CS-5630 / CS-6630 Visualization for Data Science
Interaction

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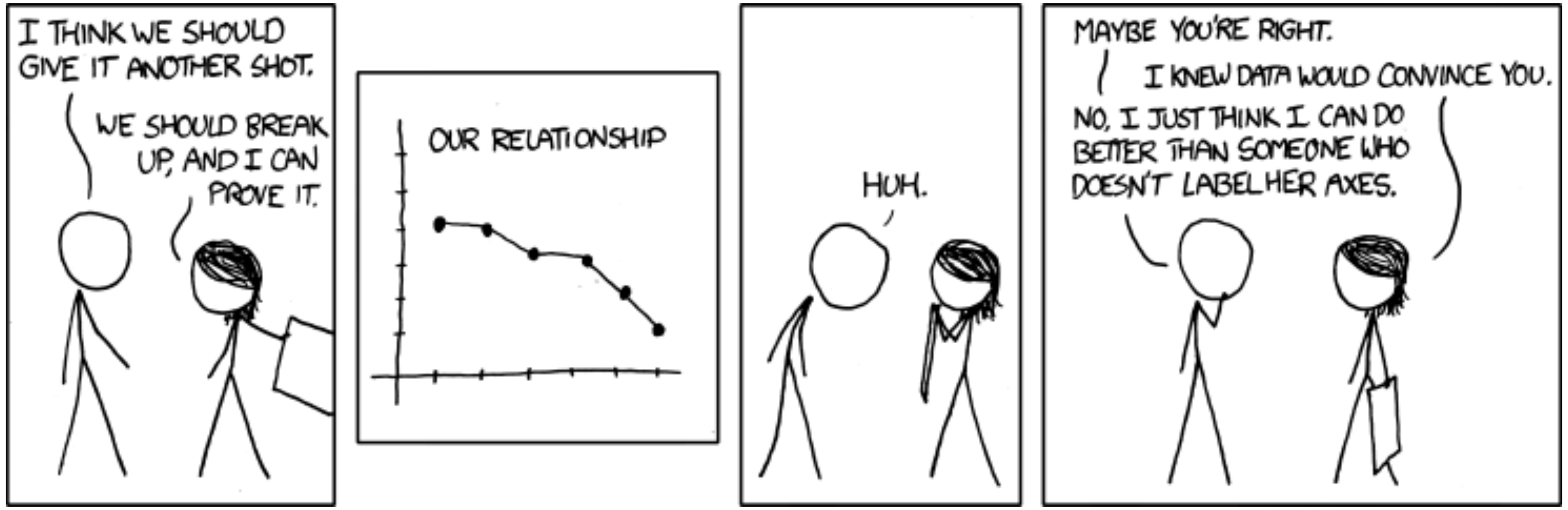
THE UNIVERSITY OF UTAH



[xkcd]

Project

It’s time to start thinking about your project.

Announce your project by Oct 19

Your project proposal, due Oct 26

- Use fall break to get started!
- Come to my office hours!

What you need:

- A team – use #looking-f-teammember channel
- An idea
- A dataset (that you actually can get!) http://dataviscourse.net/2018/resources/

More Info: http://dataviscourse.net/2018/project/

Stages

Announcement (not graded)

Proposal (5%)

Project Milestone (10%)

Final Project (25%)

- Process Book
- Narrated Video
- Vis live on website

Project Requirements

Scope as agreed upon with TAs

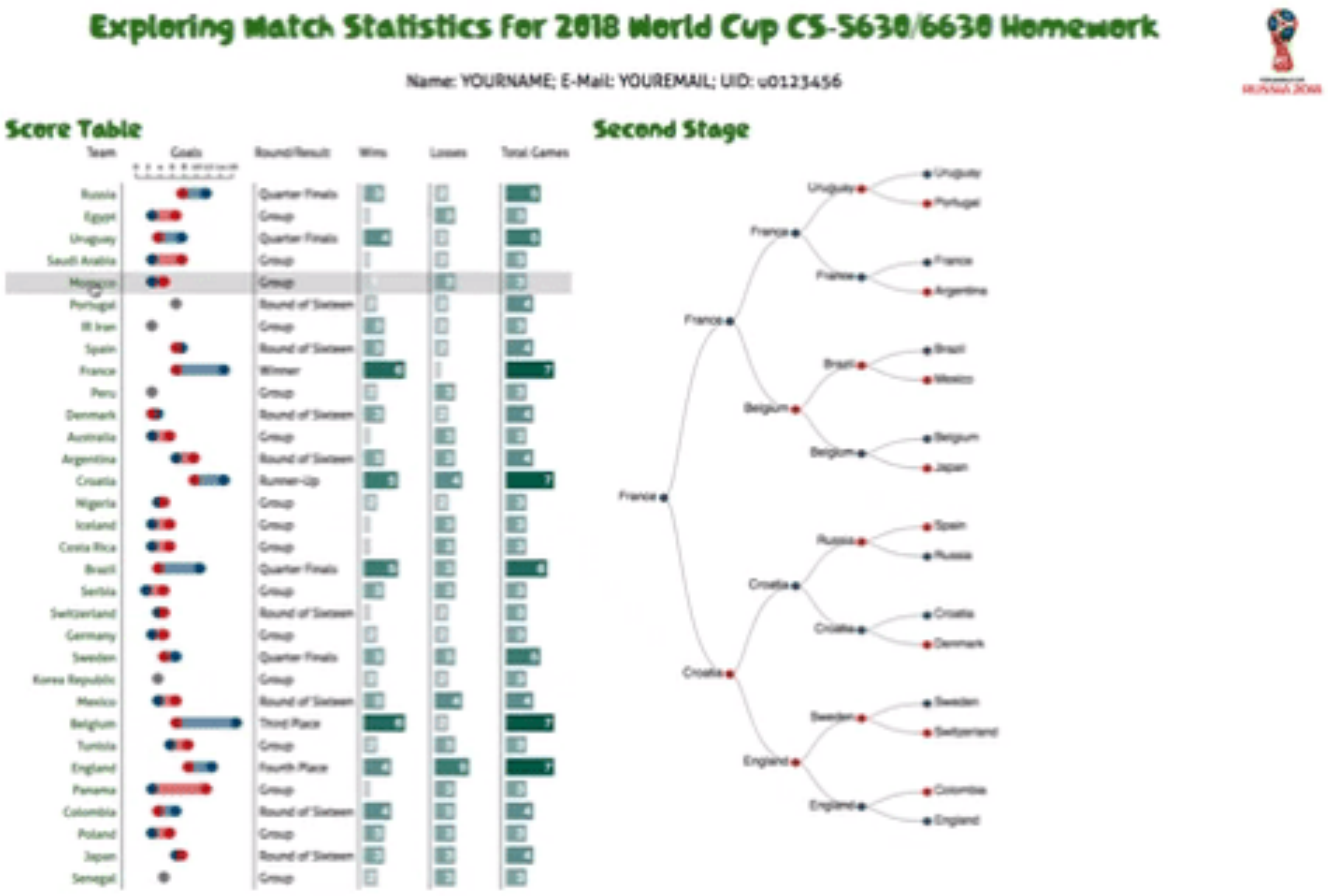
Be ambitious! Define your goals and categorize them:

- must have, nice to have, etc.
- check out the hall of fame!

Minimum:

- original idea of dataset/vis combo
- interactive
- at least two coordinated views

We'd like to see custom Visses!



Next Week

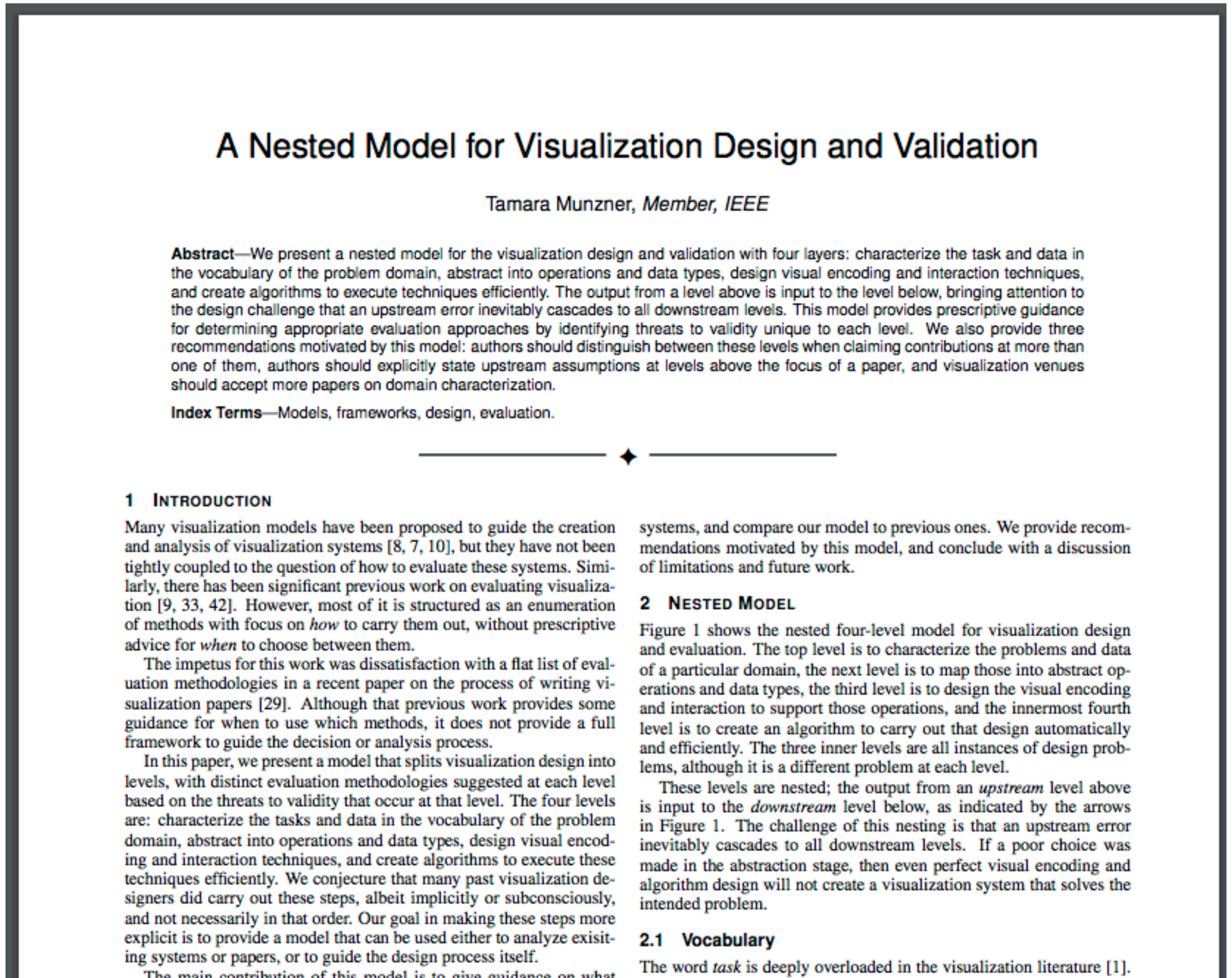
Tuesday:

Designing Visualizations, Tasks

Mandatory Reading

A nested model for visualization design and validation. Tamara Munzner. IEEE Transactions on Visualization and Computer Graphics 15(6), 2009.

Thursday: D3 Layouts (Sam)



A Nested Model for Visualization Design and Validation

Tamara Munzner, *Member, IEEE*

Abstract—We present a nested model for the visualization design and validation with four layers: characterize the task and data in the vocabulary of the problem domain, abstract into operations and data types, design visual encoding and interaction techniques, and create algorithms to execute techniques efficiently. The output from a level above is input to the level below, bringing attention to the design challenge that an upstream error inevitably cascades to all downstream levels. This model provides prescriptive guidance for determining appropriate evaluation approaches by identifying threats to validity unique to each level. We also provide three recommendations motivated by this model: authors should distinguish between these levels when claiming contributions at more than one of them, authors should explicitly state upstream assumptions at levels above the focus of a paper, and visualization venues should accept more papers on domain characterization.

Index Terms—Models, frameworks, design, evaluation.

1 INTRODUCTION

Many visualization models have been proposed to guide the creation and analysis of visualization systems [8, 7, 10], but they have not been tightly coupled to the question of how to evaluate these systems. Similarly, there has been significant previous work on evaluating visualization [9, 33, 42]. However, most of it is structured as an enumeration of methods with focus on *how* to carry them out, without prescriptive advice for *when* to choose between them.

The impetus for this work was dissatisfaction with a flat list of evaluation methodologies in a recent paper on the process of writing visualization papers [29]. Although that previous work provides some guidance for when to use which methods, it does not provide a full framework to guide the decision or analysis process.

In this paper, we present a model that splits visualization design into levels, with distinct evaluation methodologies suggested at each level based on the threats to validity that occur at that level. The four levels are: characterize the tasks and data in the vocabulary of the problem domain, abstract into operations and data types, design visual encoding and interaction techniques, and create algorithms to execute these techniques efficiently. We conjecture that many past visualization designers did carry out these steps, albeit implicitly or subconsciously, and not necessarily in that order. Our goal in making these steps more explicit is to provide a model that can be used either to analyze existing systems or papers, or to guide the design process itself.

systems, and compare our model to previous ones. We provide recommendations motivated by this model, and conclude with a discussion of limitations and future work.

2 NESTED MODEL

Figure 1 shows the nested four-level model for visualization design and evaluation. The top level is to characterize the problems and data of a particular domain, the next level is to map those into abstract operations and data types, the third level is to design the visual encoding and interaction to support those operations, and the innermost fourth level is to create an algorithm to carry out that design automatically and efficiently. The three inner levels are all instances of design problems, although it is a different problem at each level.

These levels are nested; the output from an *upstream* level above is input to the *downstream* level below, as indicated by the arrows in Figure 1. The challenge of this nesting is that an upstream error inevitably cascades to all downstream levels. If a poor choice was made in the abstraction stage, then even perfect visual encoding and algorithm design will not create a visualization system that solves the intended problem.

2.1 Vocabulary

The word *task* is deeply overloaded in the visualization literature [1].

Interaction

Spectrum

Static Content

e.g., infographics, books

Dynamic Content

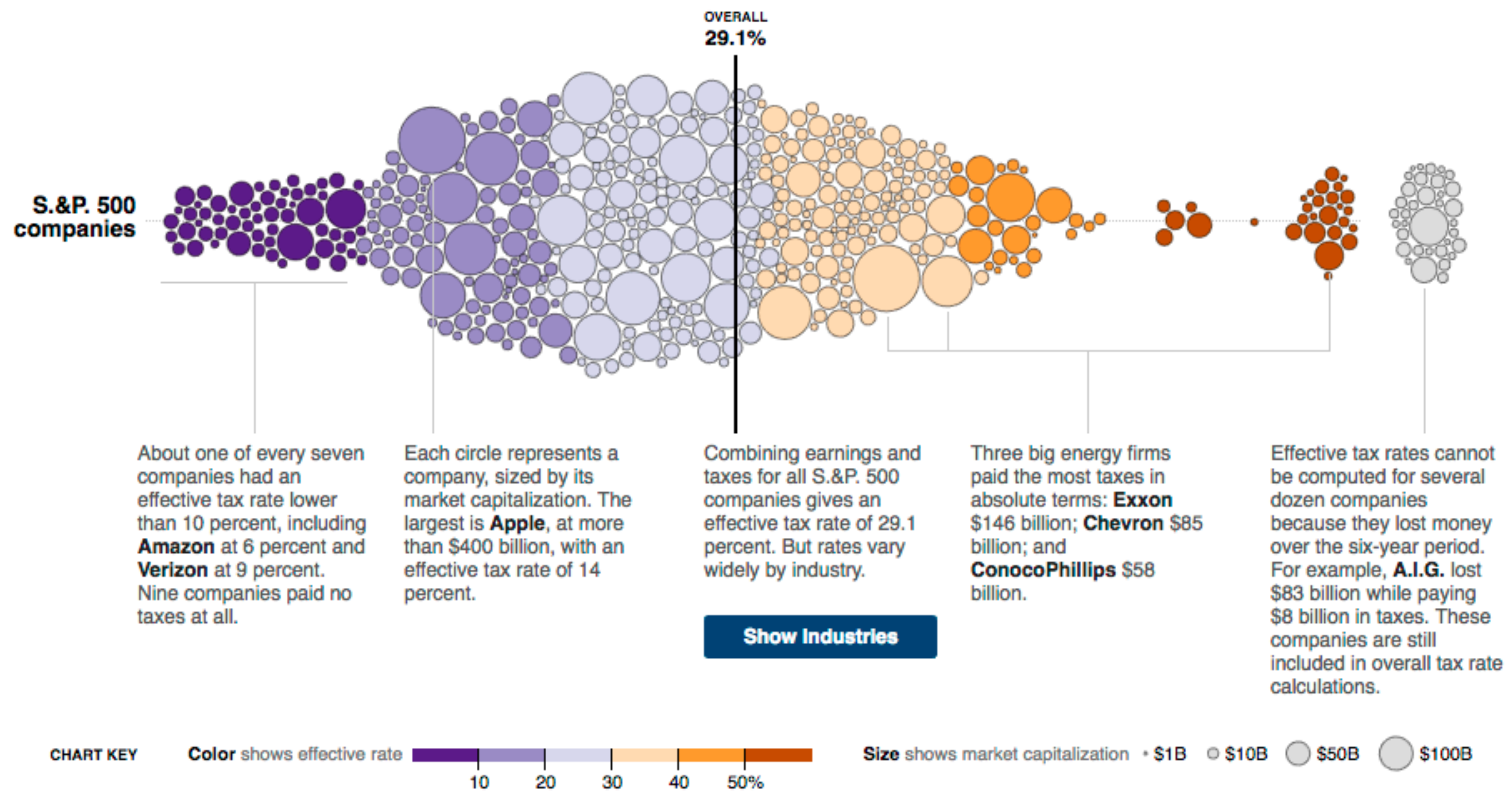
1. Animated Content
   “Auto-play”, user not in control
2. Interactive Content
   Changes are a result of user actions

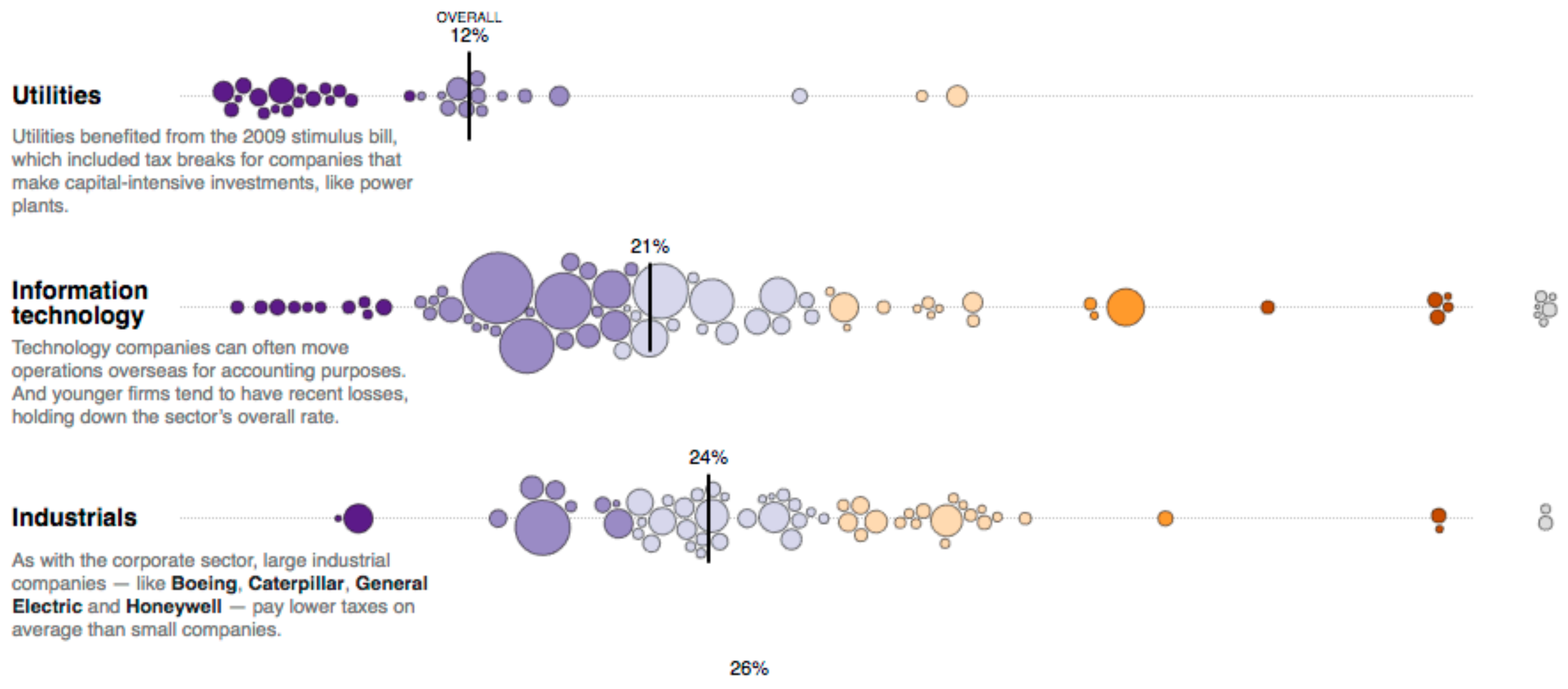
Why Interact with Visualization?

Explore data that is big / complex

There is too much data

There are too many ways to show it



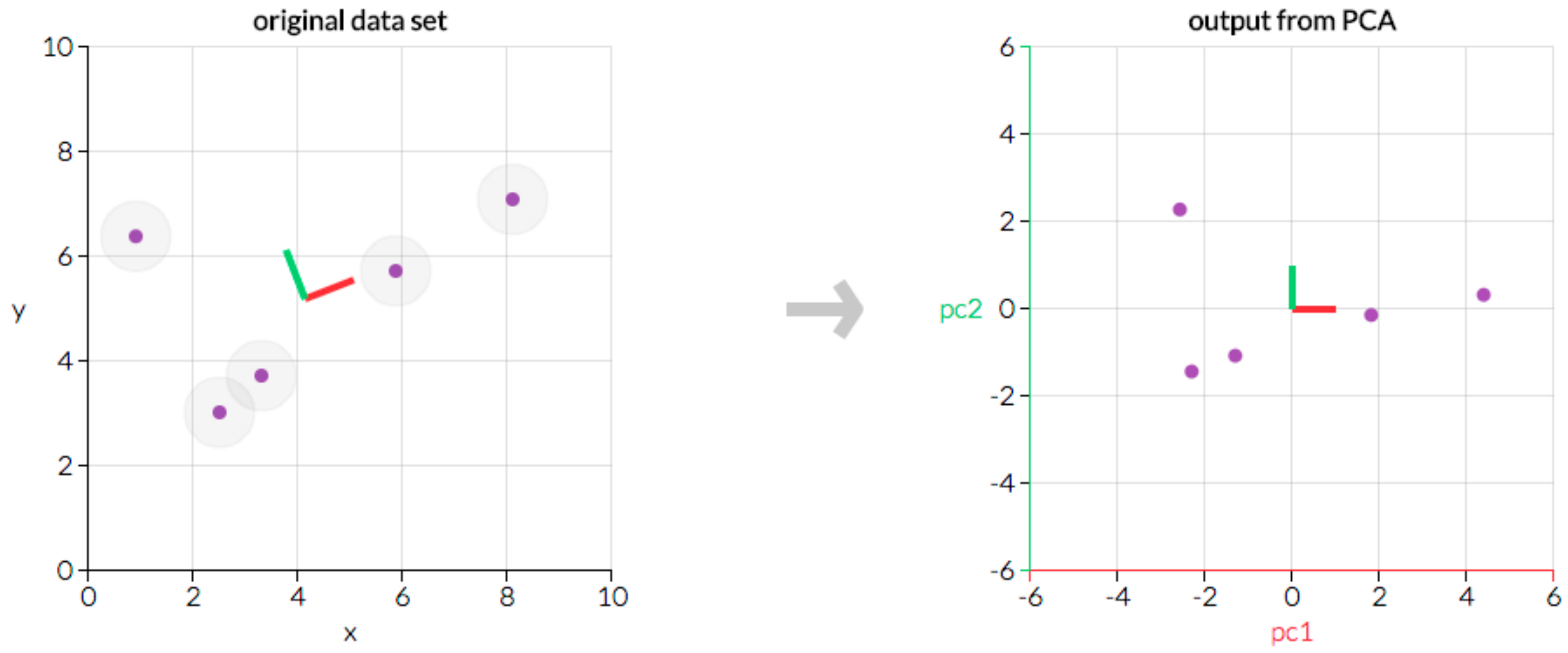


http://www.nytimes.com/interactive/2013/05/25/sunday-review/corporate-taxes.html

Why Interact with Visualization?

Interaction amplifies cognition

- We understand things better if we can touch them
- If we can observe cause and effect



Interaction Methods

What do you design for?

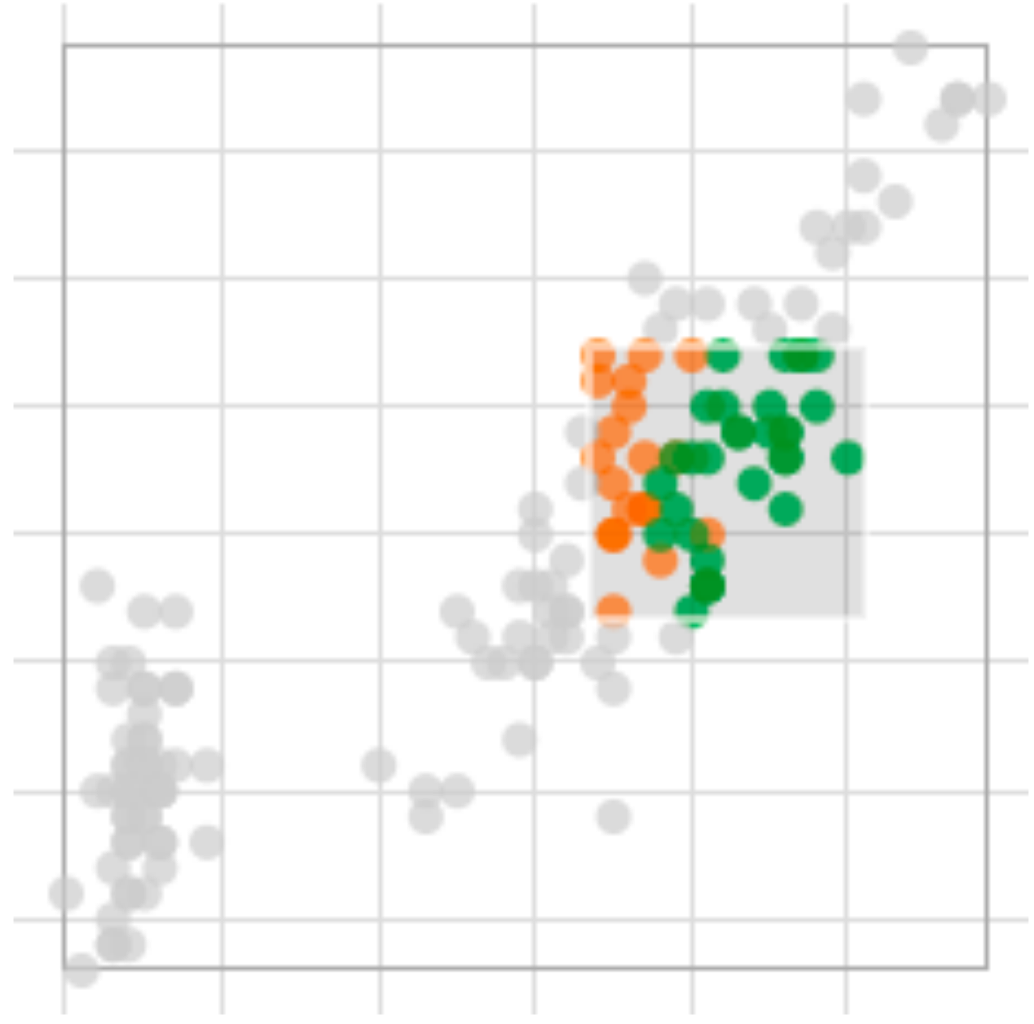
- Mouse, keyboard?
- Touch interaction / mobile?
- Gestures?
- Eye Movement?
- Speech?

https://www.youtube.com/watch?v=QXLfT9sFcbc

Direct Manipulation

Interact directly with object

Continuous feedback / updates



Compare to using a query, a slider, etc.

Types of Interaction

Single View

Change over time

Navigation

Semantic zooming

Filtering and Querying

Focus + Context

Multiple Views

Selection (Details on Demand)

Linking & Brushing

Adapting Representations

Next Lecture

Purposes of Interaction

DOI:10.1145/2133806.2133821

Article development led by acmqueue
queue.acm.org

A taxonomy of tools that support the fluent and flexible use of visualizations.

BY JEFFREY HEER AND BEN SHNEIDERMAN

Interactive Dynamics for Visual Analysis

THE INCREASING SCALE and availability of digital data provides an extraordinary resource for informing public policy, scientific discovery, business strategy, and even our personal lives. To get the most out of such data, however, users must be able to make sense of it: To pursue questions, uncover patterns of interest, and identify (and potentially correct) errors. In concert with data-management systems and statistical algorithms, analysis requires contextualized hu- analysis consists of repeated explorations as users develop insights about significant relationships, domain-specific contextual influences, and causal

TABLE 1: Taxonomy of interactive dynamics for visual analysis

Data & View Specification	**Visualize** data by choosing visual encodings. **Filter** out data to focus on relevant items. **Sort** items to expose patterns. **Derive** values or models from source data.
View Manipulation	**Select** items to highlight, filter, or manipulate them. **Navigate** to examine high-level patterns and low-level detail. **Coordinate** views for linked, multi-dimensional exploration. **Organize** multiple windows and workspaces.
Process & Provenance	**Record** analysis histories for revisitation, review and sharing. **Annotate** patterns to document findings. **Share** views and annotations to enable collaboration. **Guide** users through analysis tasks or stories.

Data & View Specification, View Manipulation

https://taggle-daily.caleydoapp.org /

Process and Provenance:

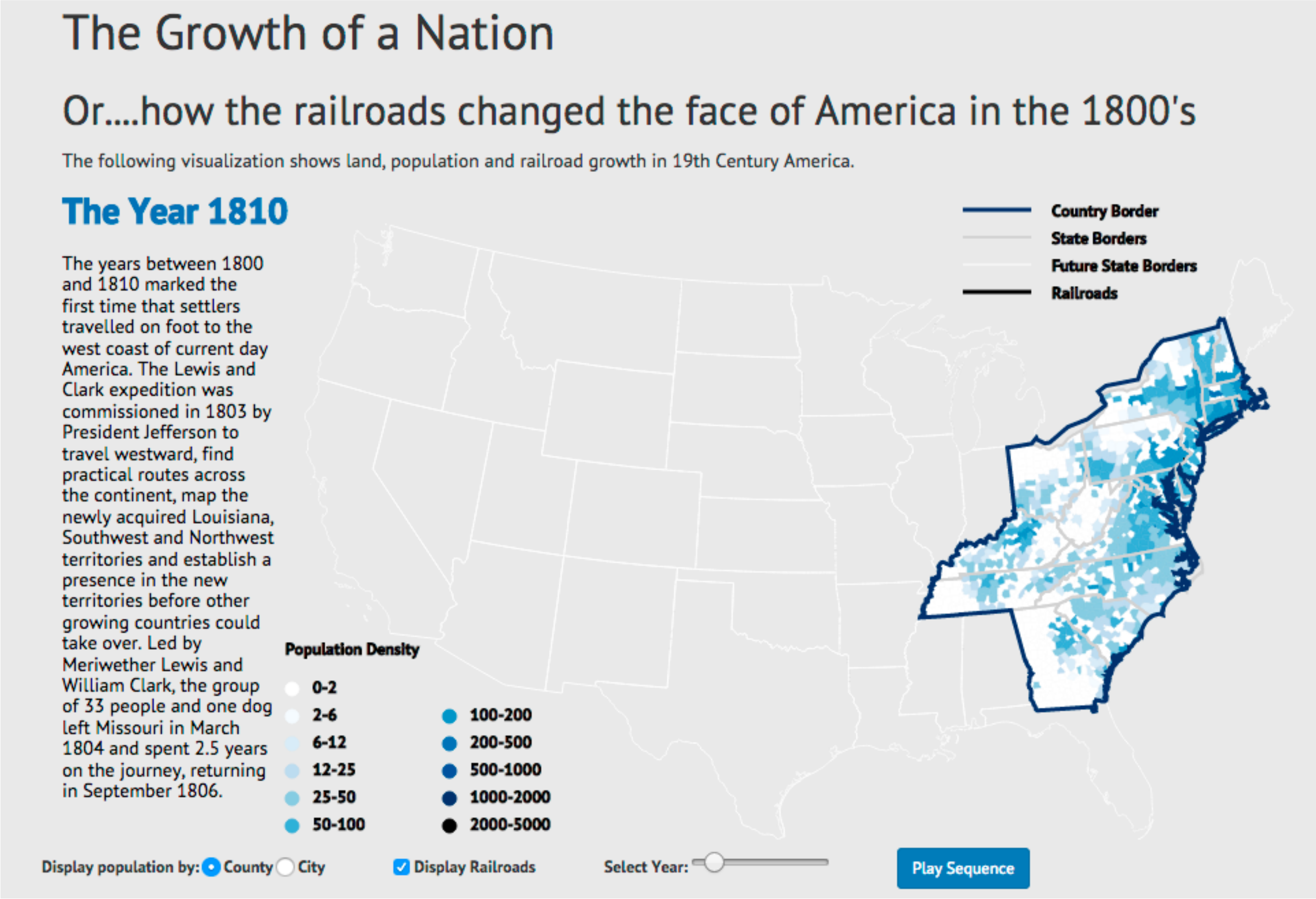
https://gapminder.caleydoapp.org/#clue_graph=clue_gapminder0&clue_state=30&clue=P&clue_slide=41

Change over Time / Transitions

Change over Time

Use, e.g., slider to see view with data at different times

Sometimes better to show difference explicitly



[Lauren Wood]

Change over Time

Doesn’t have to be literal time:

- change as you go
- as part of an analysis process

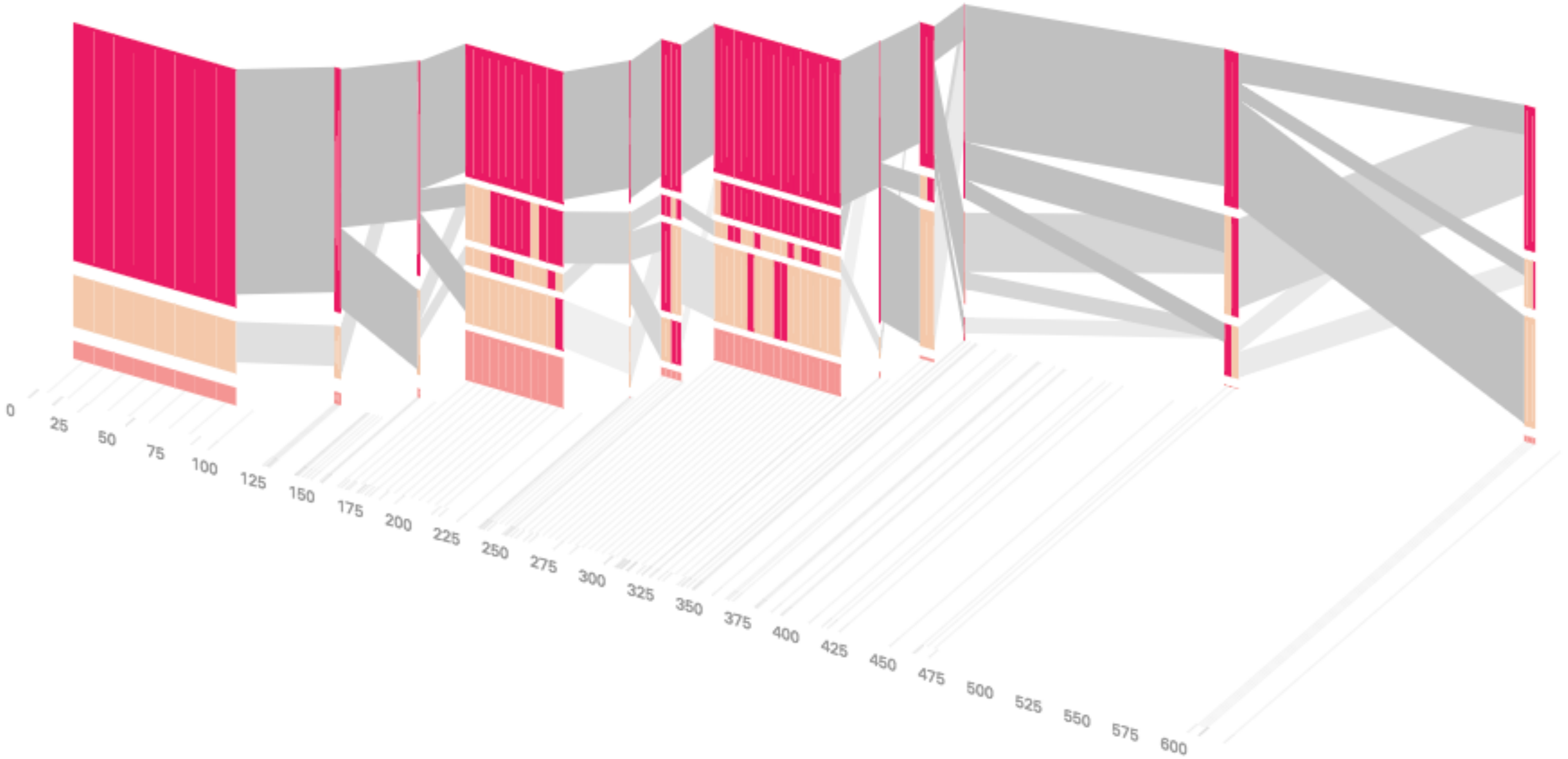
Why Transition?

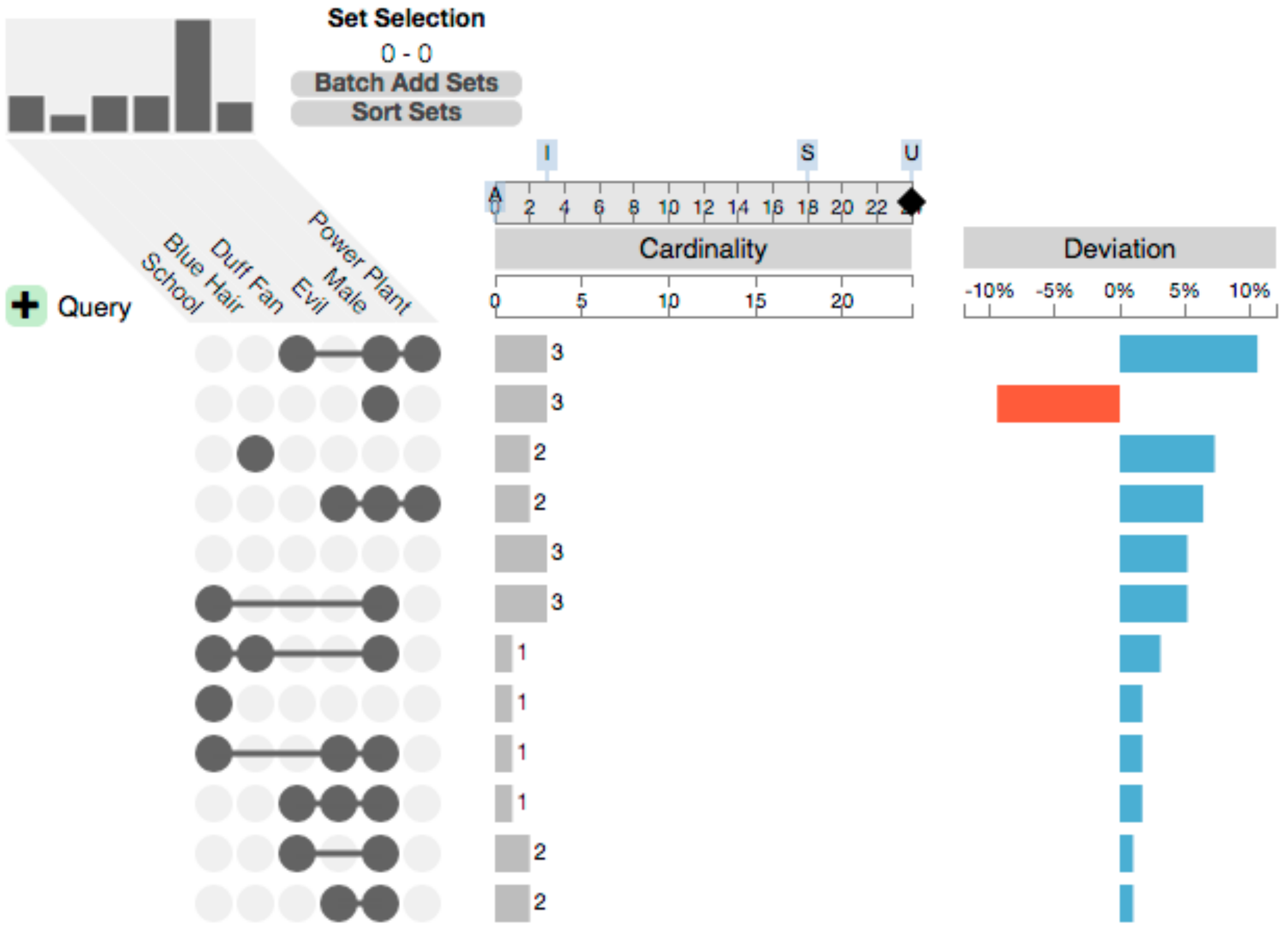
Different representations support different tasks

bar chart, vs stacked bar chart

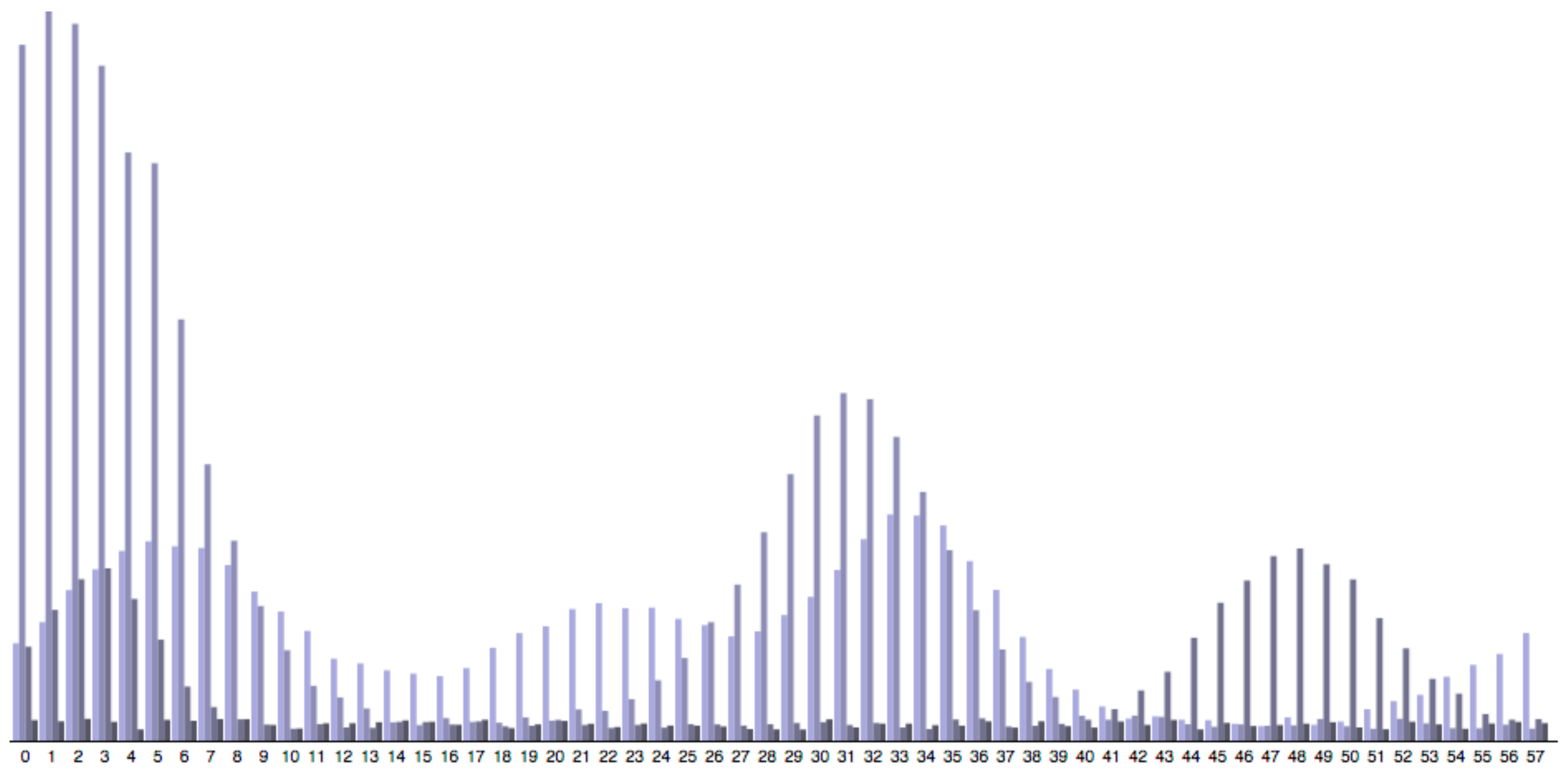
Change Ordering

Transition make it possible for users to track what is going on





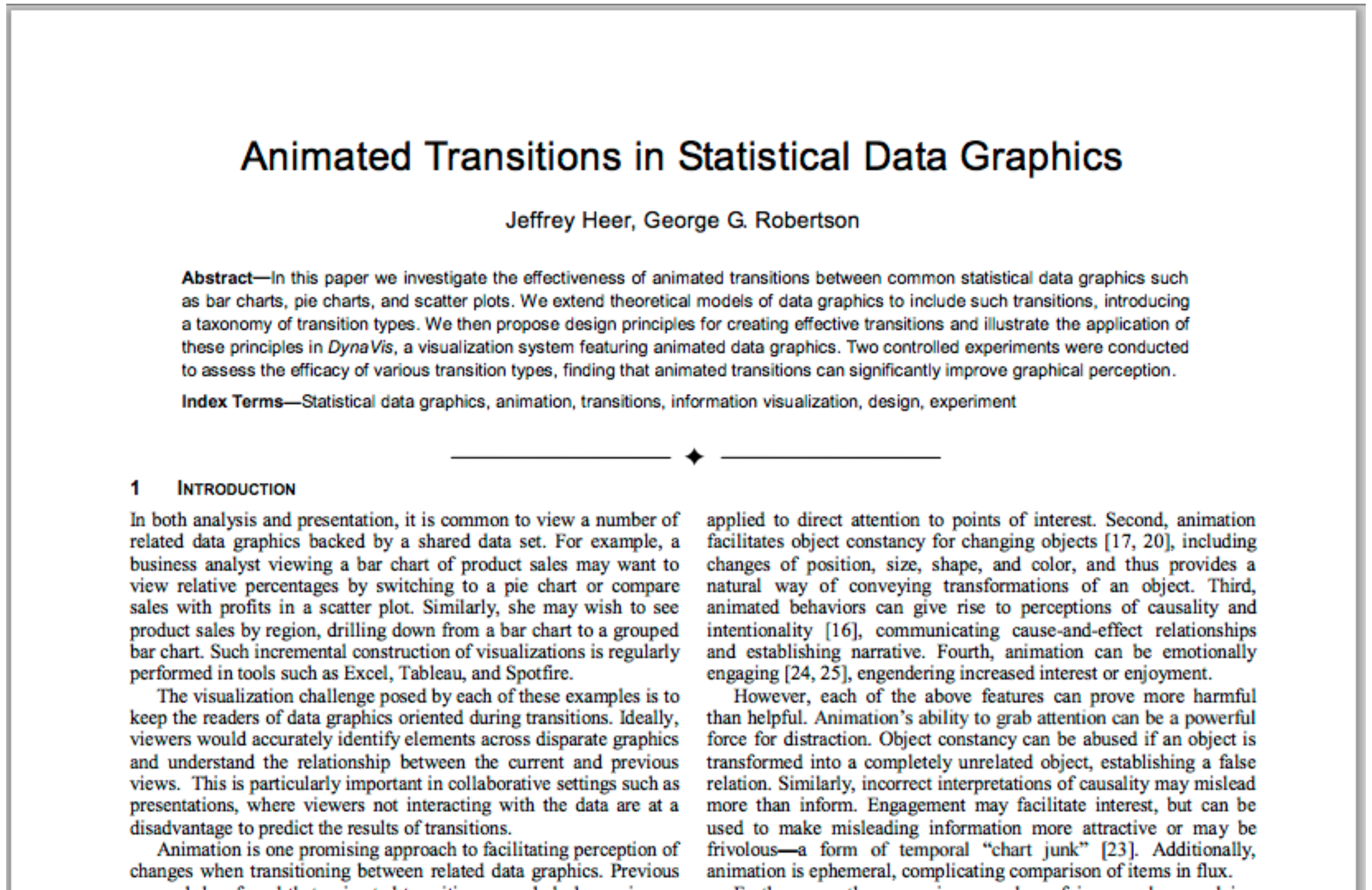
Animated Transitions



Smooth interpolation between states or visualization techniques

[Sunburst by John Stasko, Implementation in Caleydo by Christian Partl]

Why Animated Transition?



Animated Transitions in Statistical Data Graphics

Jeffrey Heer, George G. Robertson

Abstract—In this paper we investigate the effectiveness of animated transitions between common statistical data graphics such as bar charts, pie charts, and scatter plots. We extend theoretical models of data graphics to include such transitions, introducing a taxonomy of transition types. We then propose design principles for creating effective transitions and illustrate the application of these principles in *DynaVis*, a visualization system featuring animated data graphics. Two controlled experiments were conducted to assess the efficacy of various transition types, finding that animated transitions can significantly improve graphical perception.

Index Terms—Statistical data graphics, animation, transitions, information visualization, design, experiment

1 Introduction

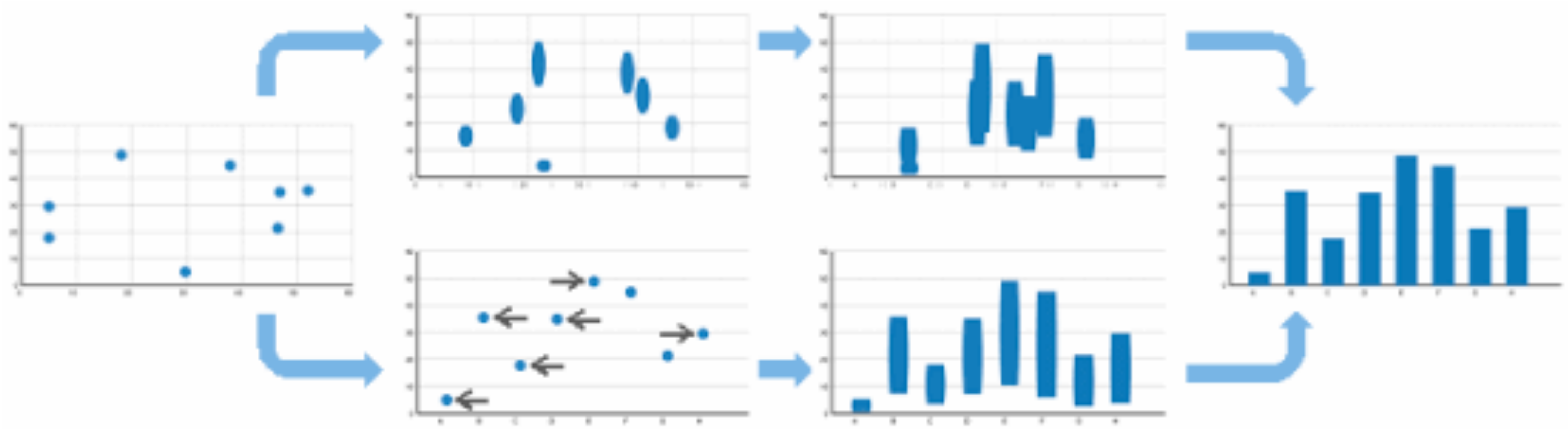
In both analysis and presentation, it is common to view a number of related data graphics backed by a shared data set. For example, a business analyst viewing a bar chart of product sales may want to view relative percentages by switching to a pie chart or compare sales with profits in a scatter plot. Similarly, she may wish to see product sales by region, drilling down from a bar chart to a grouped bar chart. Such incremental construction of visualizations is regularly performed in tools such as Excel, Tableau, and Spotfire.

The visualization challenge posed by each of these examples is to keep the readers of data graphics oriented during transitions. Ideally, viewers would accurately identify elements across disparate graphics and understand the relationship between the current and previous views. This is particularly important in collaborative settings such as presentations, where viewers not interacting with the data are at a disadvantage to predict the results of transitions.

Animation is one promising approach to facilitating perception of changes when transitioning between related data graphics. Previous

applied to direct attention to points of interest. Second, animation facilitates object constancy for changing objects [17, 20], including changes of position, size, shape, and color, and thus provides a natural way of conveying transformations of an object. Third, animated behaviors can give rise to perceptions of causality and intentionality [16], communicating cause-and-effect relationships and establishing narrative. Fourth, animation can be emotionally engaging [24, 25], engendering increased interest or enjoyment.

However, each of the above features can prove more harmful than helpful. Animation's ability to grab attention can be a powerful force for distraction. Object constancy can be abused if an object is transformed into a completely unrelated object, establishing a false relation. Similarly, incorrect interpretations of causality may mislead more than inform. Engagement may facilitate interest, but can be used to make misleading information more attractive or may be frivolous—a form of temporal "chart junk" [23]. Additionally, animation is ephemeral, complicating comparison of items in flux.



https://www.youtube.com/watch?v=vLk7mlAtEXI

Animation Caveats

Changes can be hard to track

Eyes over memory!

- Show all states in multiple views

Navigation

Navigation

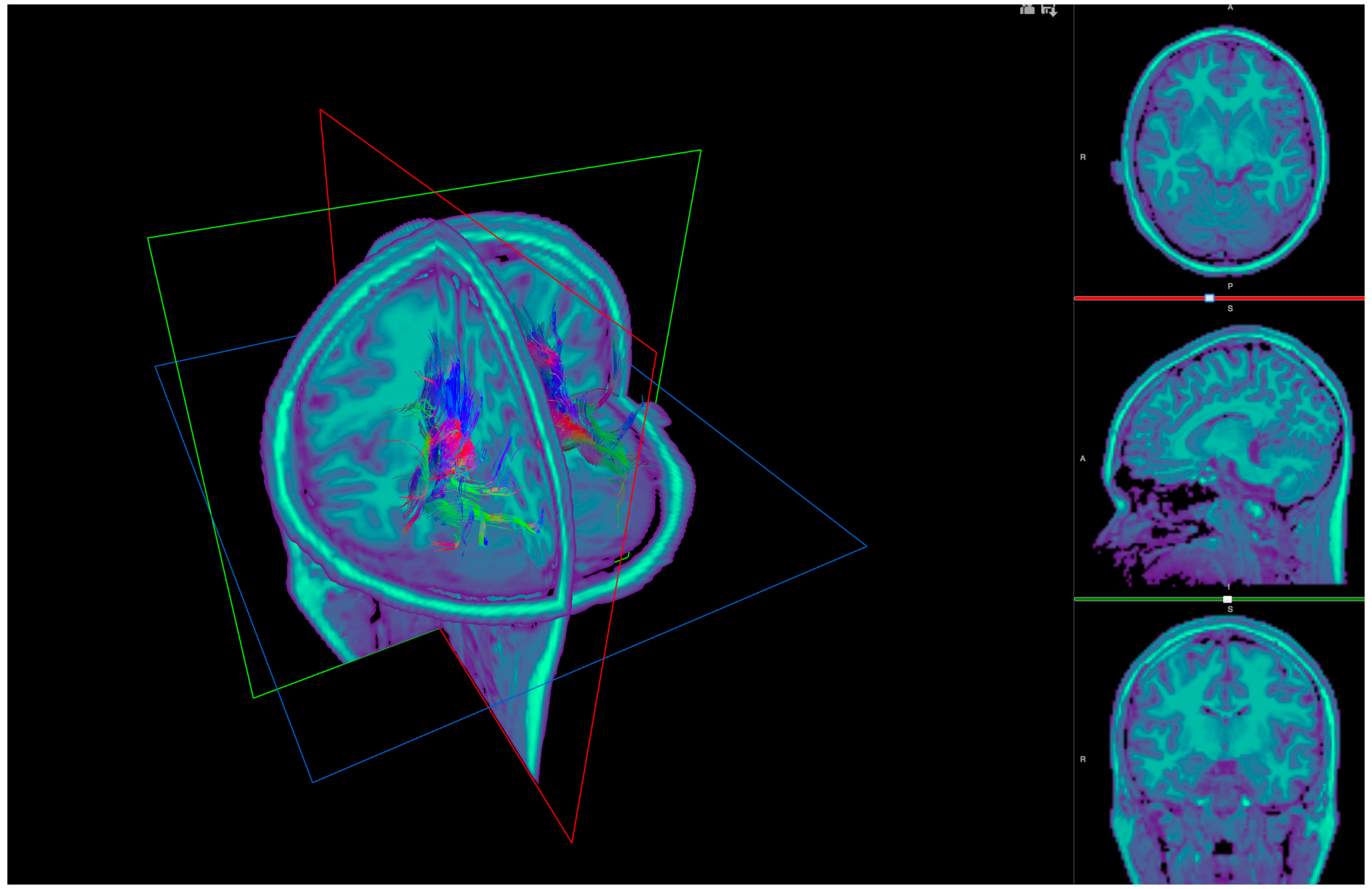
Pan

move around

Zoom

enlarge/ make smaller (move camera)

Rotate



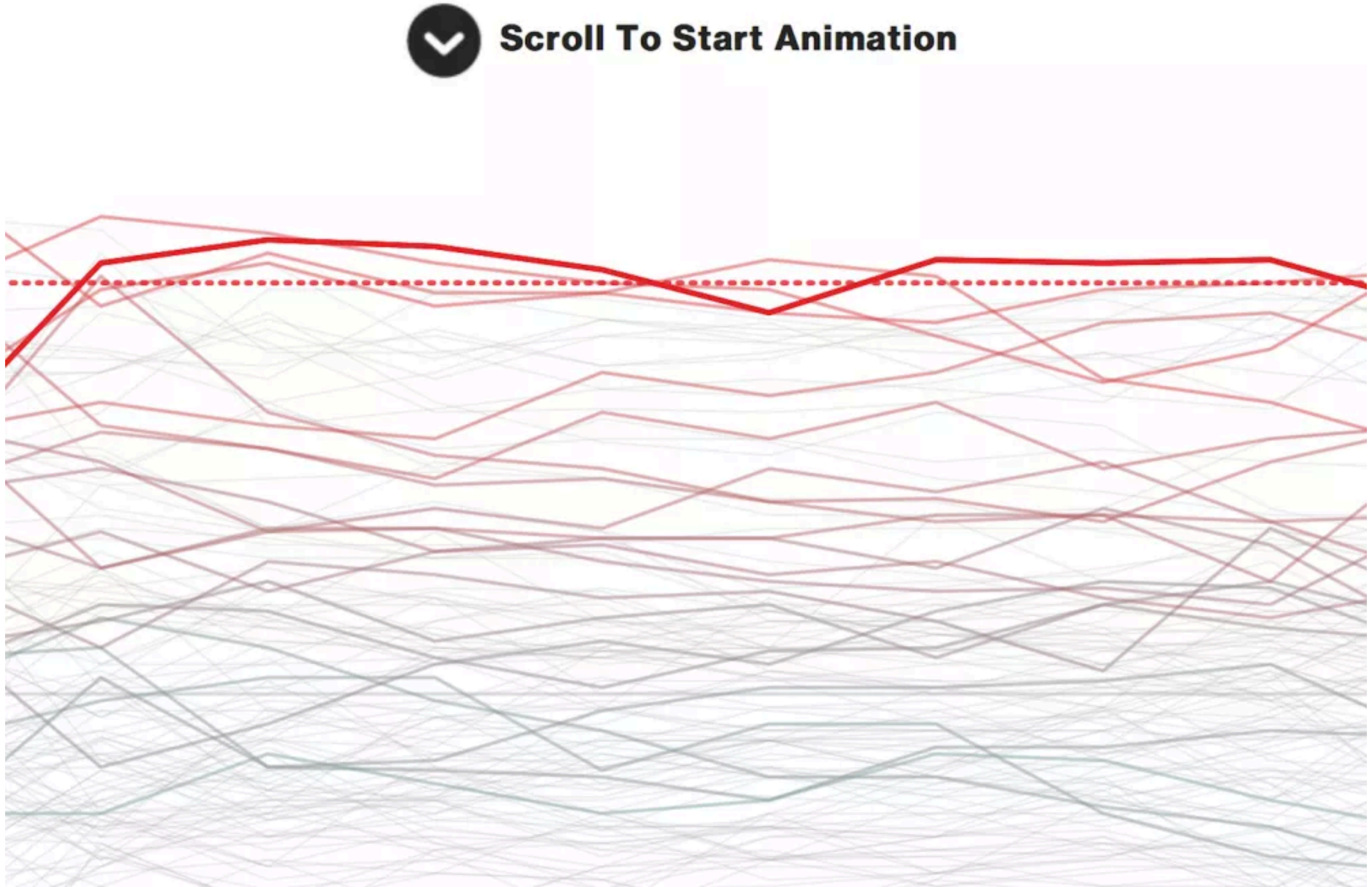
Scrollytelling

Telling an interactive story

Interaction by scrolling

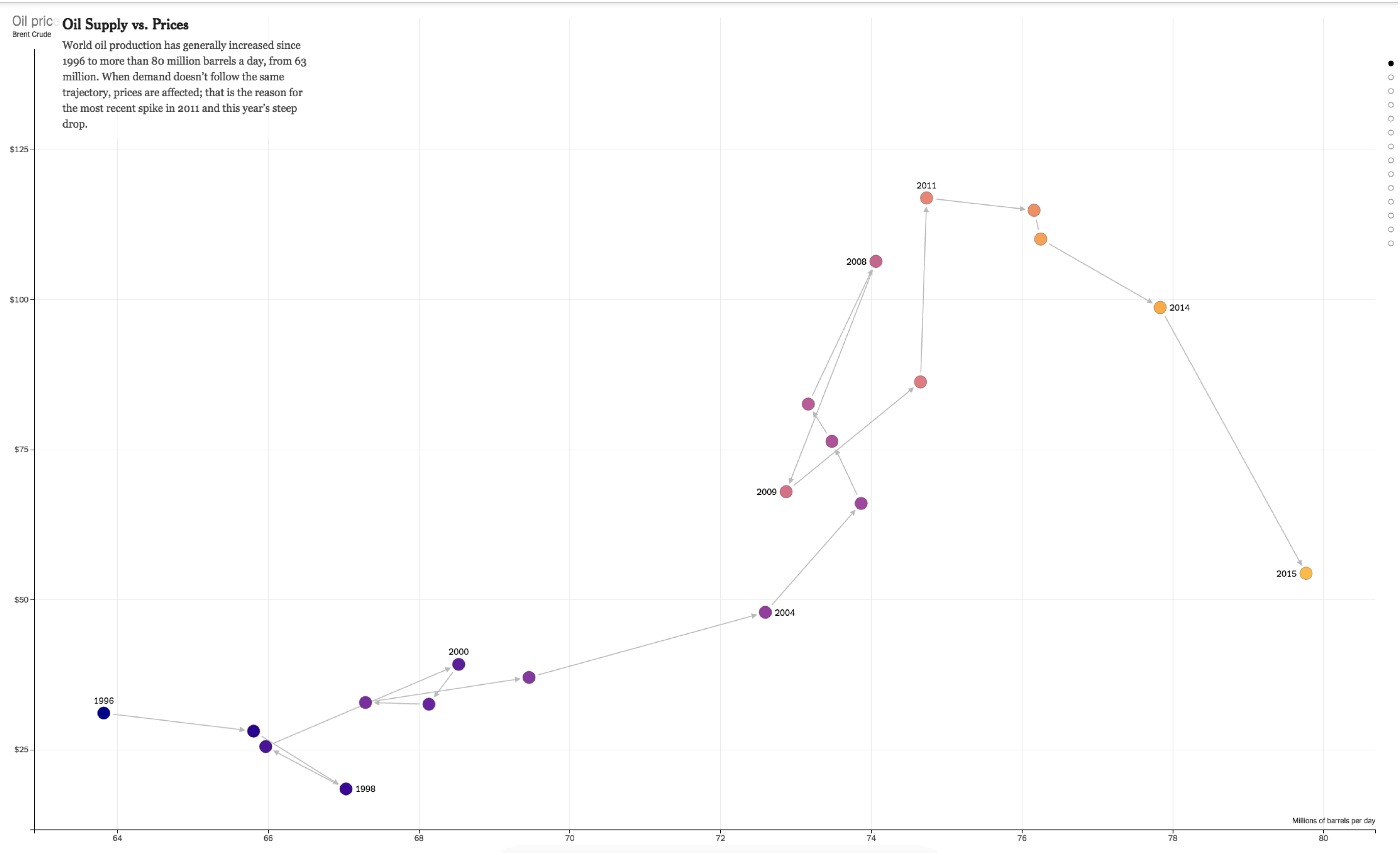
Nice but

- Continuous scrolling vs discrete states
- Direct access
- Unexpected behavior



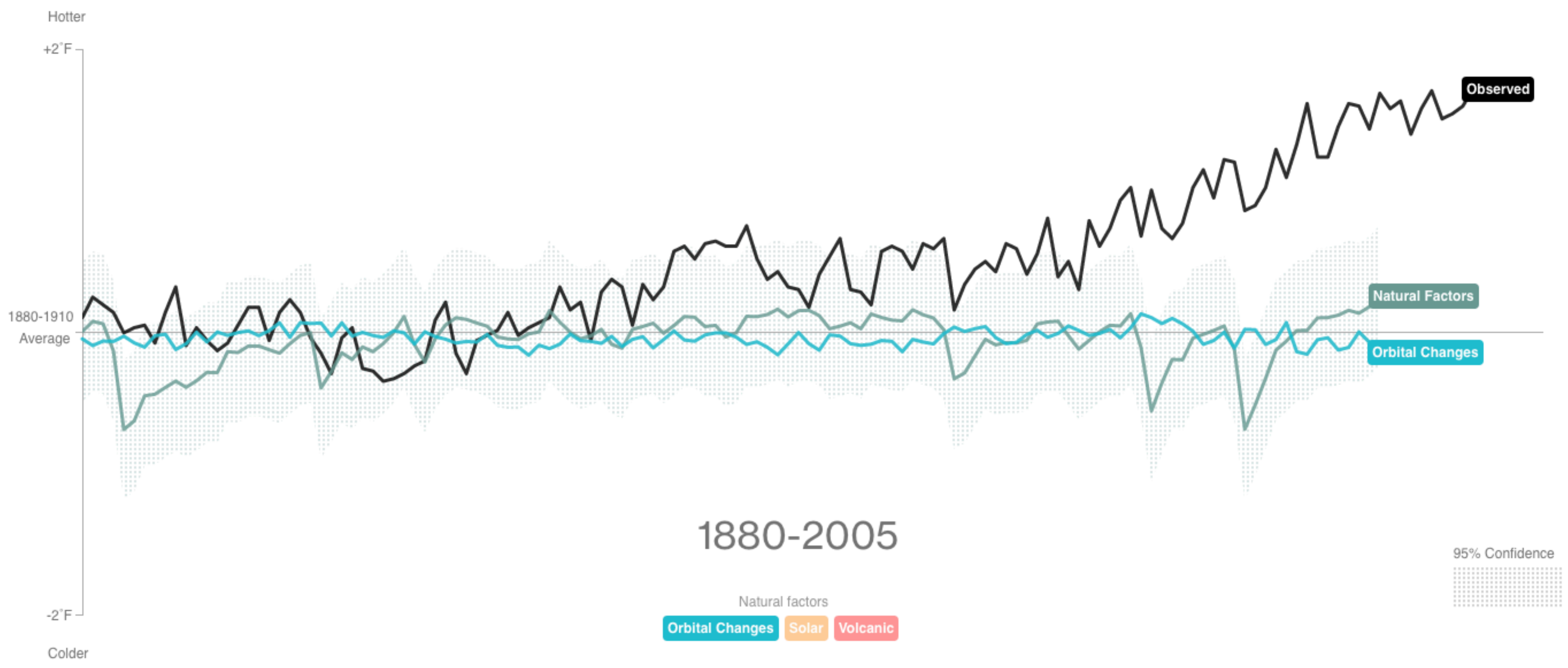
https://eagereyes.org/blog/2016/the-scrollytelling-scourge

Example: Oil Prices



http://www.nytimes.com/interactive/2015/09/30/business/how-the-us-and-opec-drive-oil-prices.html?_r=0

Example: What's Warming the World



www.bloomberg.com/graphics/2015-whats-warming-the-world/

Sent in by Siddartha Ravichandran

Semantic Zooming

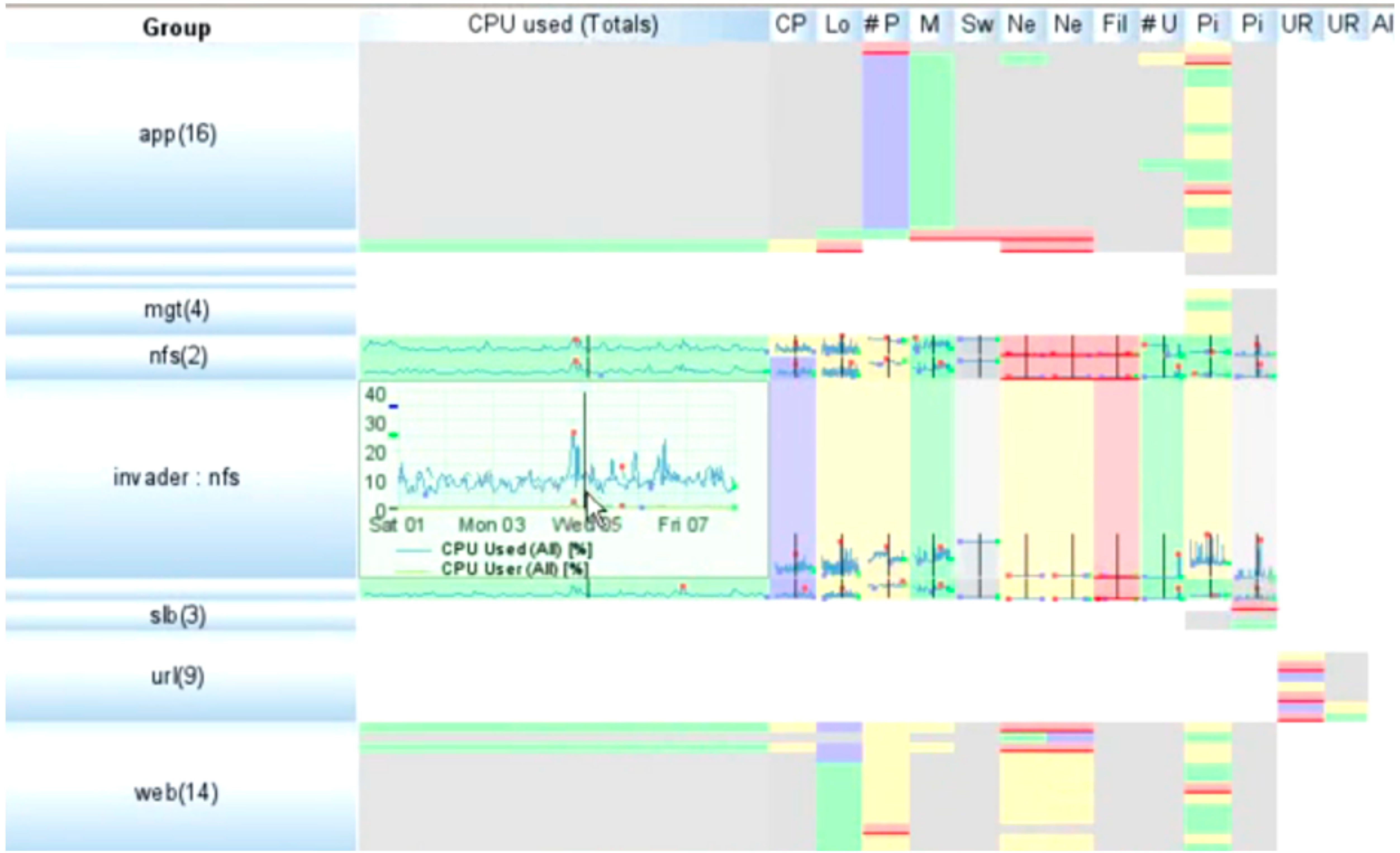
Semantic Zoom

Semantic Zooming

As you zoom in, content is updated

More detail as more space becomes available

Ideally readable at multiple resolutions



[McLachlan 2008]

Focus + Context

Focus + Context

carefully pick what to show

hint at what you are not showing

Focus + Context

synthesis of **visual encoding and interaction**

user selects region of interest (focus)
through navigation or selection

provide context through

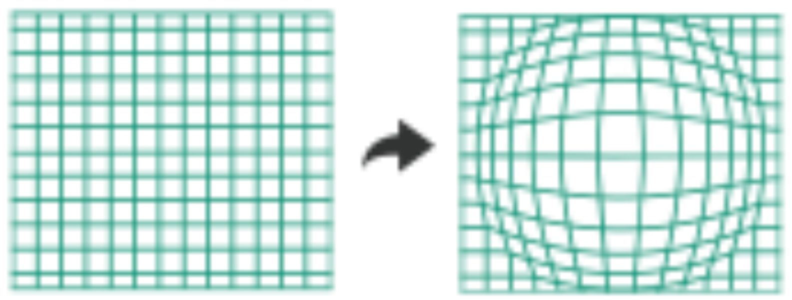
- aggregation
- reduction
- layering

Embed

→ Elide Data

→ Superimpose Layer

→ Distort Geometry



→ Elide Data

Elision

focus items shown in detail,

other items summarized for context

e·li·sion

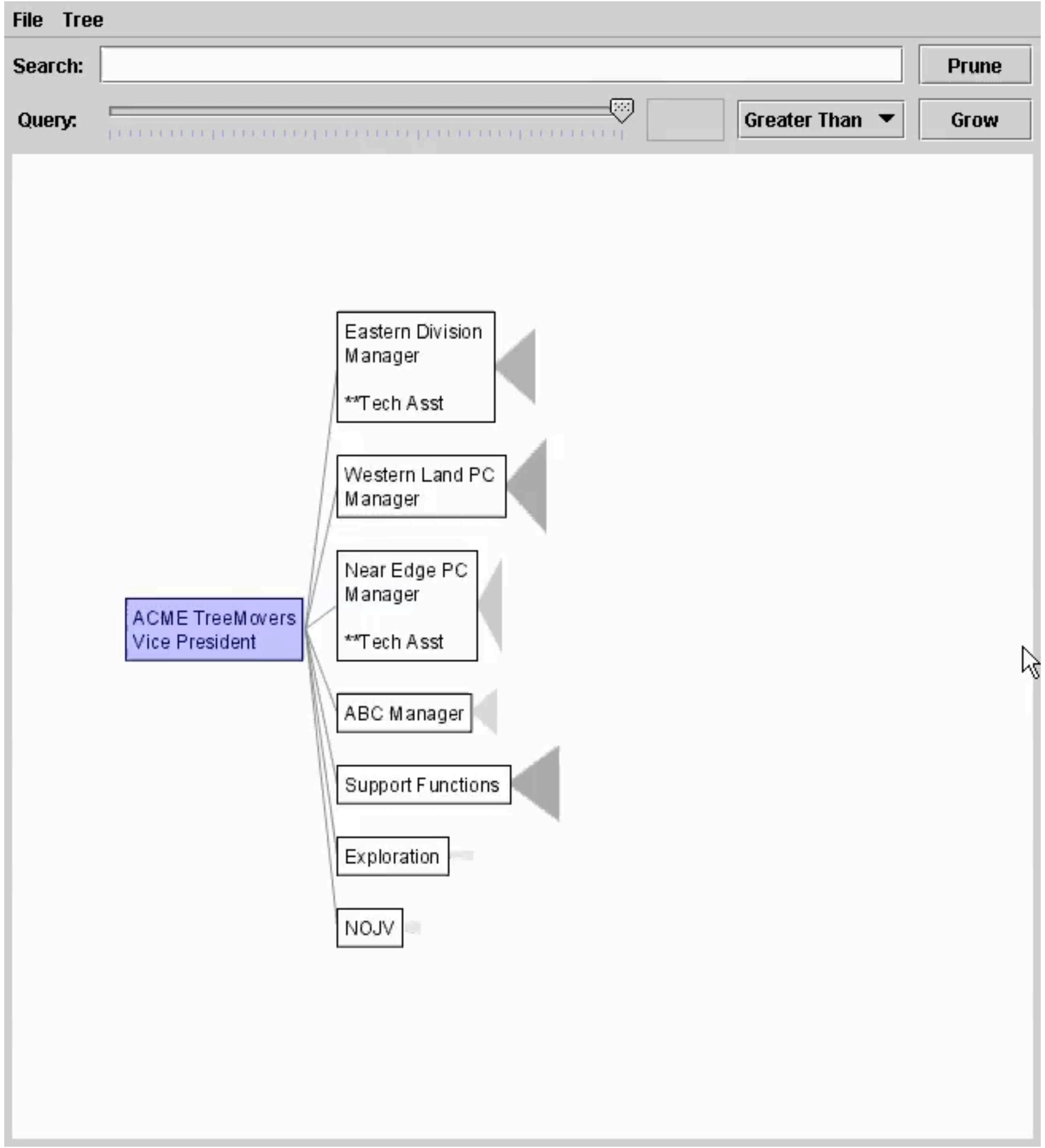
/iˈliZHən/

noun

the omission of a sound or syllable when speaking (as in *I'm*, *let's*, *e ' en*).

- an omission of a passage in a book, speech, or film.
  "the movie's elisions and distortions have been carefully thought out"
- the process of joining together or merging things, especially abstract ideas.
  "unease at the elision of so many vital questions"

SpaceTree



→ Elide Data

Grosjean 2002

Degree of Interest (DOI)

based on observation that humans often represent their own neighborhood in detail, yet only major landmarks far away

goal is balance between local detail and global context

$$DOI(x) = API(x) - D(x,y)$$

API - a priori interest
D - a distance function to the current focus
can have multiple foci

Furnas 1986

➔ Elide Data

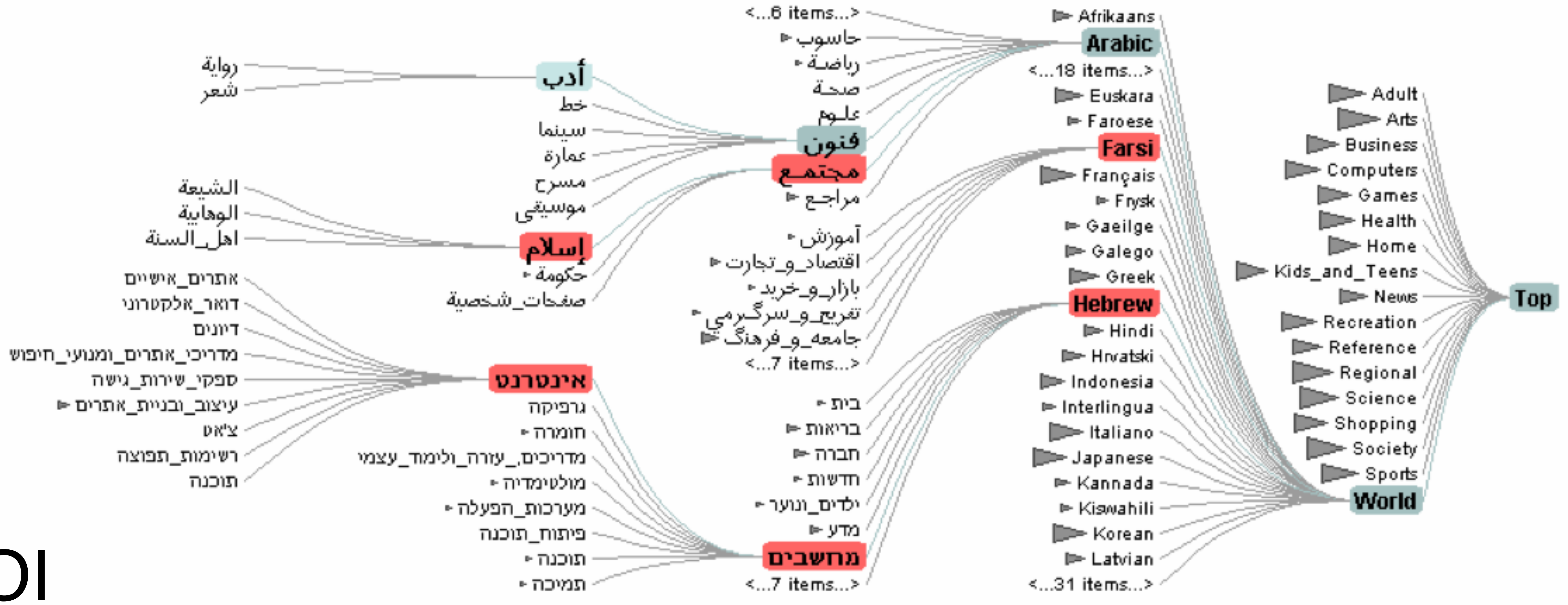
DOI Tree

interactive trees with animated transitions that fit within a bounded region of space

layout depends on the user's estimated DOI

use:

- logical filtering based on DOI
- geometric distortion of node size based on DOI
- semantic zooming on content based on node size
- aggregate representations of elided subtrees



[Heer 2004]

→ Elide Data

DOI without distance function

Distance function can lead to big, involuntary changes.

Useful also without distance function

Superimpose

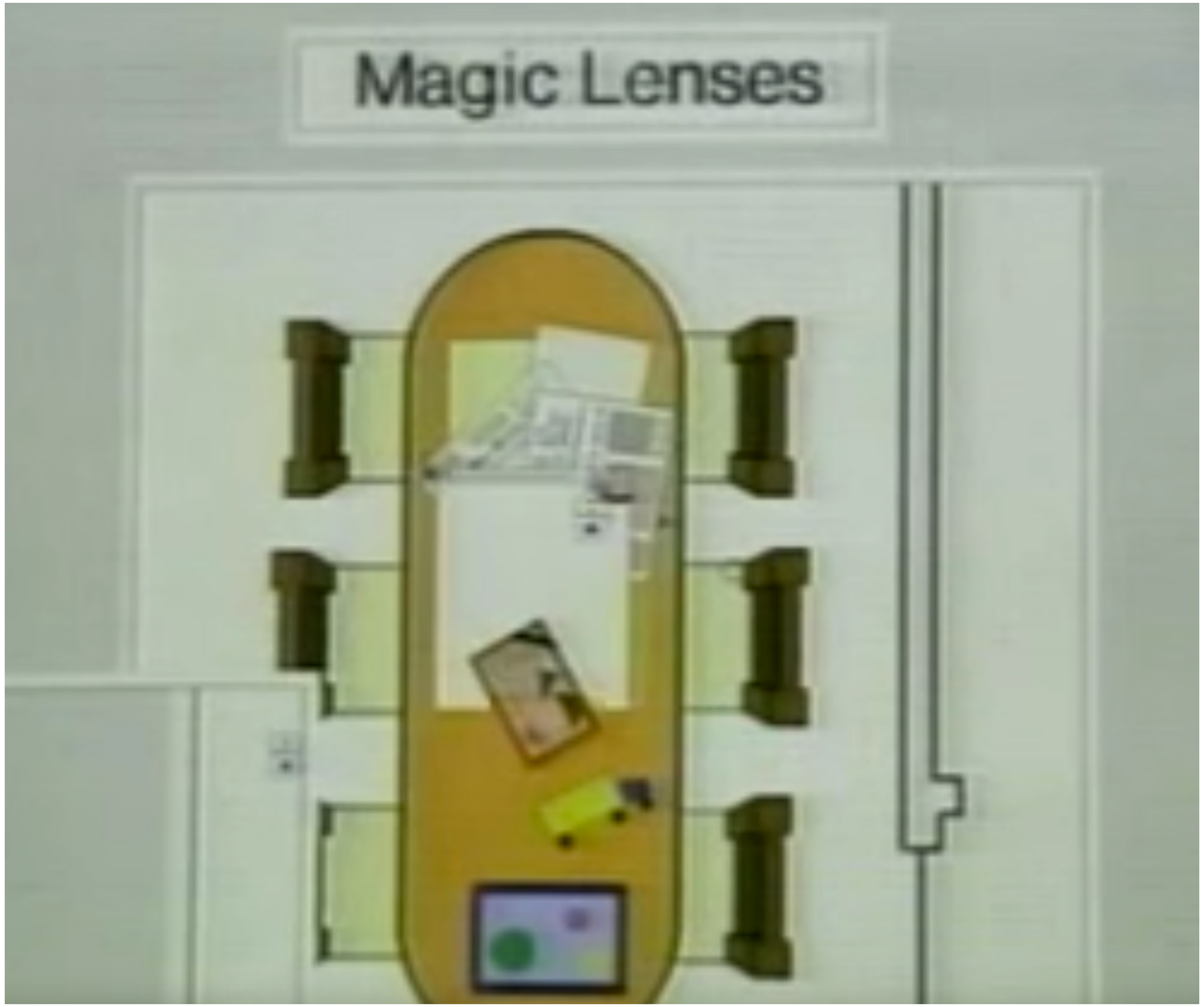
focus layer limited to a local region of view,
instead of stretching across the entire view

Toolglass & Magic Lenses

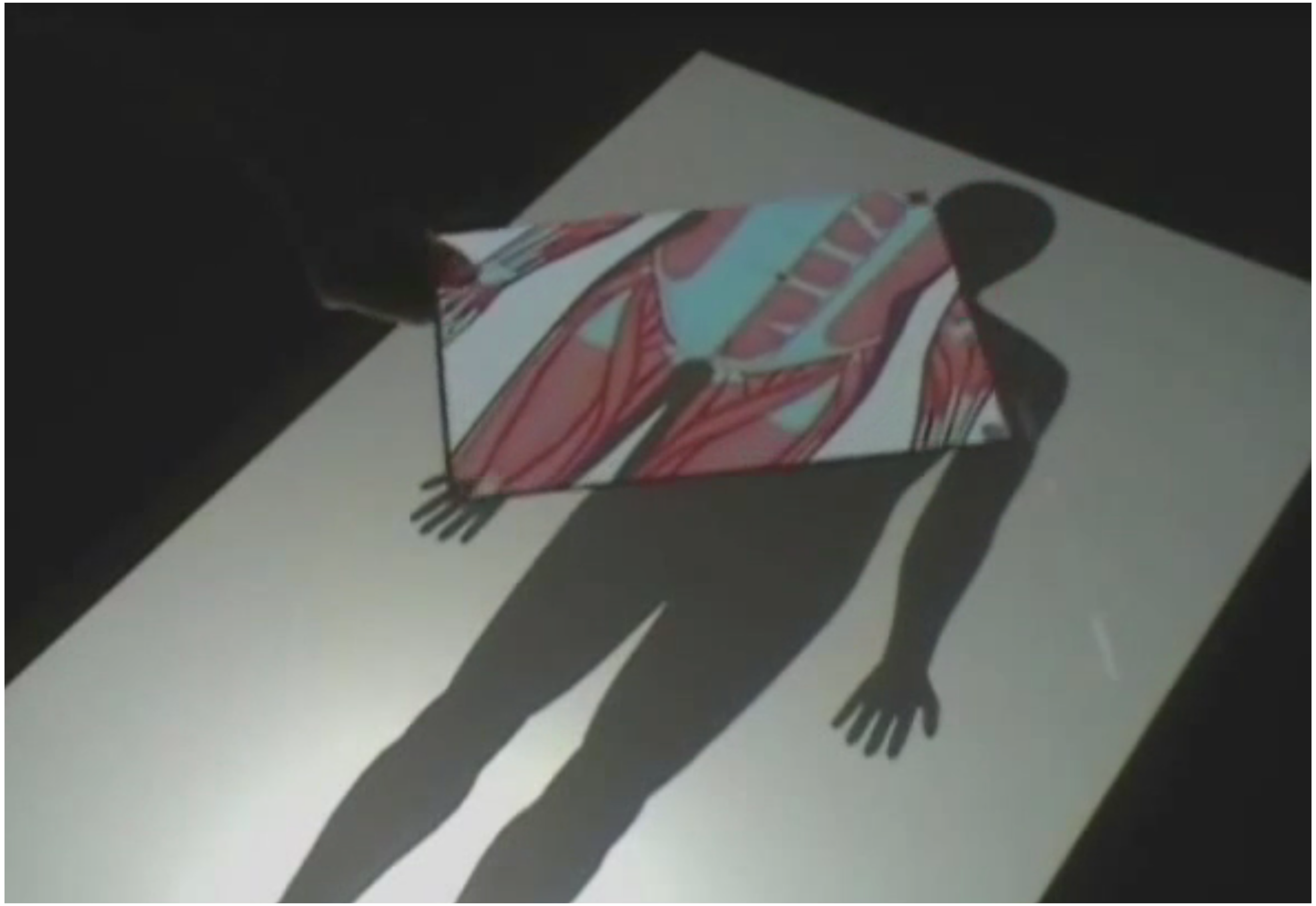
Magic Lense:

details/different data is shown
when moving a lens
over a scene

[Bier, Siggraph 1993]

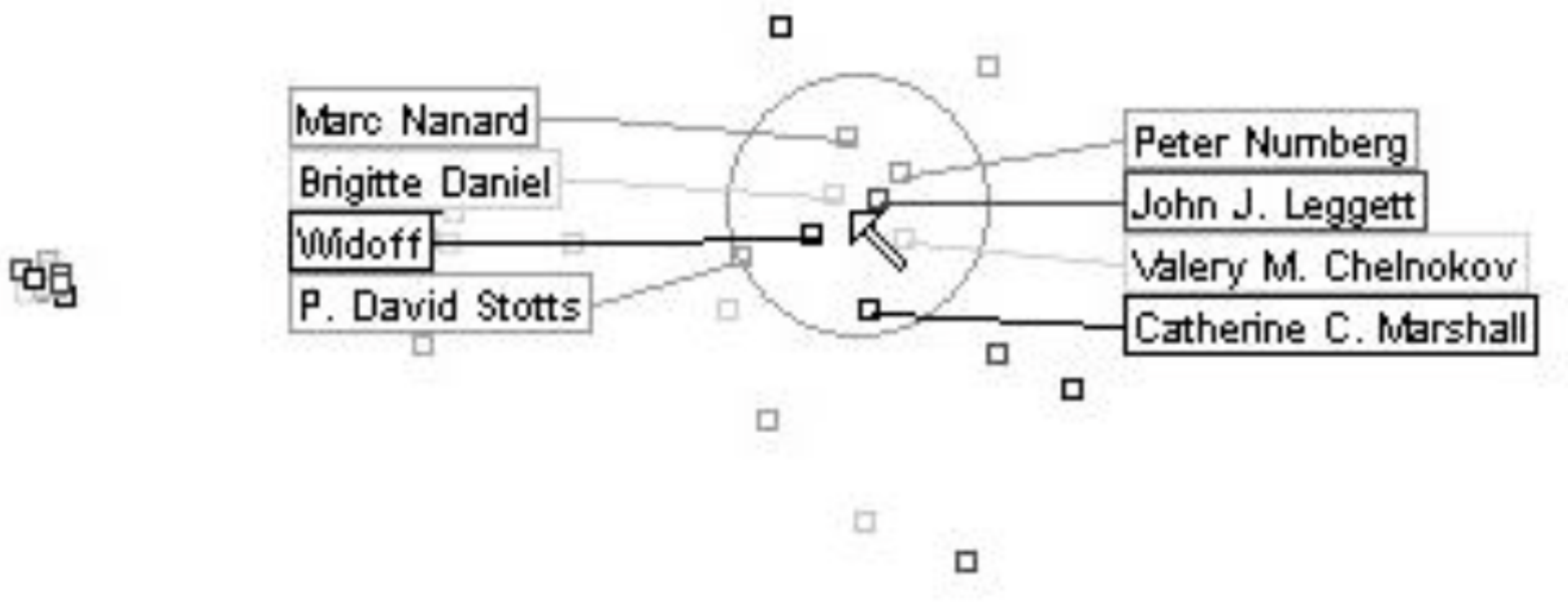


Magic Lense with Tangible Interface

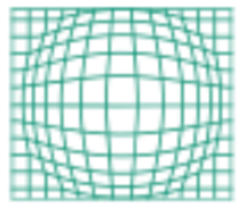


[Spindler, CHI 2010]

Magic Lense: Labeling

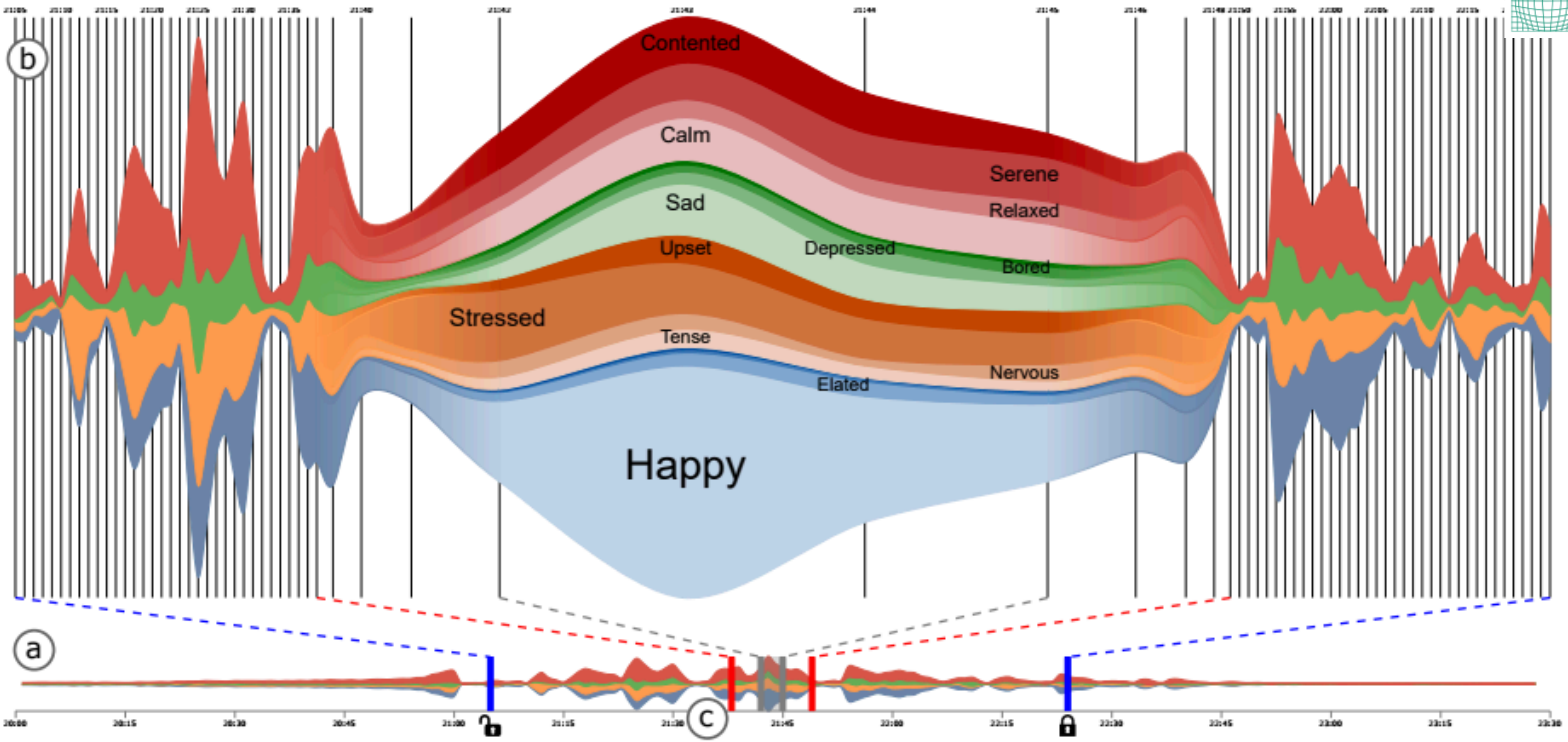


[Fekete and Plaisant, 1999]



Distortion

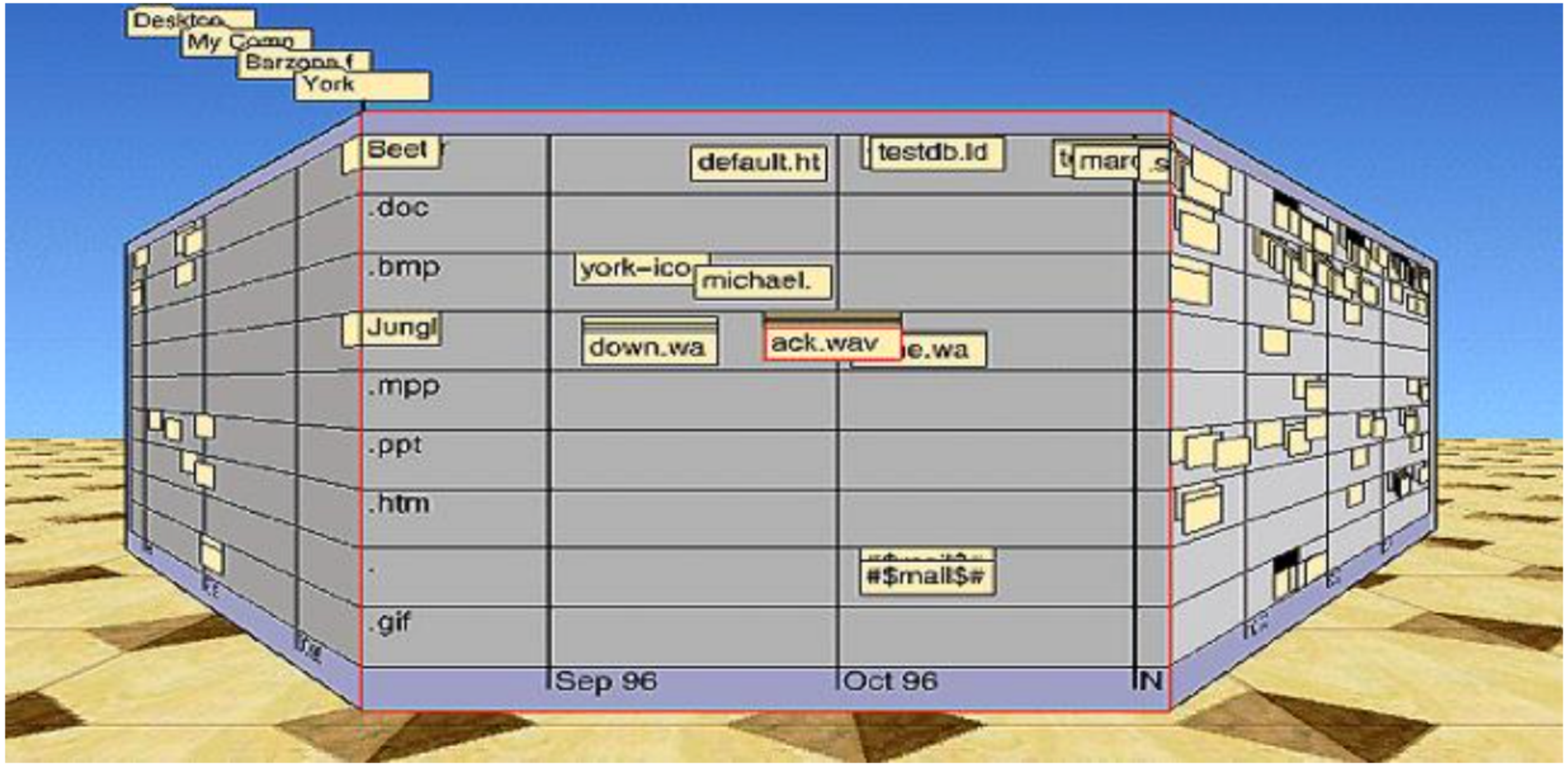
use geometric distortion of the contextual regions to make room for the details in the focus region(s)



http://advanse.lirmm.fr/multistream/

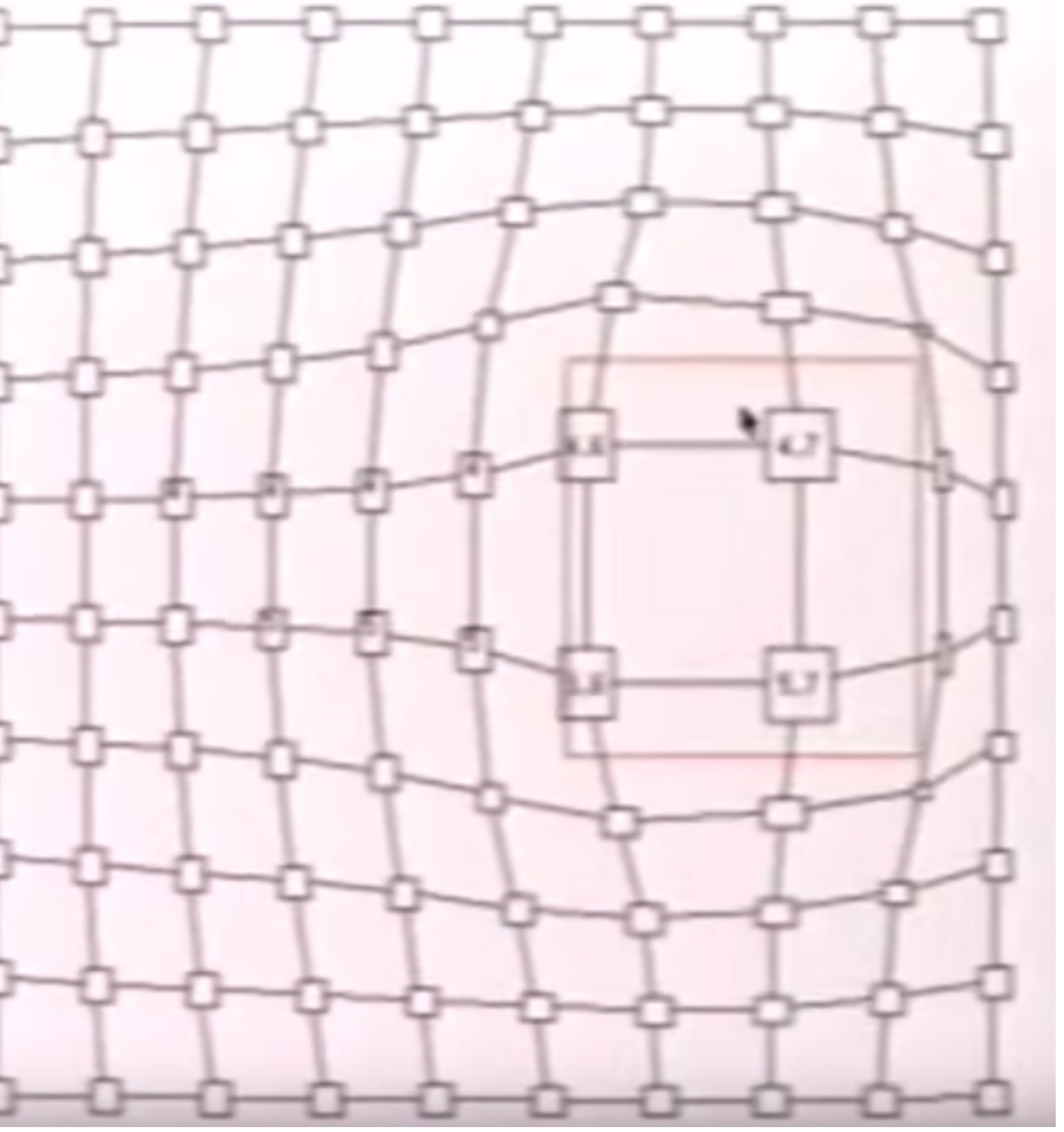
[Cuenca, MultiStream, 2017]

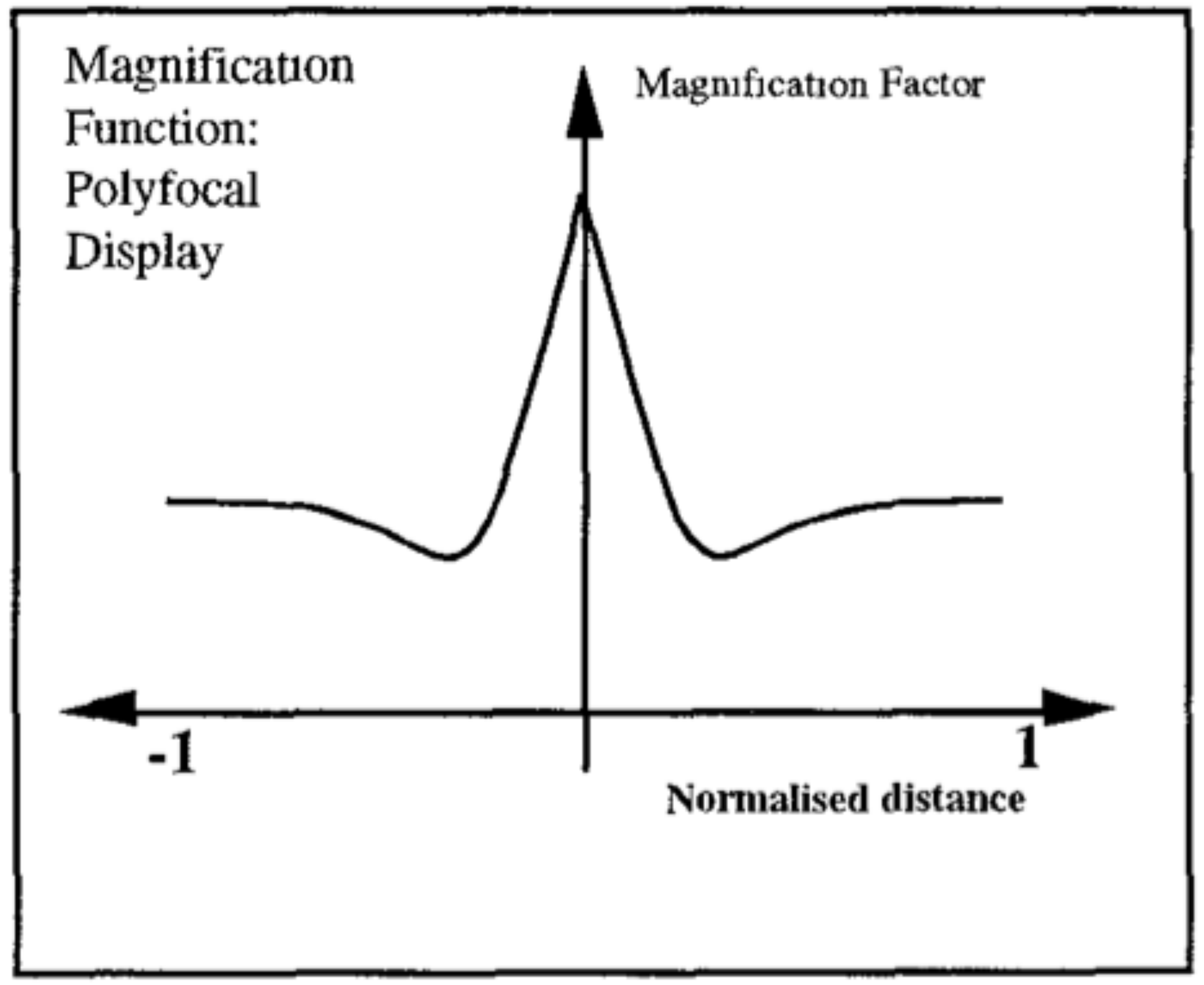
Perspective Wall

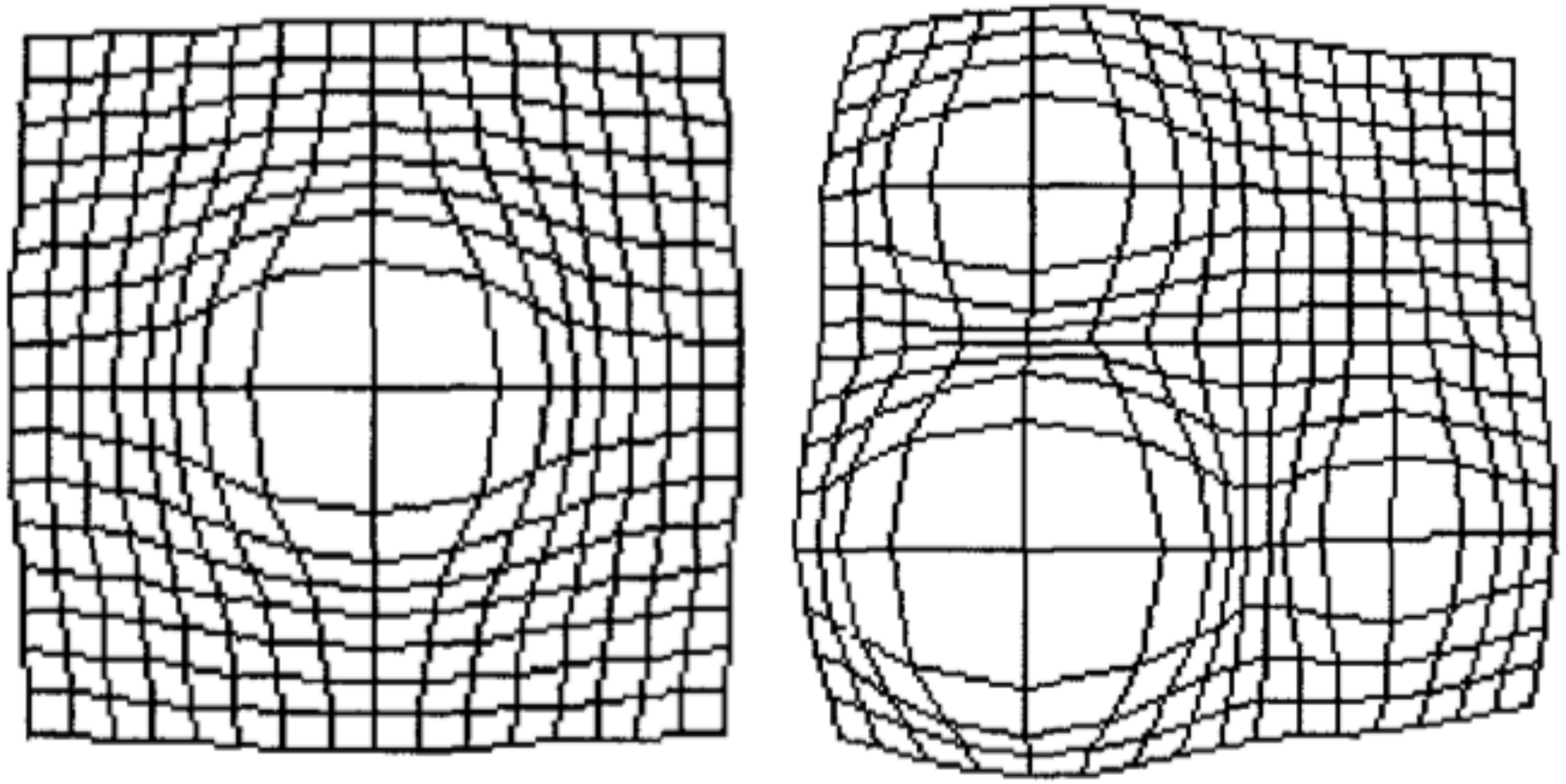


[Mackinlay, 1991]

Fisheye



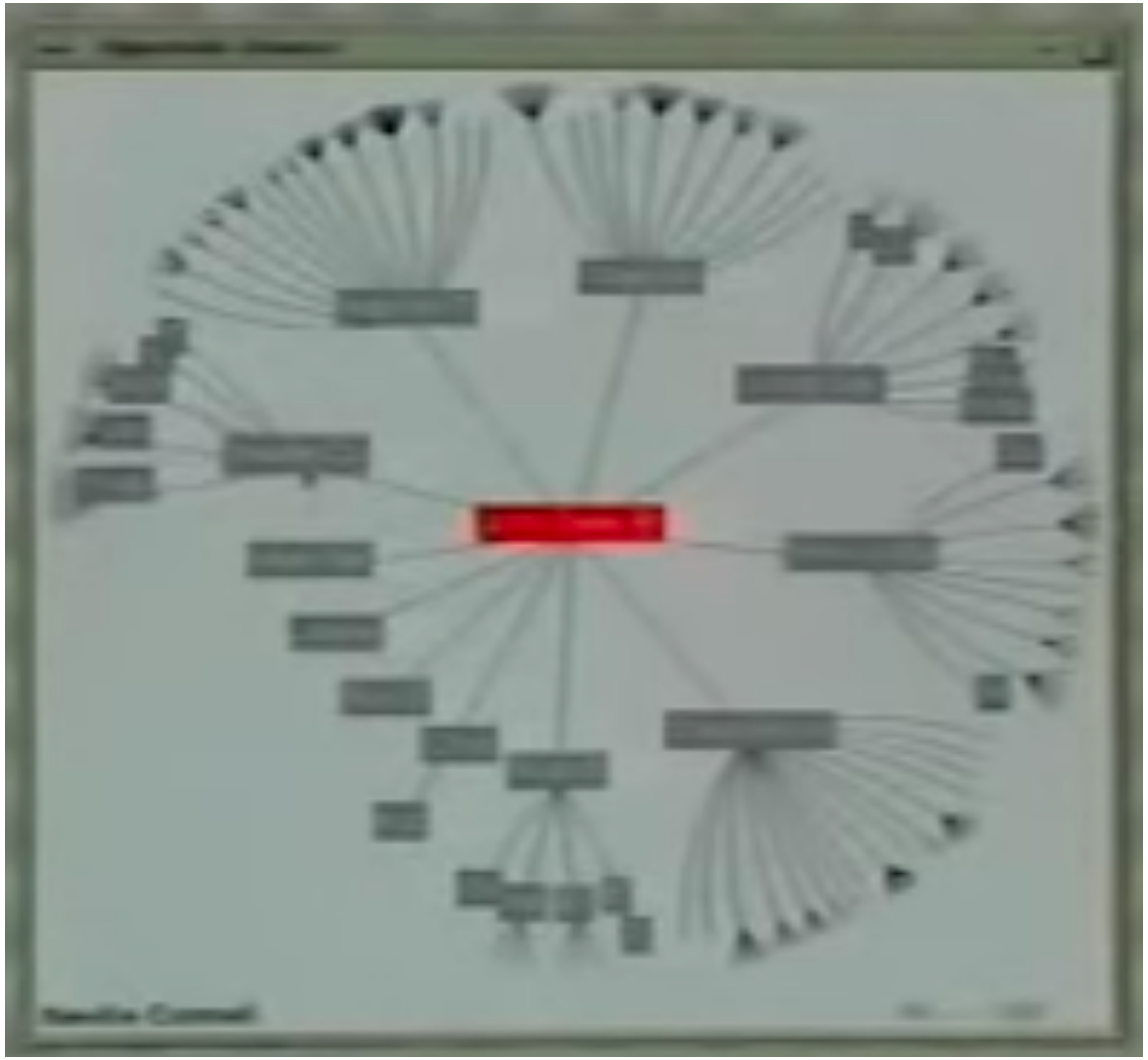




[Sarkar, 1993]

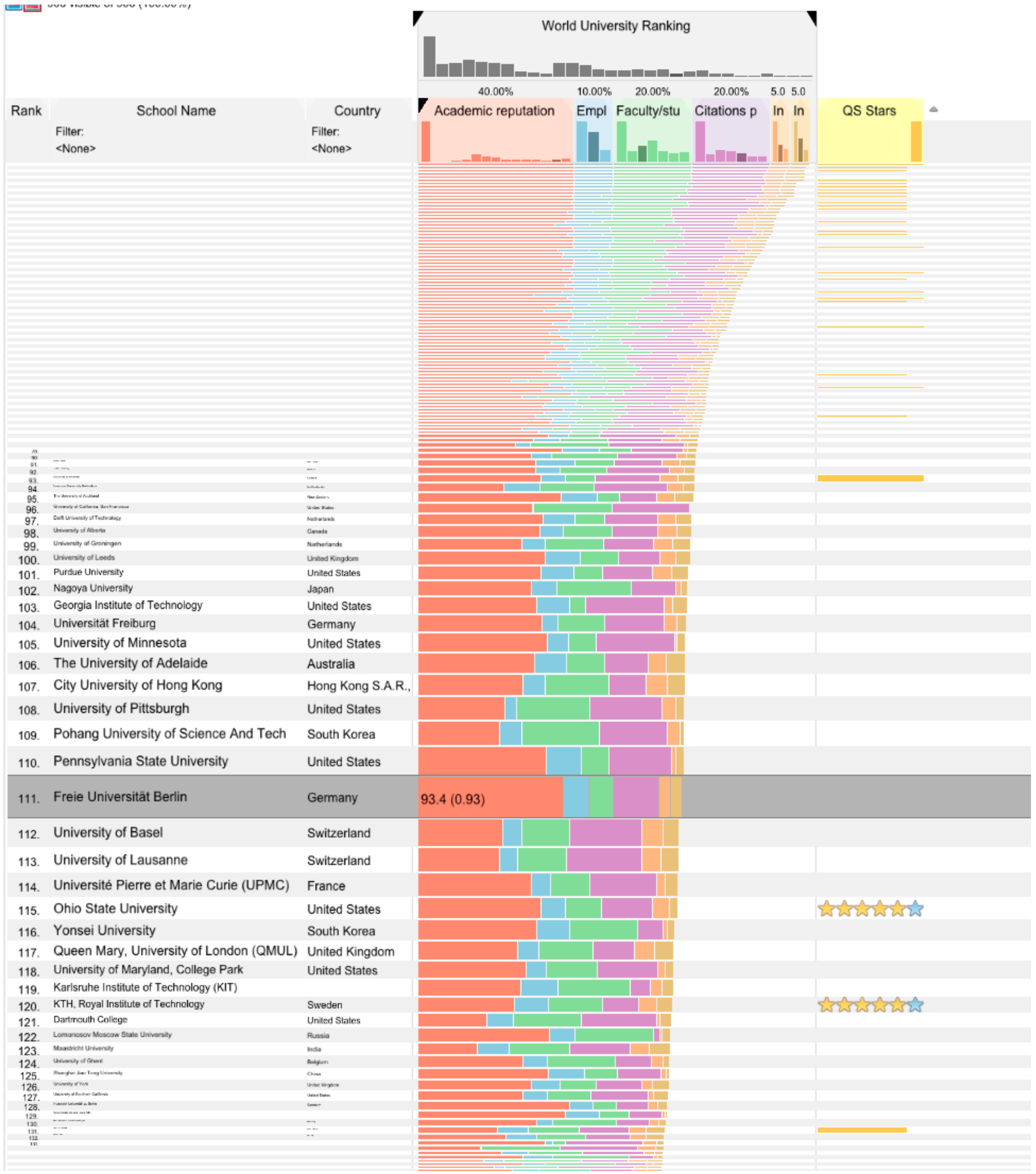
Leung 1994

Hyperbolic Geometry



[Lamping, 1995]

http://pmcruz.com/information-visualization/data-lenses


World University Ranking
Rank
School Name
Country
Filter:
<None>
Academic reputation
Empl
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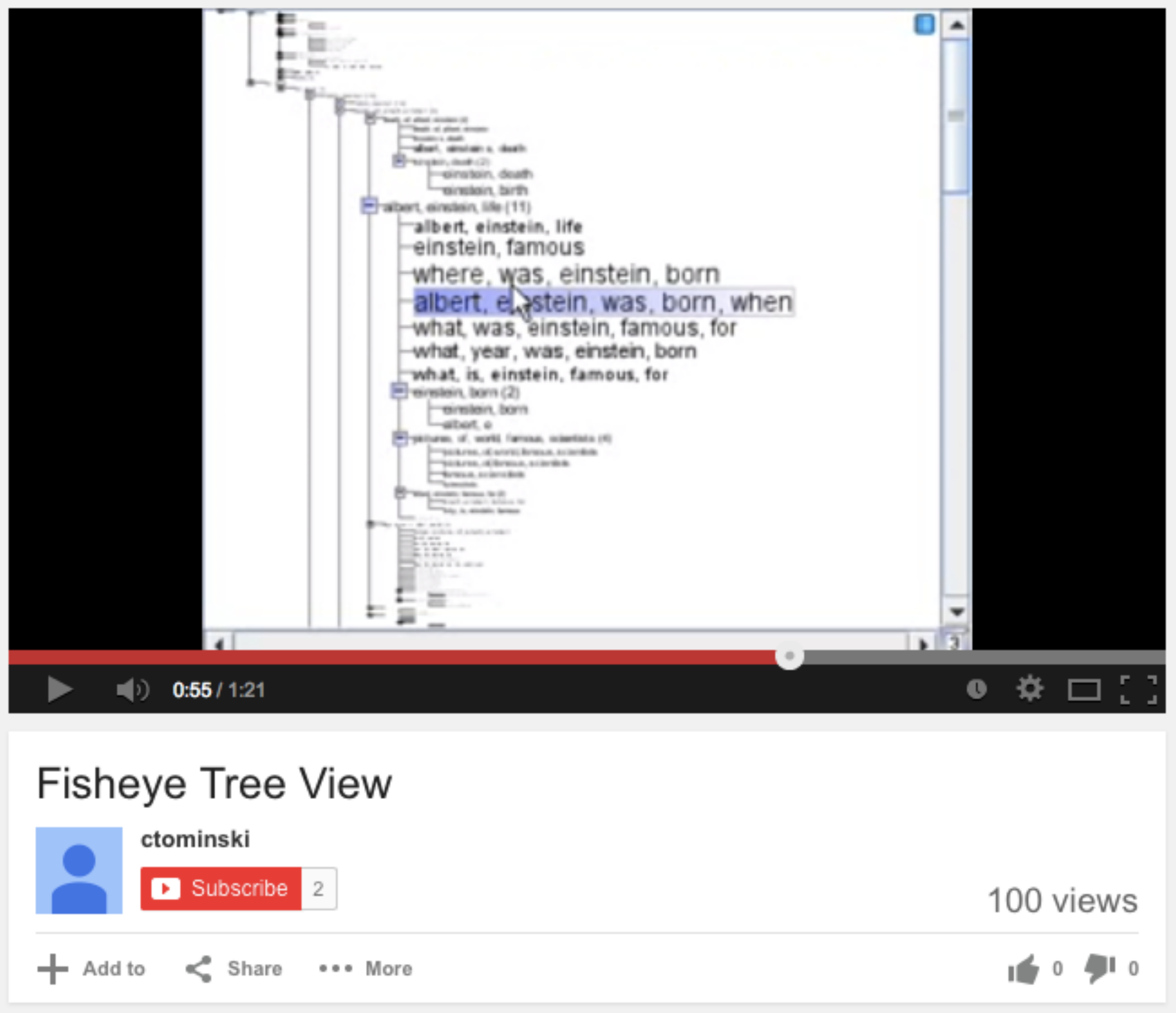
Citations p
In
QS Stars
100. University of Leeds United Kingdom
101. Purdue University United States
102. Nagoya University Japan
103. Georgia Institute of Technology United States
104. Universität Freiburg Germany
105. University of Minnesota United States
106. The University of Adelaide Australia
107. City University of Hong Kong Hong Kong S.A.R.,
108. University of Pittsburgh United States
109. Pohang University of Science And Tech South Korea
110. Pennsylvania State University United States
111. Freie Universität Berlin Germany 93.4 (0.93)
112. University of Basel Switzerland
113. University of Lausanne Switzerland
114. Université Pierre et Marie Curie (UPMC) France
115. Ohio State University United States
116. Yonsei University South Korea
117. Queen Mary, University of London (QMUL) United Kingdom
118. University of Maryland, College Park United States
119. Karlsruhe Institute of Technology (KIT)
120. KTH, Royal Institute of Technology Sweden
121. Dartmouth College United States


albert, einstein, life (11)
albert, einstein, life
einstein, famous
where, was, einstein, born
albert, einstein, was, born, when
what, was, einstein, famous, for
what, year, was, einstein, born
what, is, einstein, famous, for
0:55 / 1:21
Fisheye Tree View
ctominski
Subscribe
2
100 views
Add to
Share
More
0
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What do you think about distortion?

Distortion Concerns

unsuitable for relative spatial judgements

overhead of tracking distortion

visual communication of distortion

- gridlines, shading

target acquisition problem

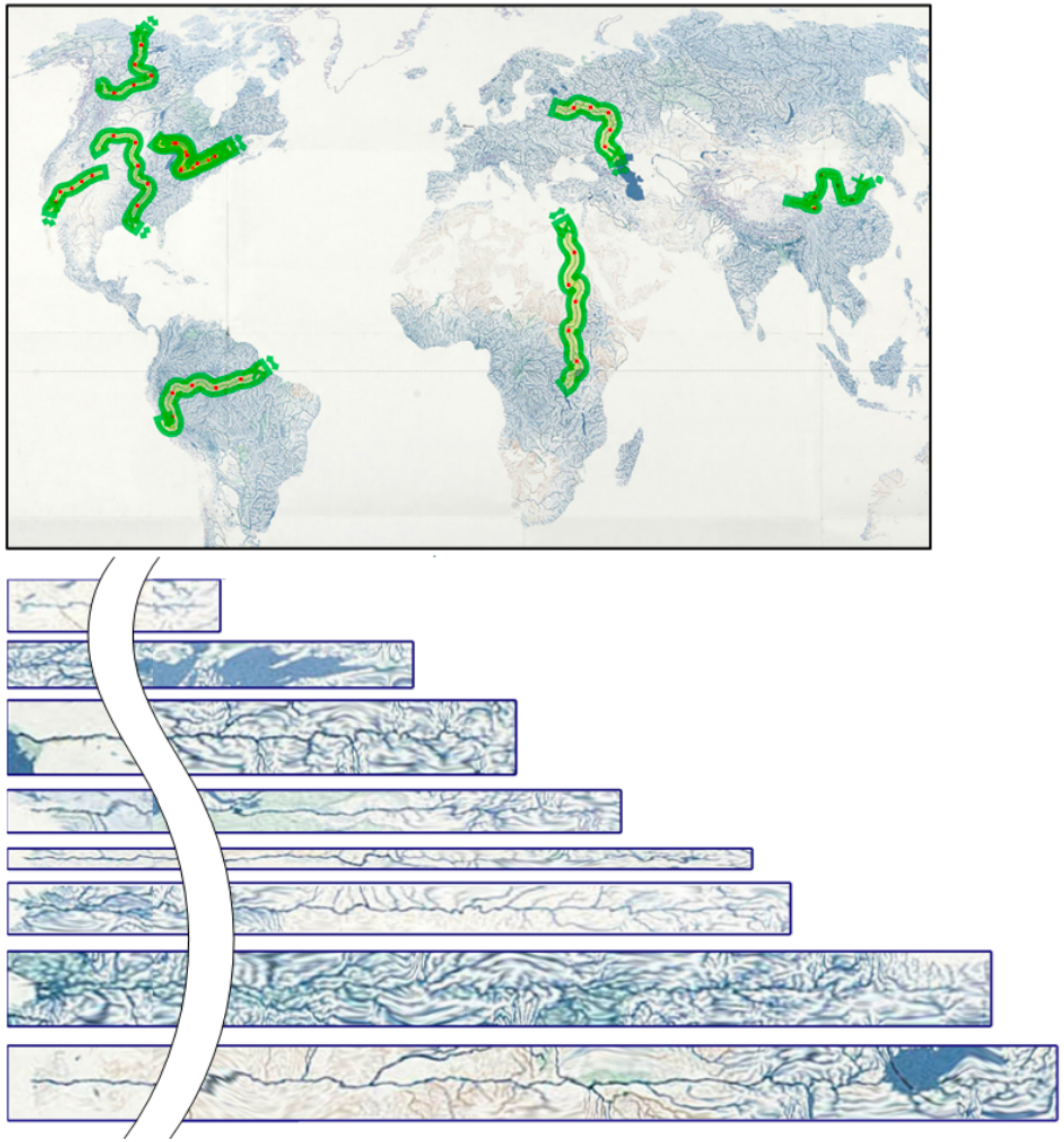
- lens displacing items away from screen location

mixed results compared to separate views and temporal navigation

Transmorgification

Idea: straighten complex shapes in image space

Can be spatial data, but also other vis techniques



[Brosz, 13]

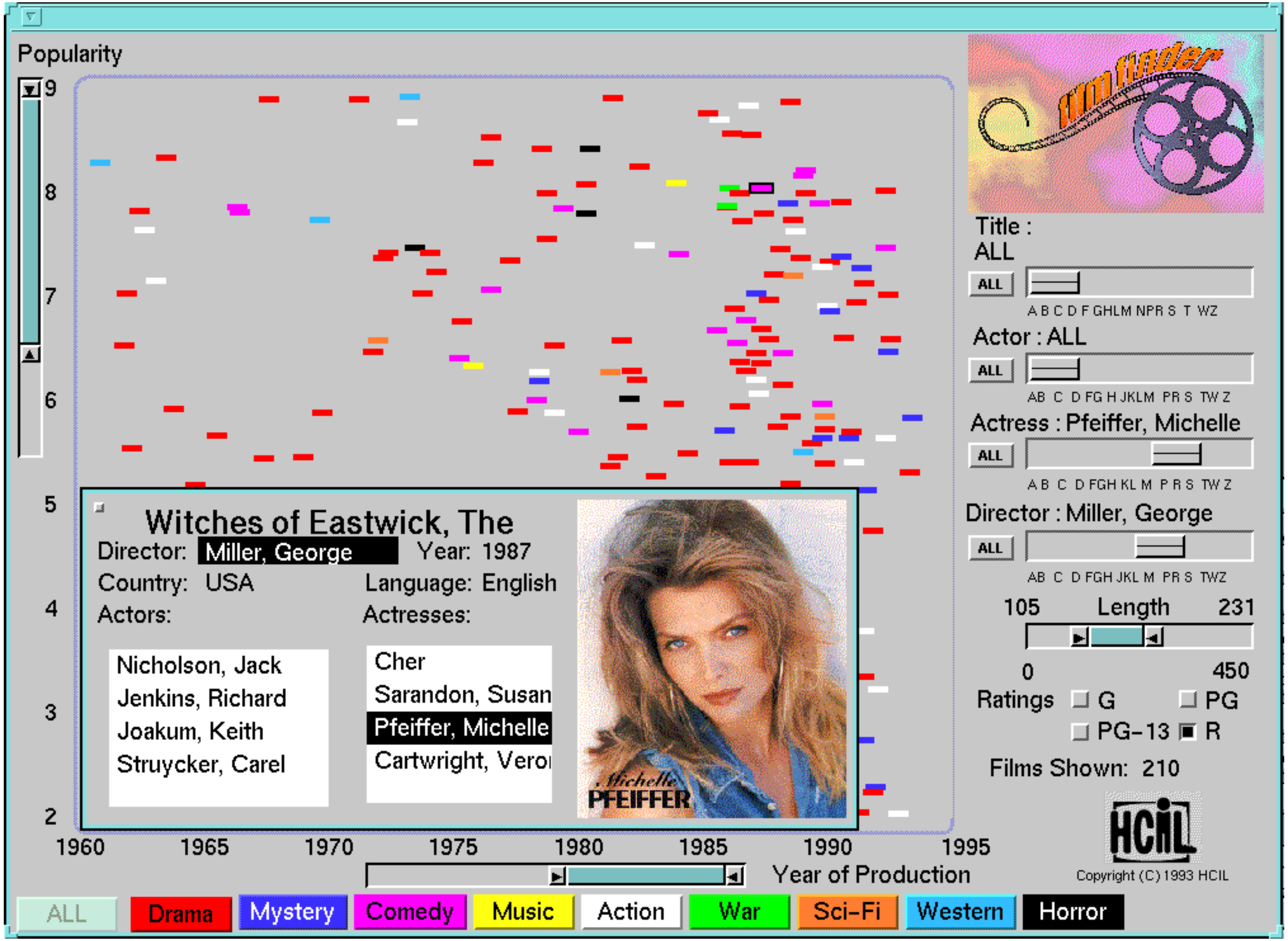
Overview + Detail

Overview and Detail

One view shows overview

Other shows detail

Warcraft III



[FilmFinder, Ahlberg & Shneiderman, 1994]

Filtering
& dynamic querying

aka brushing, aka selecting

The MANTRA

Visual Information Seeking Mantra (Shneiderman, 1996)

Overview first,

zoom and filter,

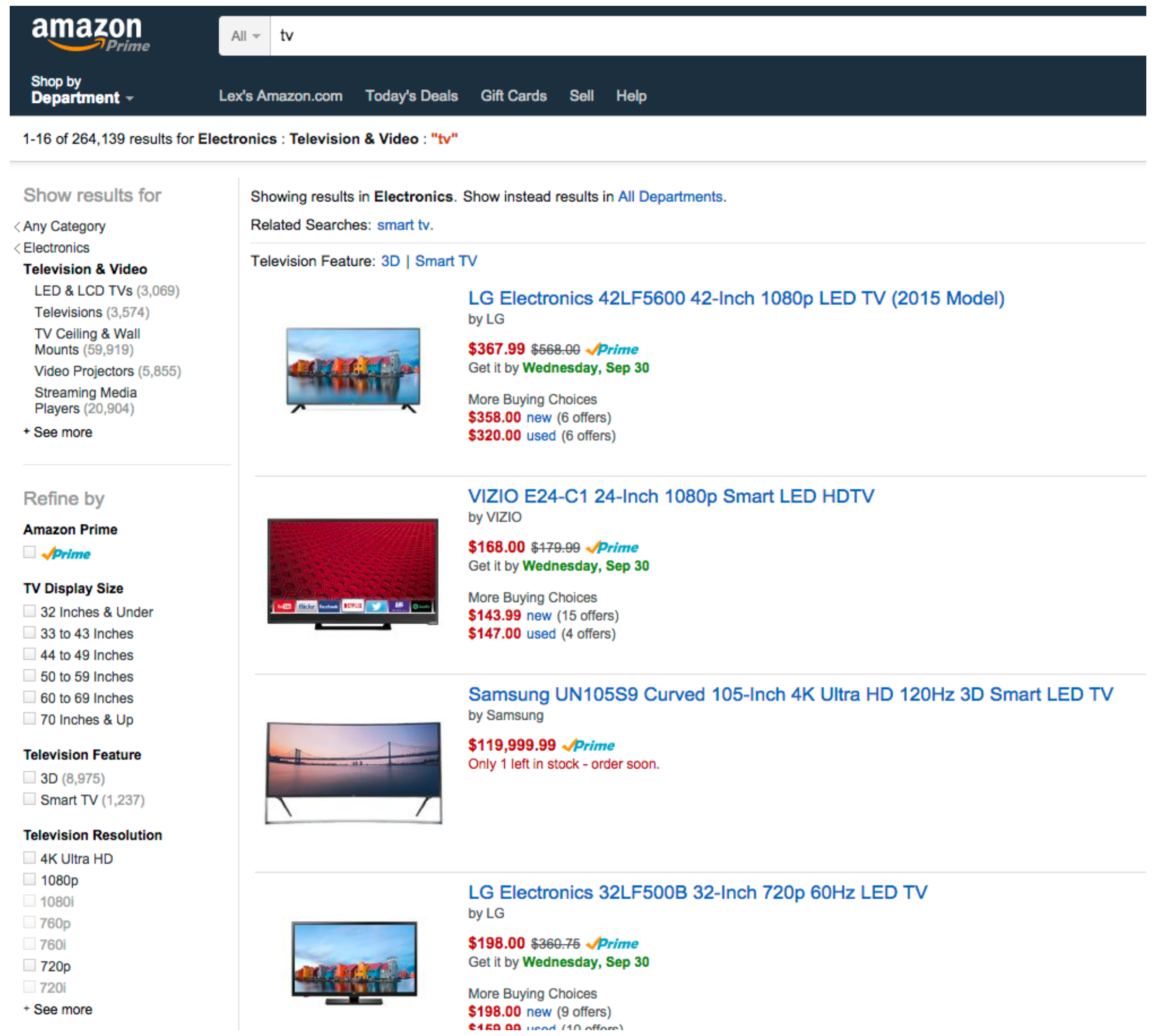
then details on demand

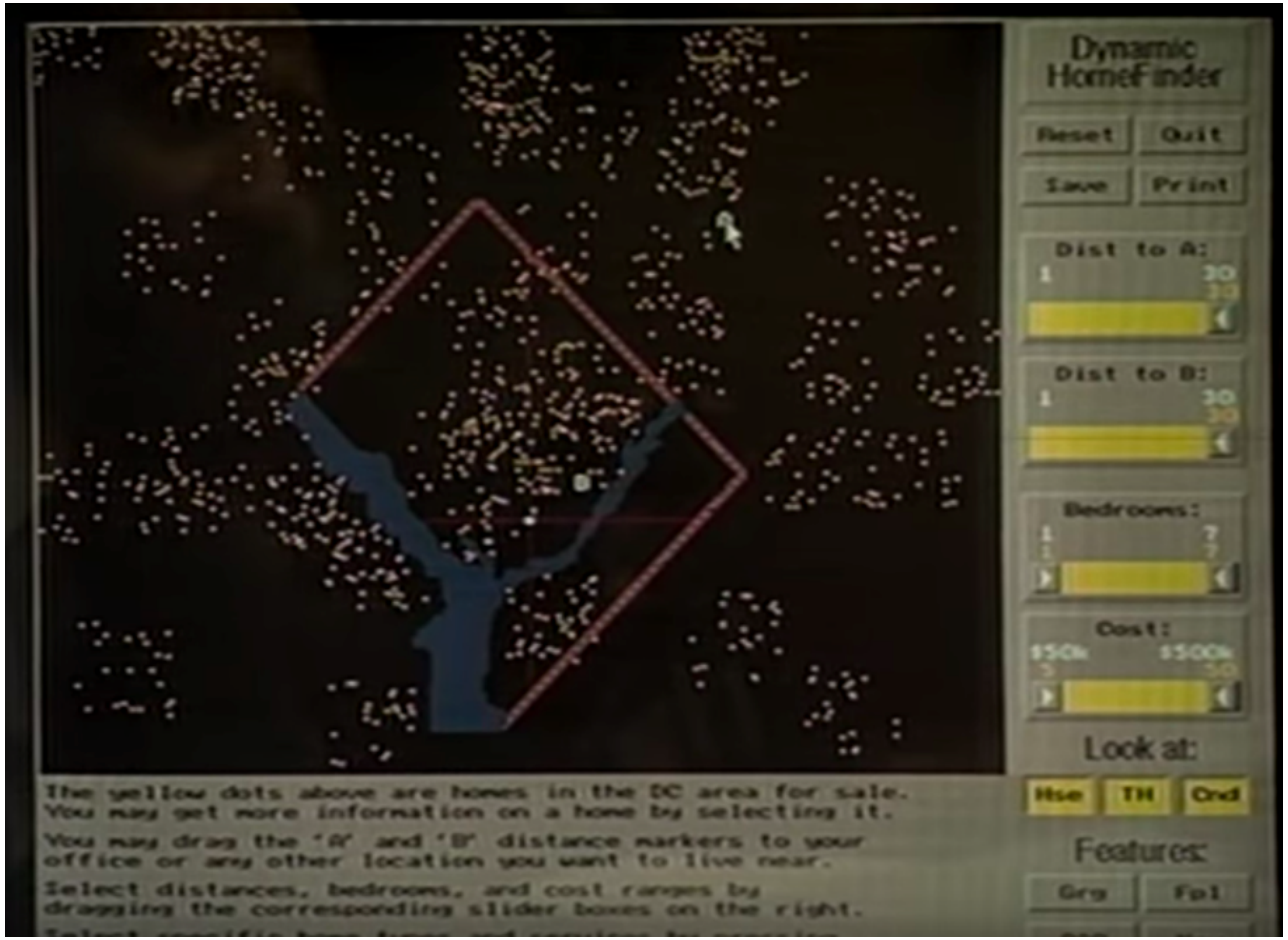
relate, history, extract

Dynamic Queries

Define criteria for inclusion/ exclusion

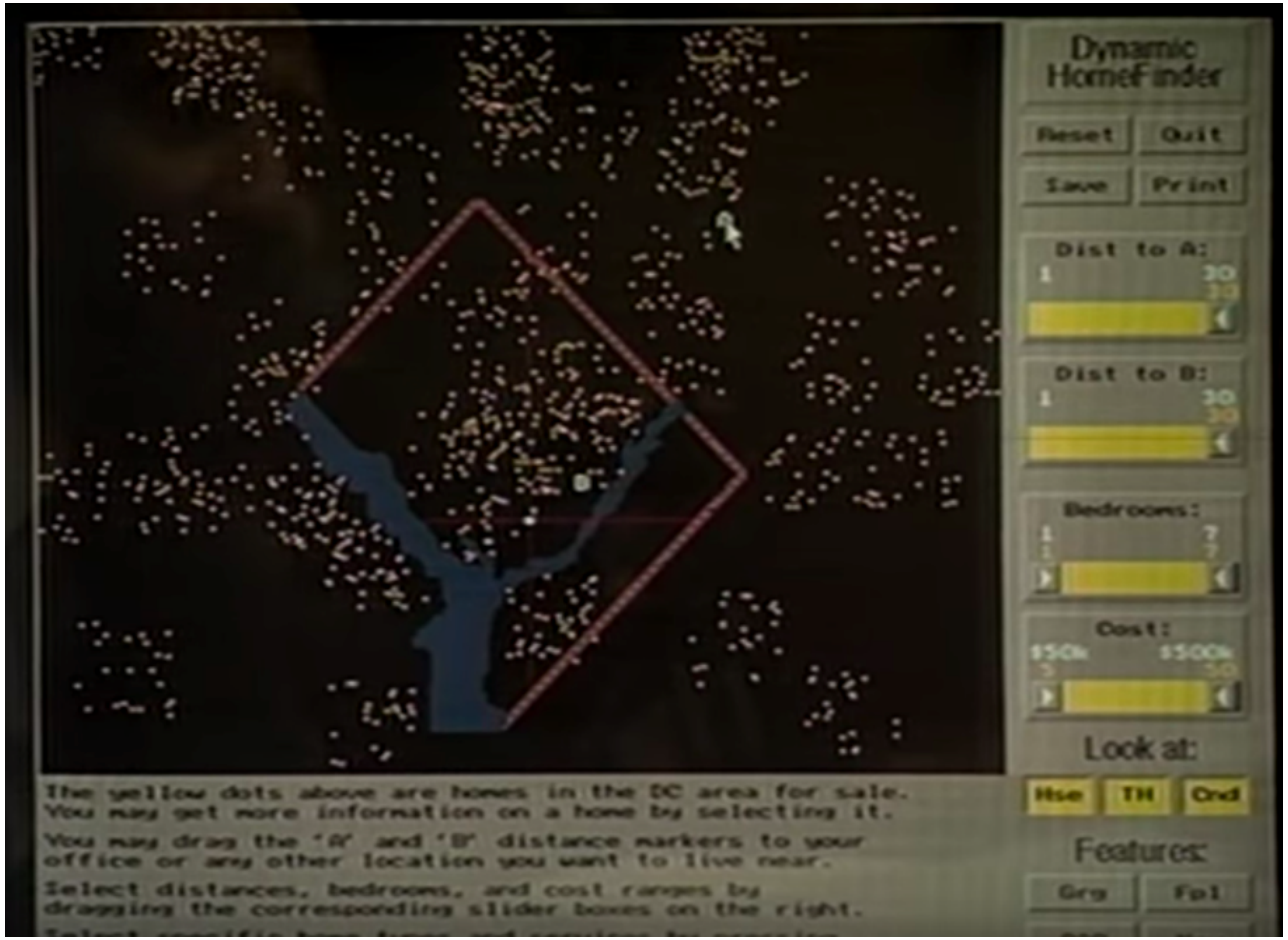
“Faceted Search”





[Ahlberg & Shneiderman, 1994]

Exercise: Redesign



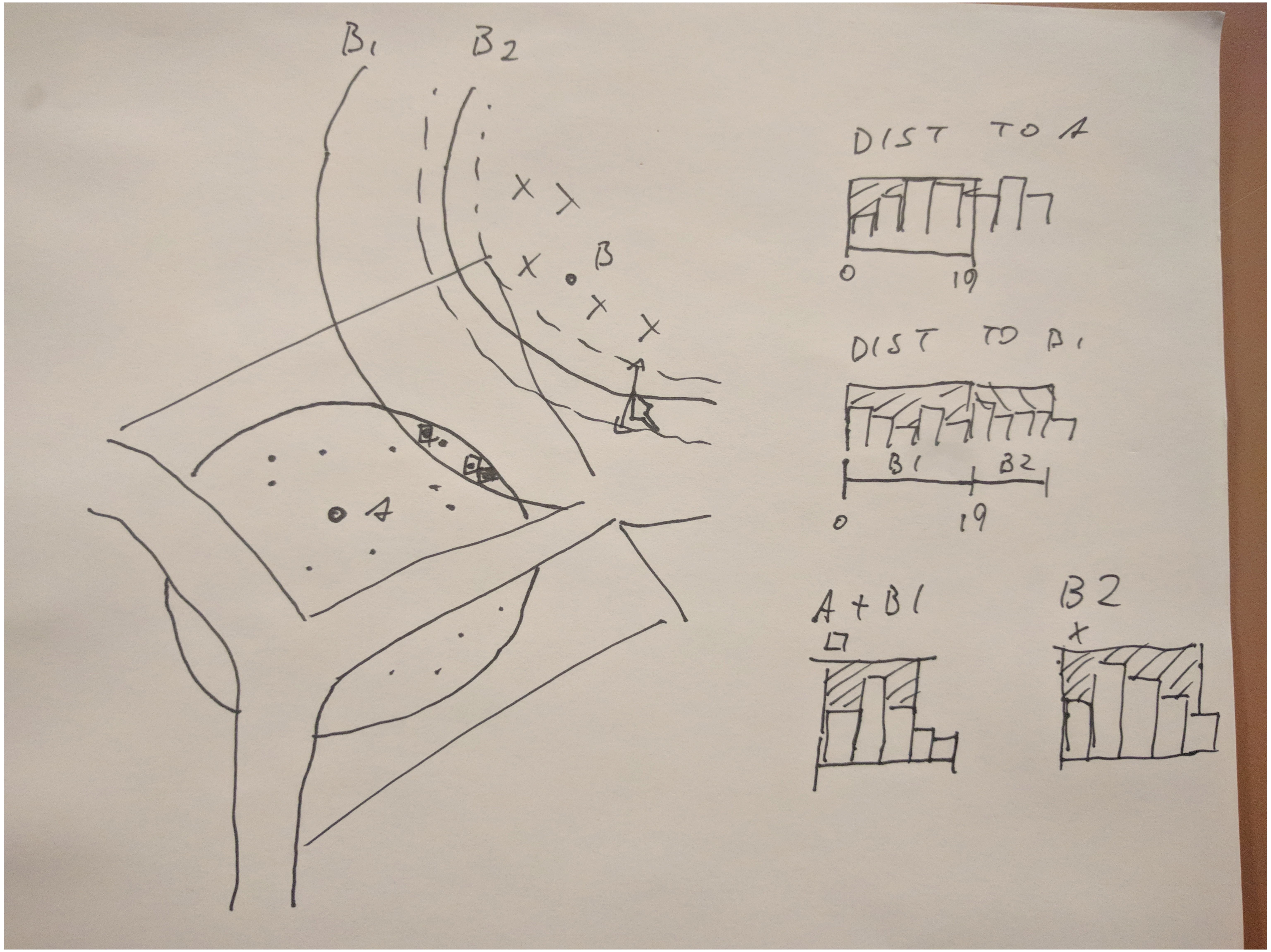
Include Direct Manipulation

Show distribution of homes across variable

Sketch alternative interface to use different criteria in different areas.

Teams of 2-3; 15 minutes

[Inspired by Petra Isenberg's class]

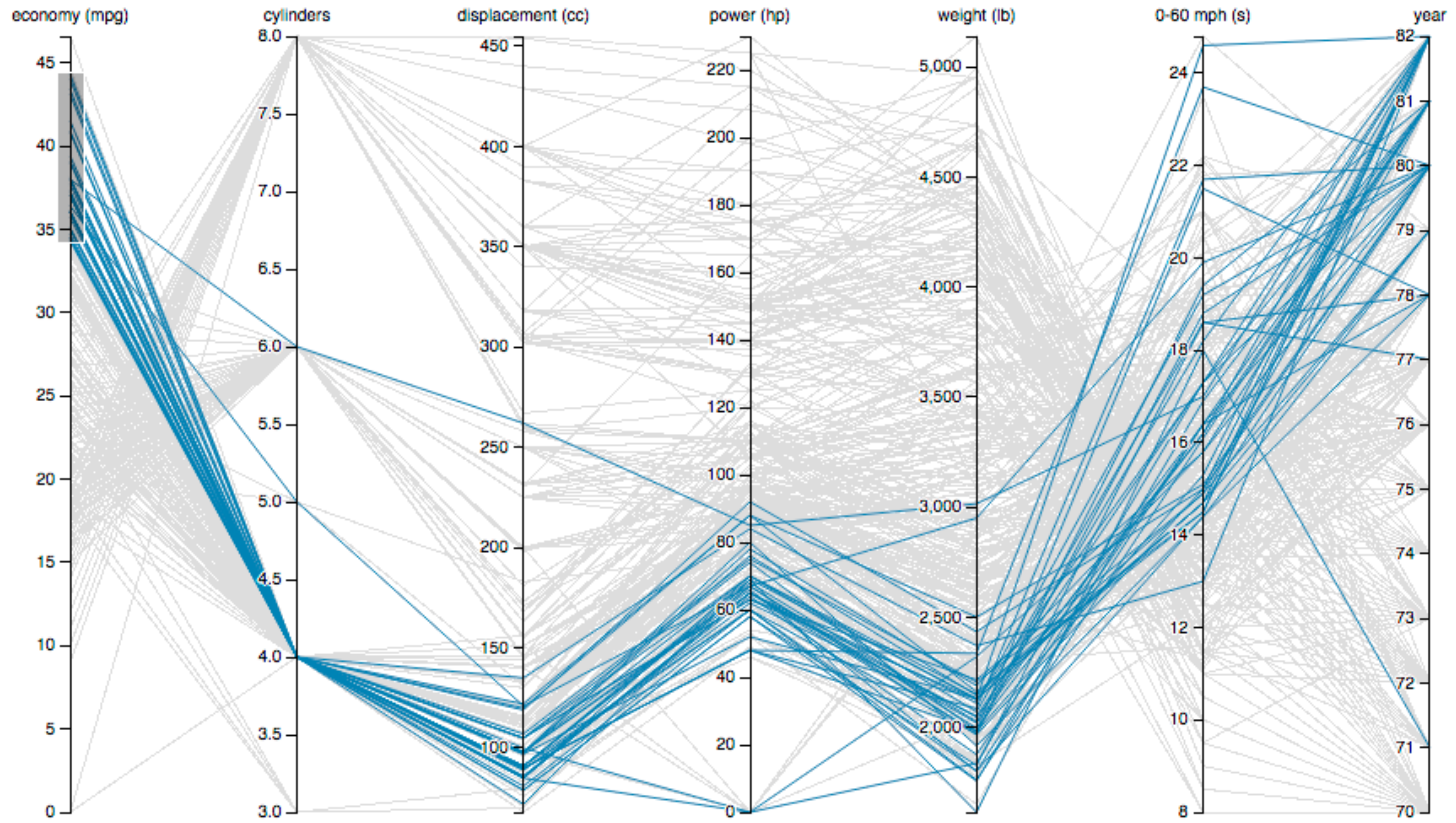


Direct manipulation realized for distance with the circles

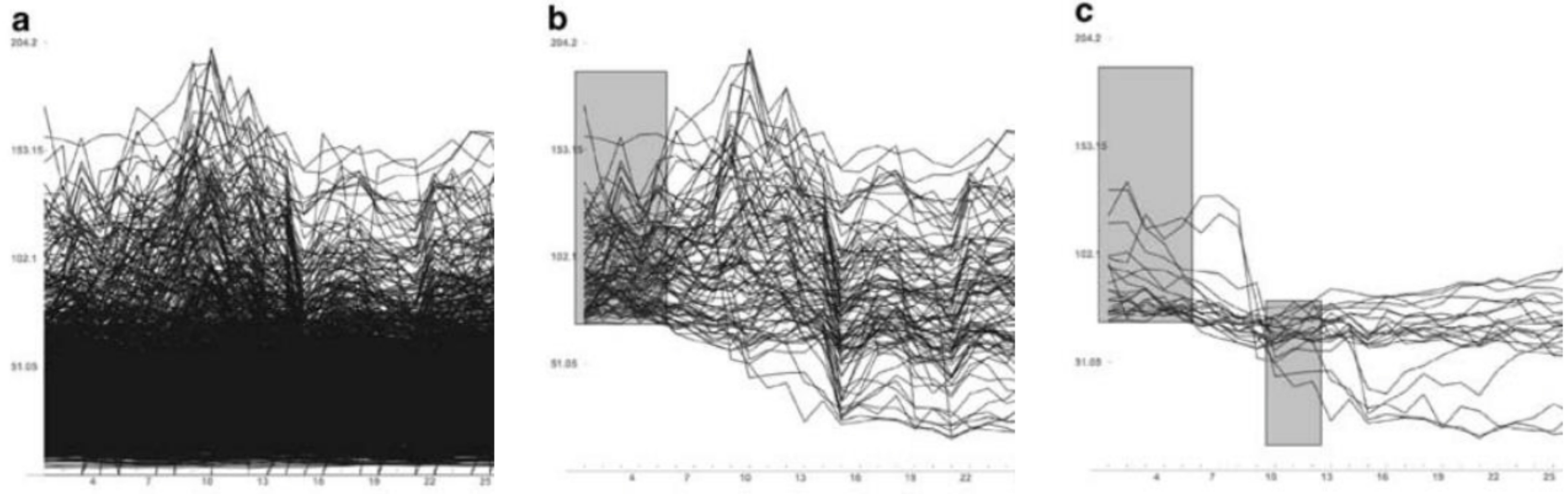
Two filters applied to B, B1 and B2,

Split up for A+B1 and just B2 for other parameters

Visual Queries

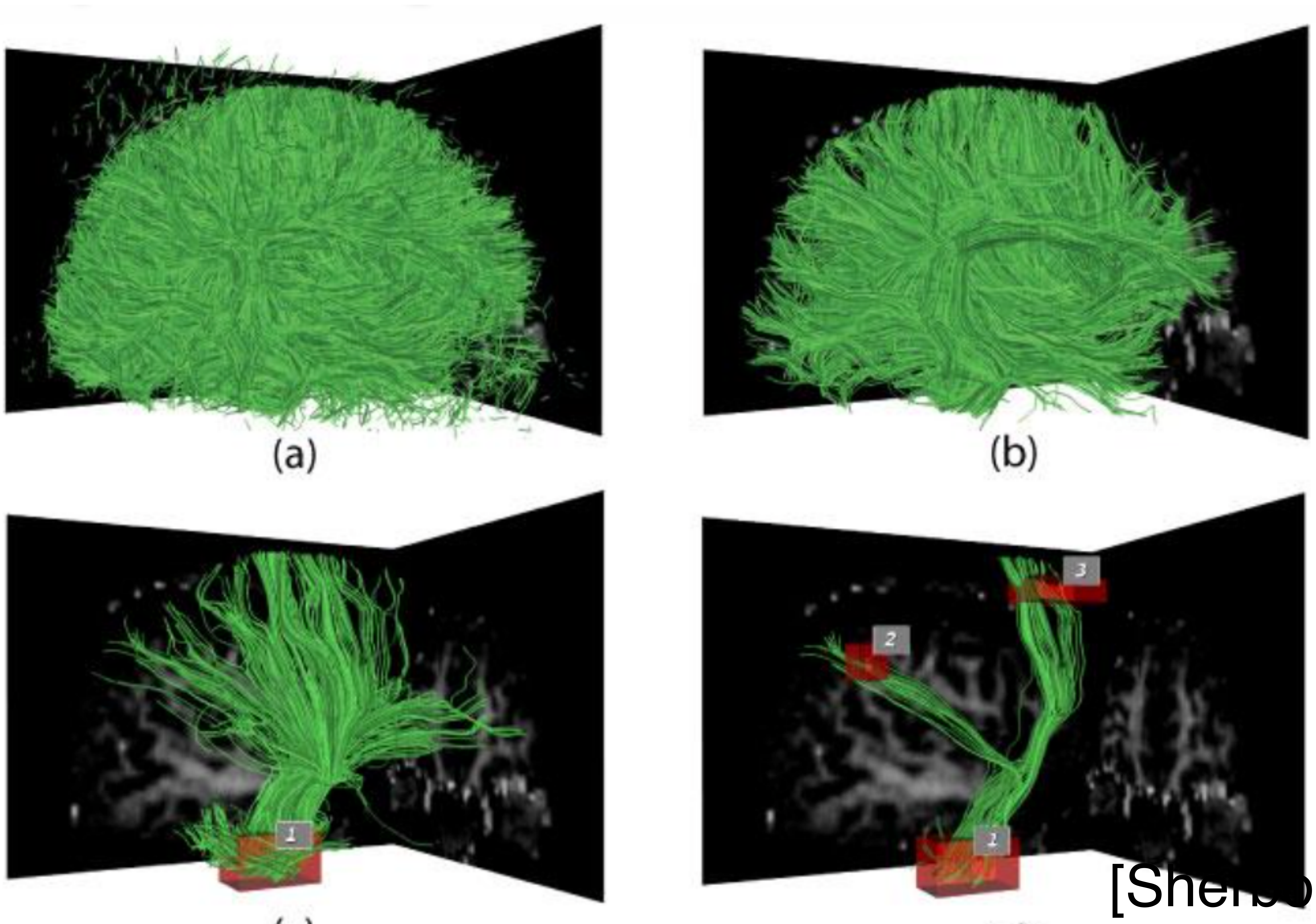


Visual Queries



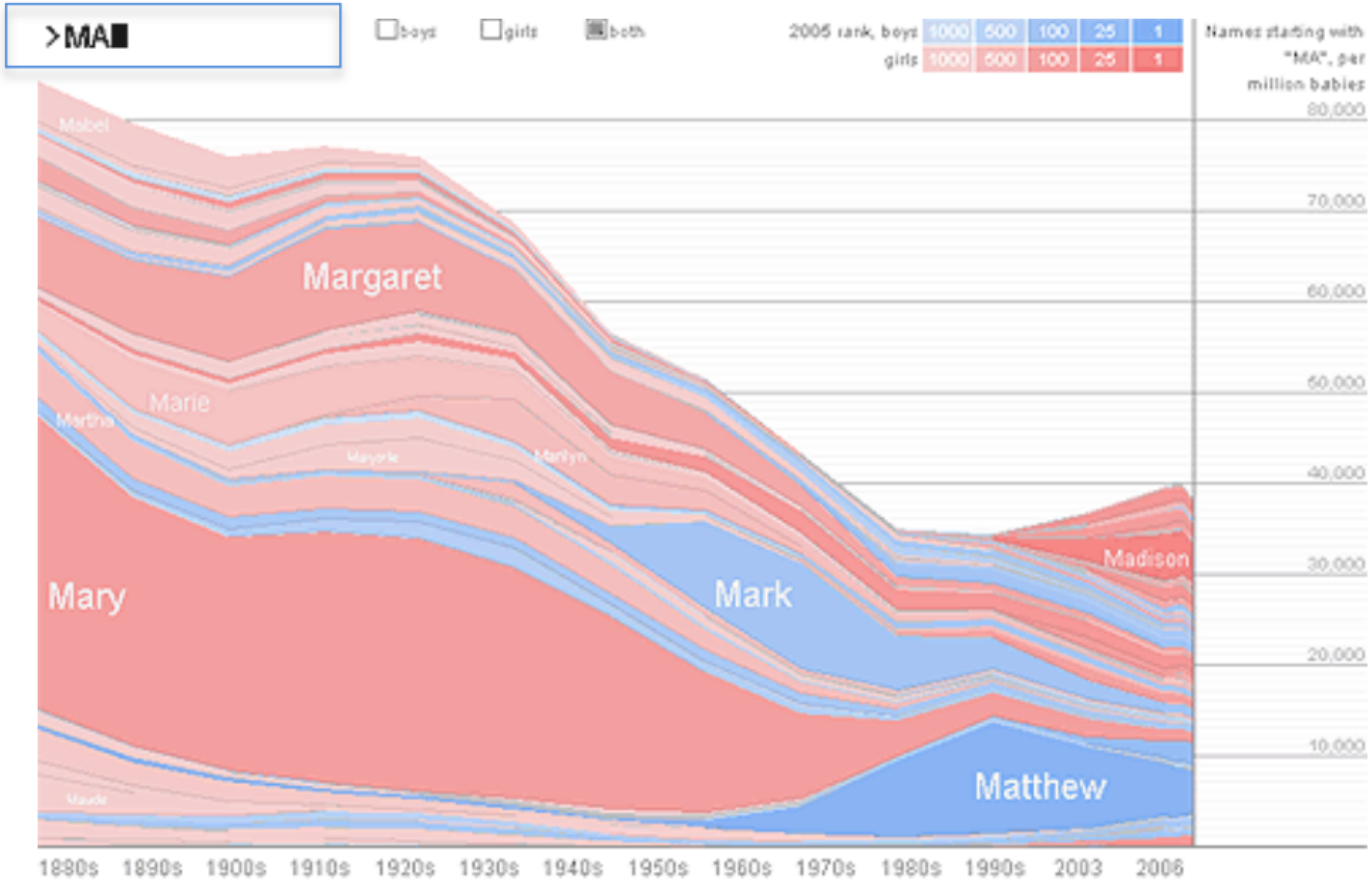
Time Searcher (Hocheiser, 2003)

Dynamic Queries for Volumes

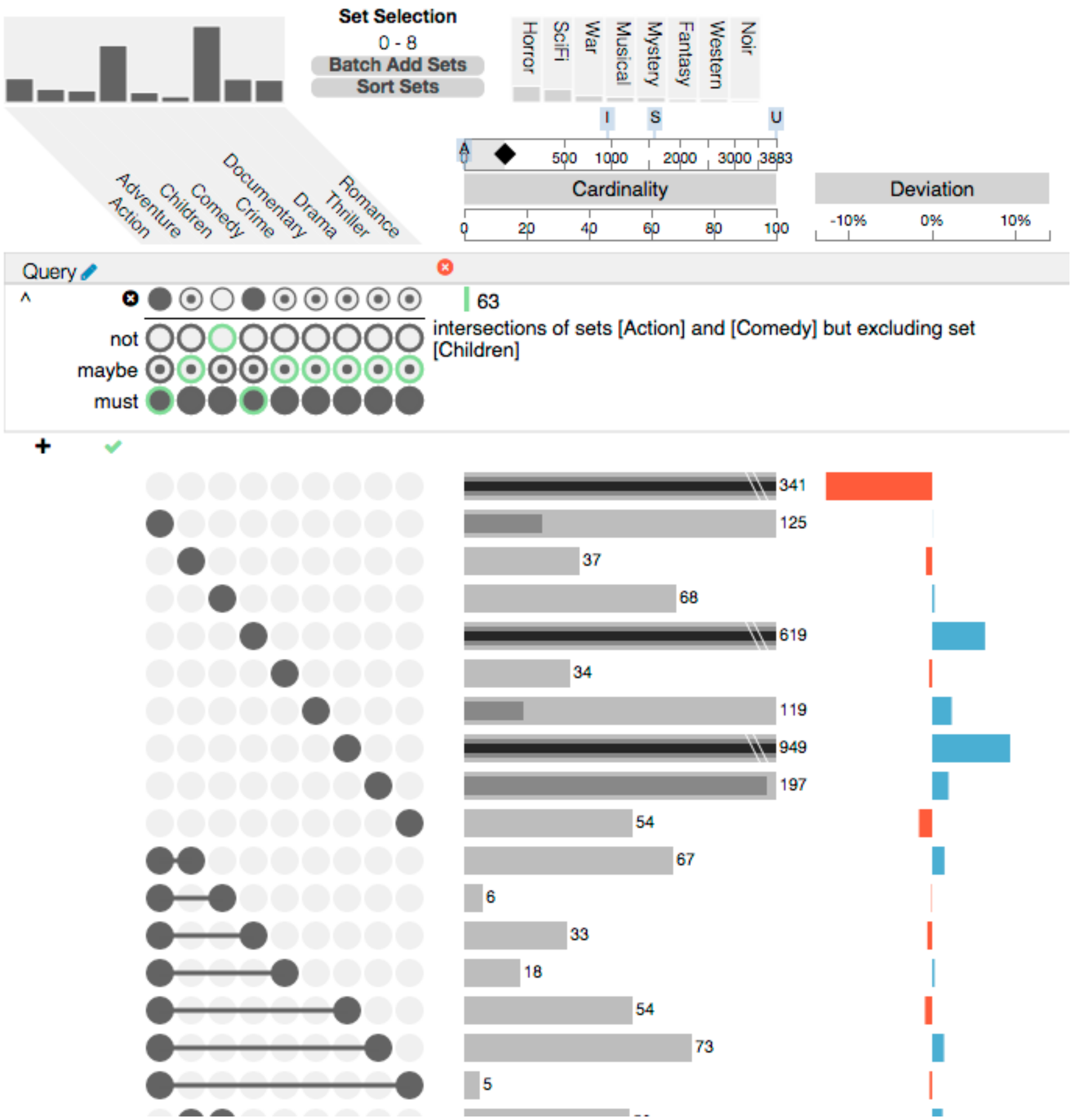


[Sherbondy 2004]

Incremental Text Search



Query Interfaces



More on Filters after the Fall Break!