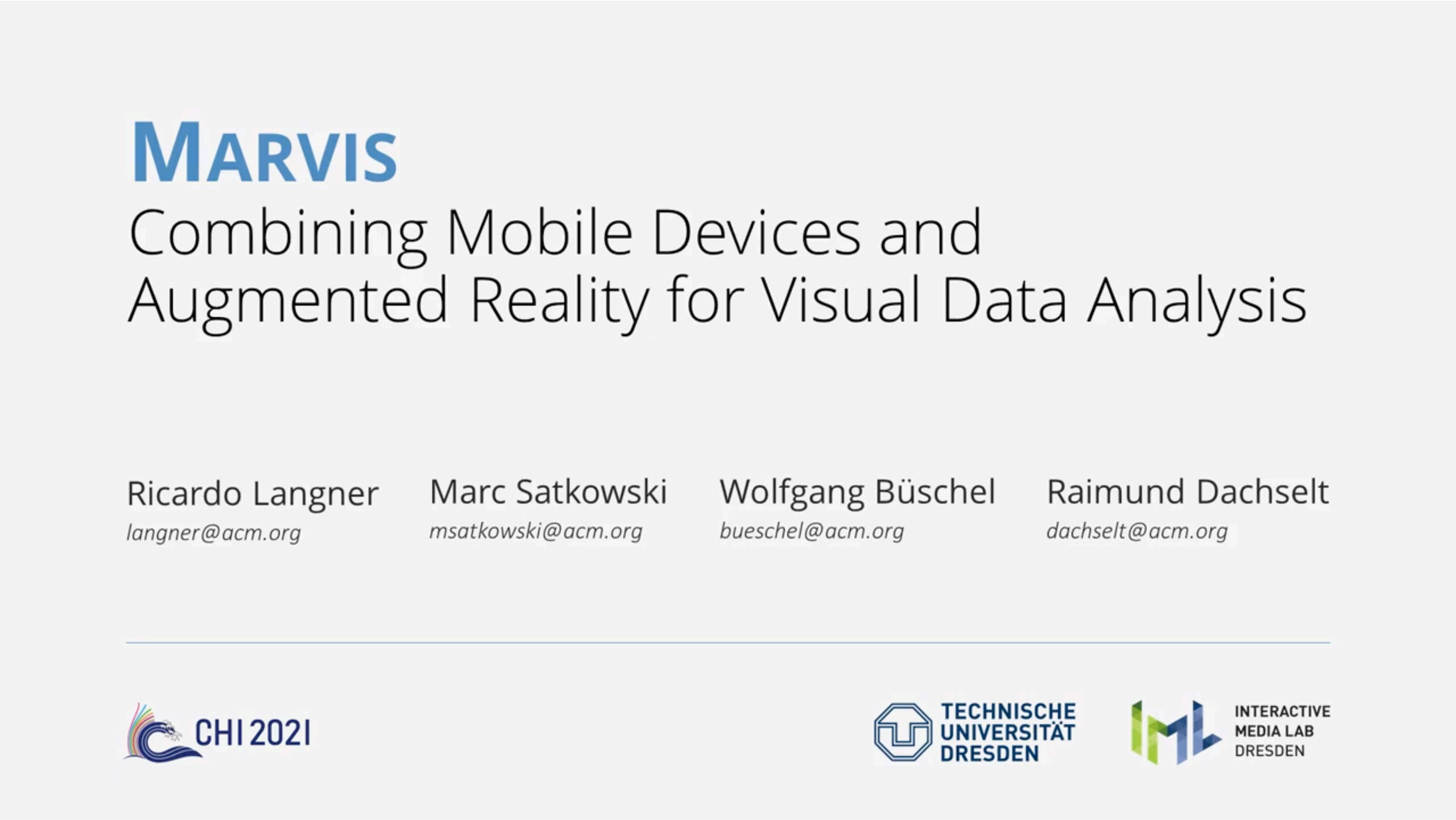
MARVIS: Mobile Devices & Augmented Reality



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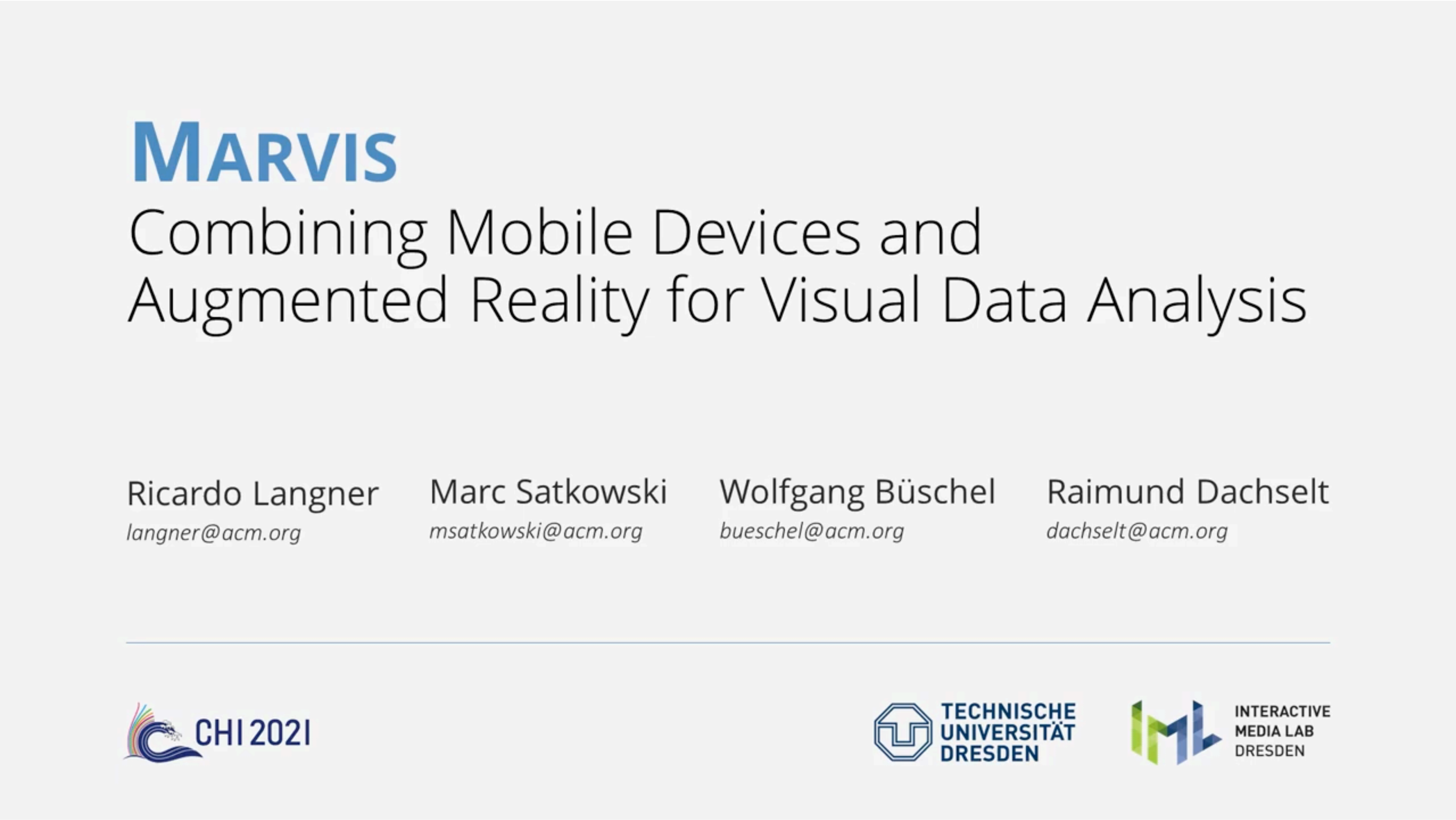
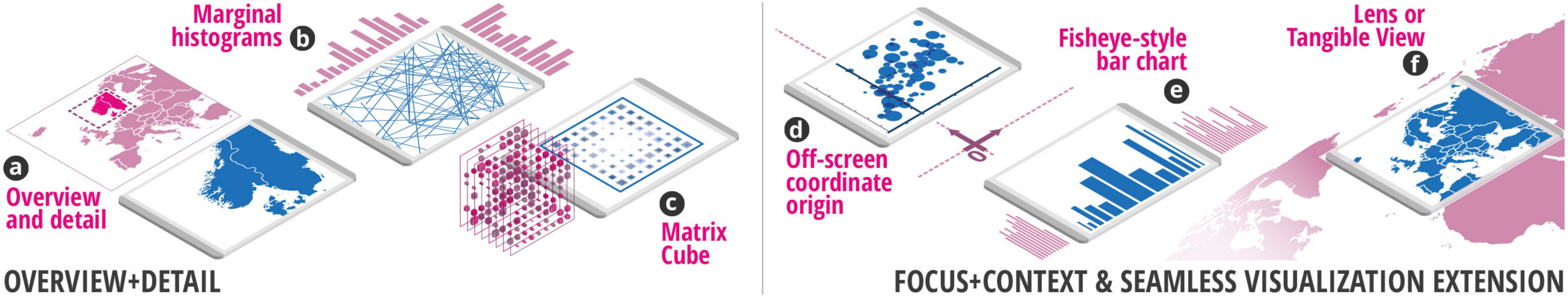


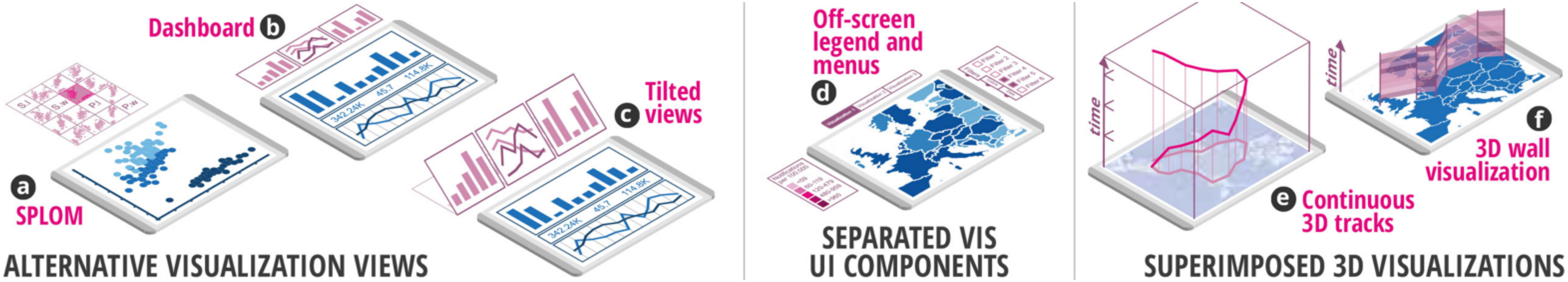
Using Tablets and Augmented Reality



Using AR for adapting different *Overview+Detail* and *Focus+Context* techniques. (a) A typical map overview; (b) Marginal histograms around the mobile device; (c) 3D visualization of a Matrix Cube; (d) Navigation support by an off-screen coordinate origin; (e) Zoomed in bar chart with fisheye-style continuation; (f) Mobile device as a detailed lens into a larger map;

[R. Langner et al.]

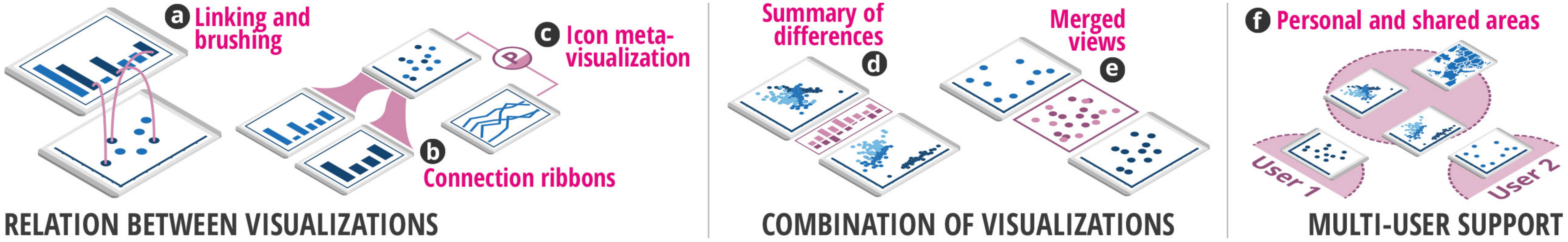
Using Tablets and Augmented Reality



Using AR for *Alternative Visualization Views*, *Separated Visualization User Interface Components*, and *Superimposed 3D Visualizations*. (a) SPLOM shows alternative scatterplots configurations; (b) Distributed views of a dashboard; (c) Tilted AR views; (d) Off-loaded legend and menus; (e) Continuous 3D track above a map; (f) 3D wall visualization aligned to a map;

[R. Langner et al.]

Using Tablets and Augmented Reality



Using AR for *Relations Between Visualizations*, *Combination of Visualizations*, and *Multi-User Support*. (a) Linking and brushing supported by curved AR connections; (b) Ribbons between devices indicate the relative proportions; (c) Icon meta-visualizations reveal view relations; (d) AR bar chart summarizes calculated differences between views; (e) Merging two views in AR; (f) Personal and shared areas for collaborative activities;

[R. Langner et al.]