



浙江大學
ZHEJIANG UNIVERSITY

2019 ZJU International Summer School on Visual Analytics



Interactions in Visualization

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Schedule

- ❖ 1/8, Tuesday: Q&A, Meeting with TAs
- ❖ 1/10, Thursday: Class 14
- ❖ 1/15, Tuesday: Project presentation

Once Upon A Time

Sketchpad Ivan Sutherland 1963



<https://www.youtube.com/watch?v=5RyU50qbvzQ>

Interactions in Visualization

“Overview first, zoom and filter, and details on demand.”

-Ben Schneiderman



<http://www.cs.umd.edu/users/ben/>

Outline

- ① Types of Interactions
- ② Overview + Details
- ③ Focus + Context
- ④ Animation
- ⑤ Interaction Hardware Design

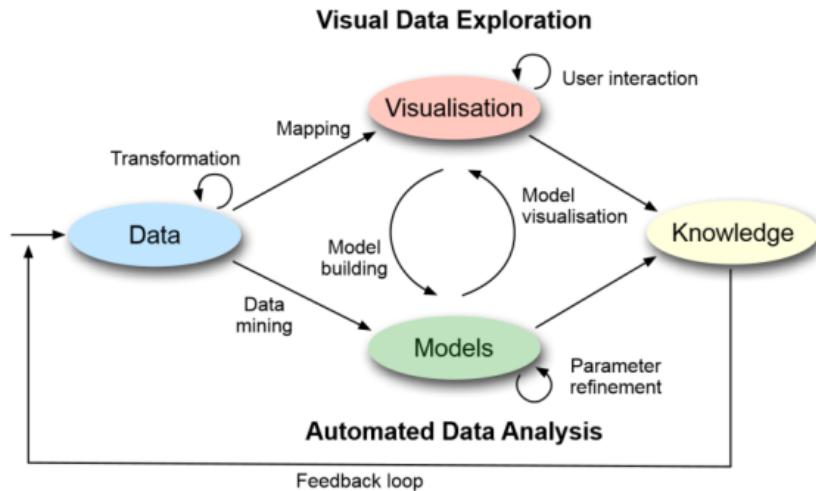
Types of Interactions

Representation and Interaction

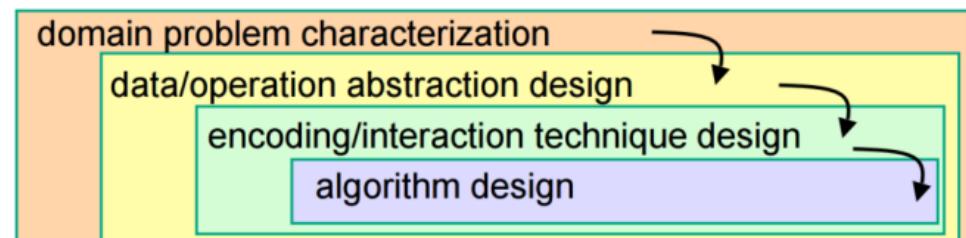
There are two major components of information visualization:

- **Representation** of objects users pay attention to, and
- **Interactions** which are operations users can apply.

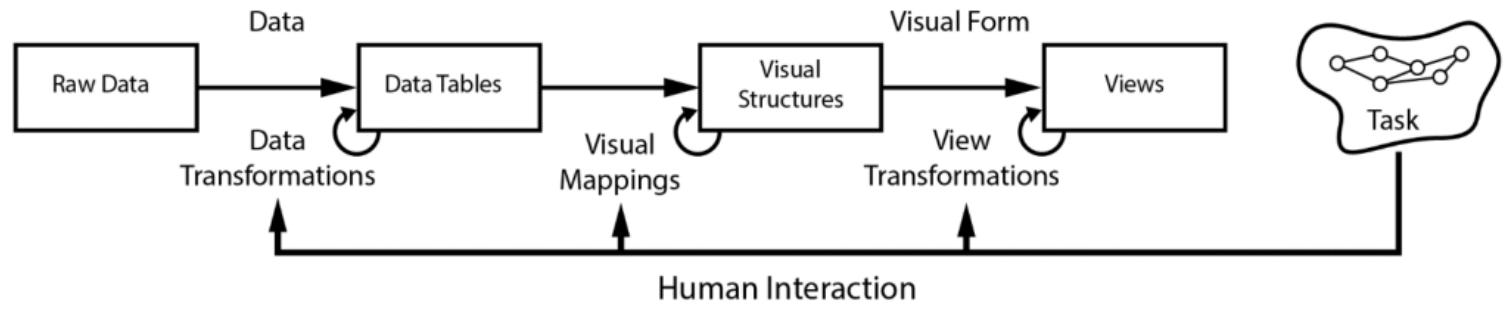
Interactions in Visualization



[Mansmann2010]



[Munzner2009]



[Card1999b]

Types of Interactions

Dix and Ellis (AVI 1998)

- Highlighting and focus
- Accessing extra info – drill down and hyperlinks
- Overview and context – zooming and fisheyes
- Same representation, changing parameters
- Linking representations –temporal fusion

Types of Interactions

Daniel Keim (TVCG 2002)

- Projection
- Filtering
- Zooming
- Distortion
- Brushing & linking

Types of Interactions

Yi et al. (TVCG 2007)

- Select
- Explore
- Reconfigure
- Encode
- Abstract/Elaborate
- Filter
- Connect

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Types of Interactions

- Select
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OUTLINE

Select

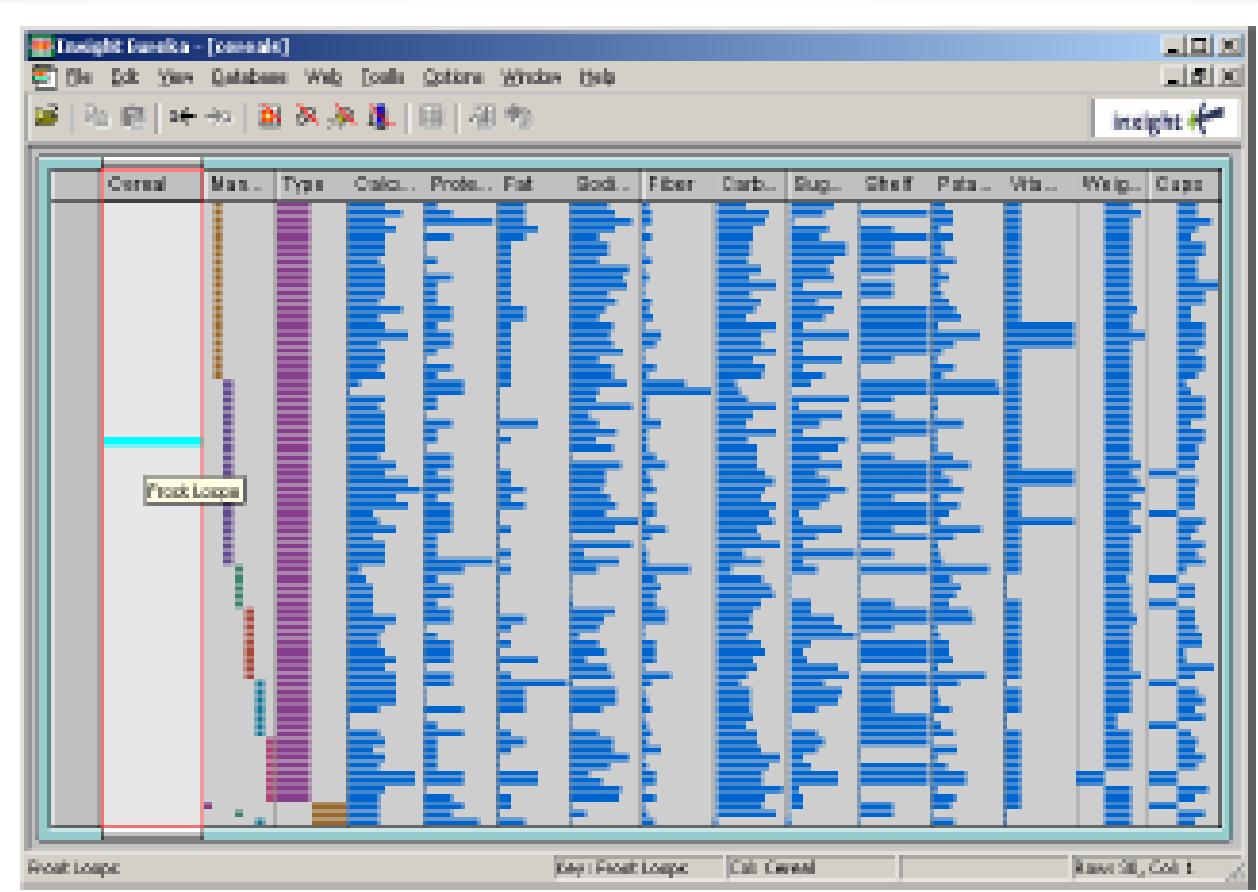
- “Mark something as interesting.”
- Mark items of interest to keep track.
- Seems to often work as a preceding action to subsequent operations.

Examples

- Select a landmark in Google Map.
- Select the Focus feature in TableLens.

Method 1: Pop-up Tooltips

Hovering mouse cursor brings up details of item.



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Hovering mouse cursor brings up details of item.

SIMPLE TOOLTIPS

2 years ago | 20 Replies

Easily add tooltips to your WordPress site. Tooltips will show when target element is hovered over. On mobile devices tooltips show when target element is tapped. You can easily pick your tooltip color settings in **Settings > Simple Tooltips**.

Now you know what it will
look like

What Will it Look Like?

To see an example hover over this text. I'm using the plugin in many places on this site (for example, when you hover over the 'about me' picture in the top left of the page).

<https://wordpress.org/plugins/simple-tooltips/>

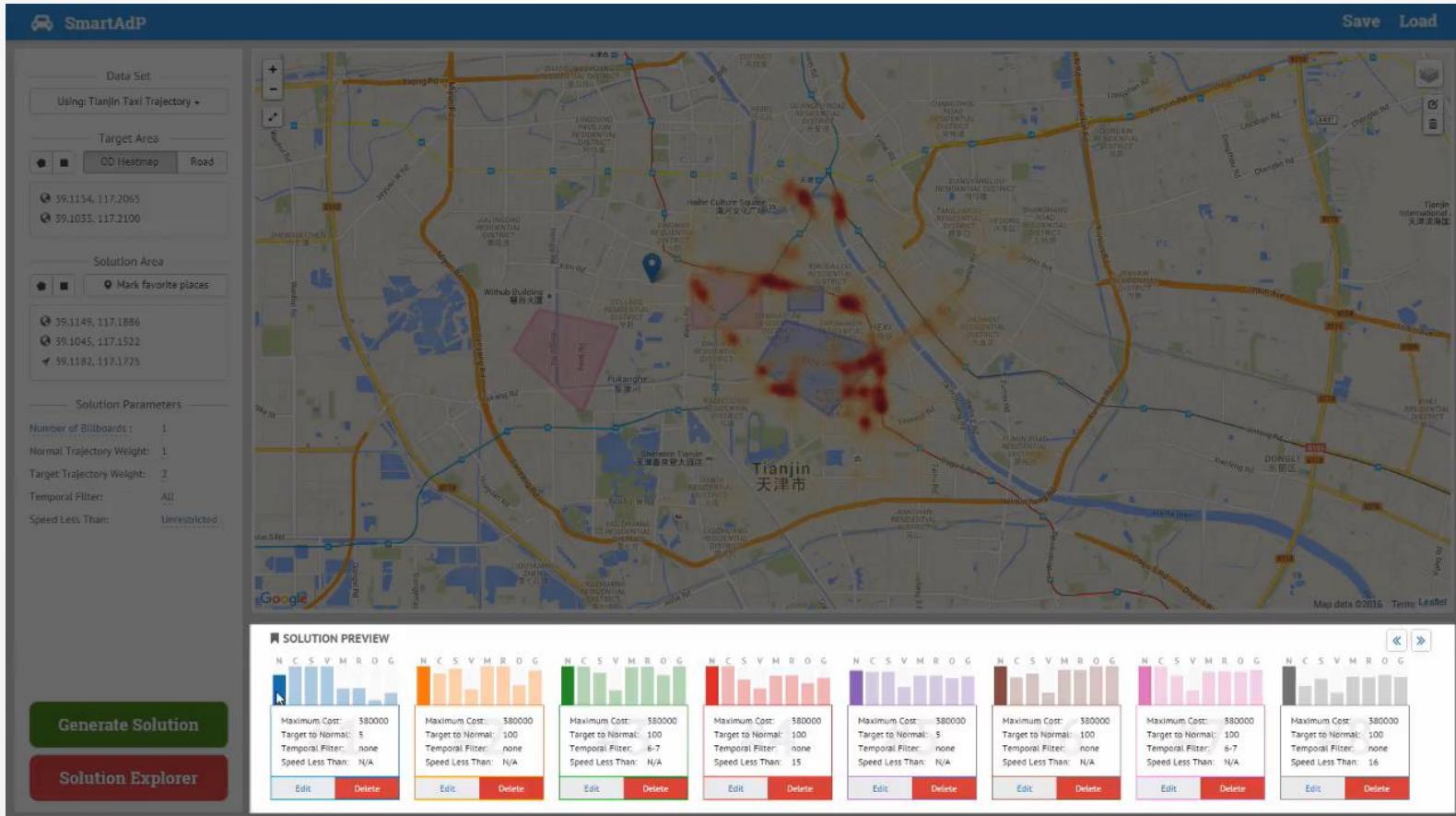
Method 1: Pop-up Tooltips

Hovering mouse cursor brings up details of item.

The screenshot shows the Logos Bible Software 5 interface with the title "Logos Bible Software 5" at the top. The main window is titled "Passage Analysis" and displays a "Forward word tree for English Standard Version ordered by Frequency". The word "God said" is highlighted. A detailed word tree diagram is shown, with "God said" branching into "the", "Let", "there be", "Noah", "to", "the", "woman", "serpent", and "Behold". Each node in the tree has a tooltip containing a portion of the text from Genesis 1:11. At the bottom of the window, there are tabs for "Compare Pericopes", "Word Tree" (which is selected), "Morph River", "Cluster Graph", and "Version River". The taskbar at the bottom of the screen shows icons for the browser, file explorer, and other applications, along with the date and time (5:08 AM 8/2/2013).

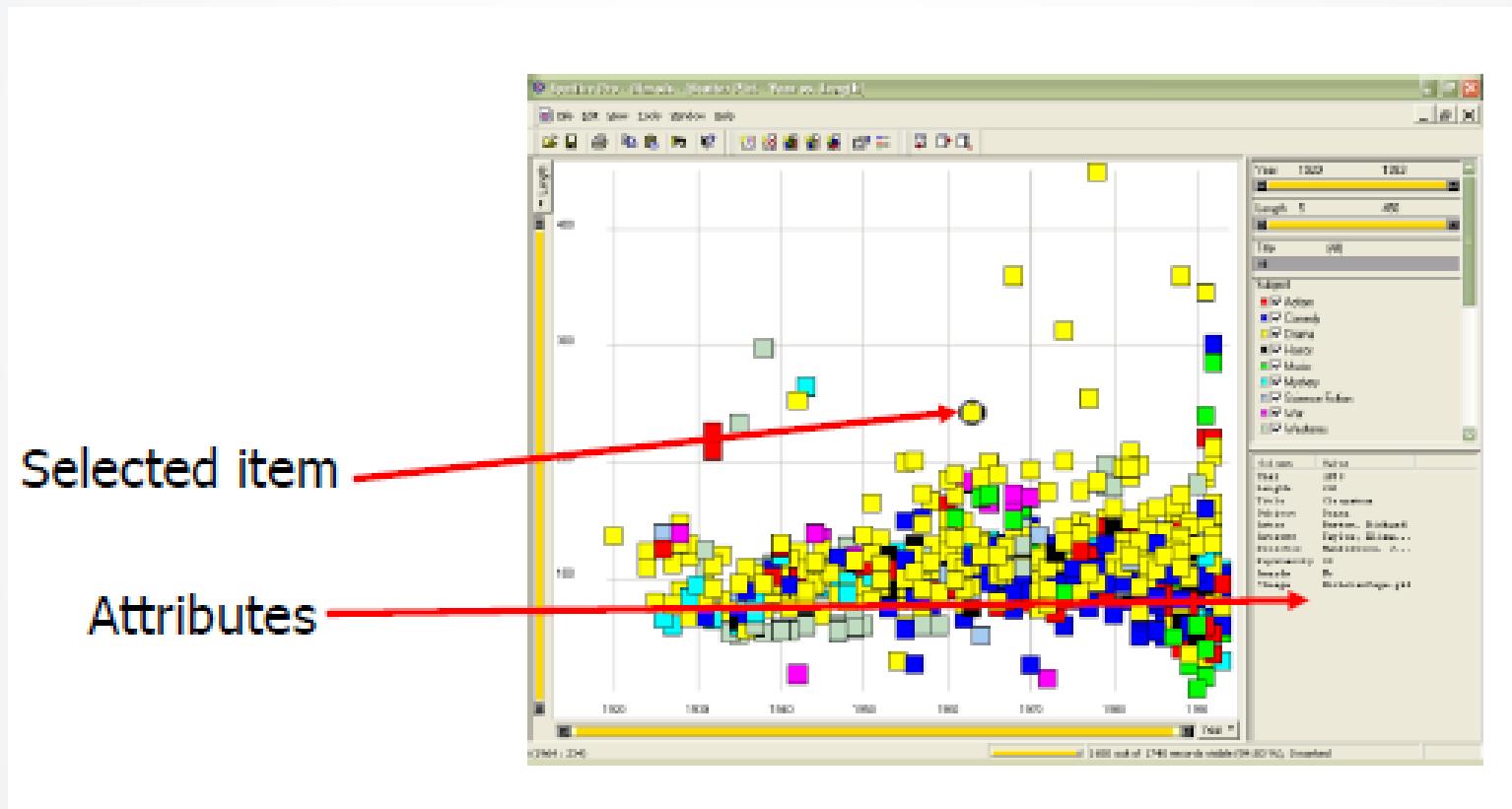
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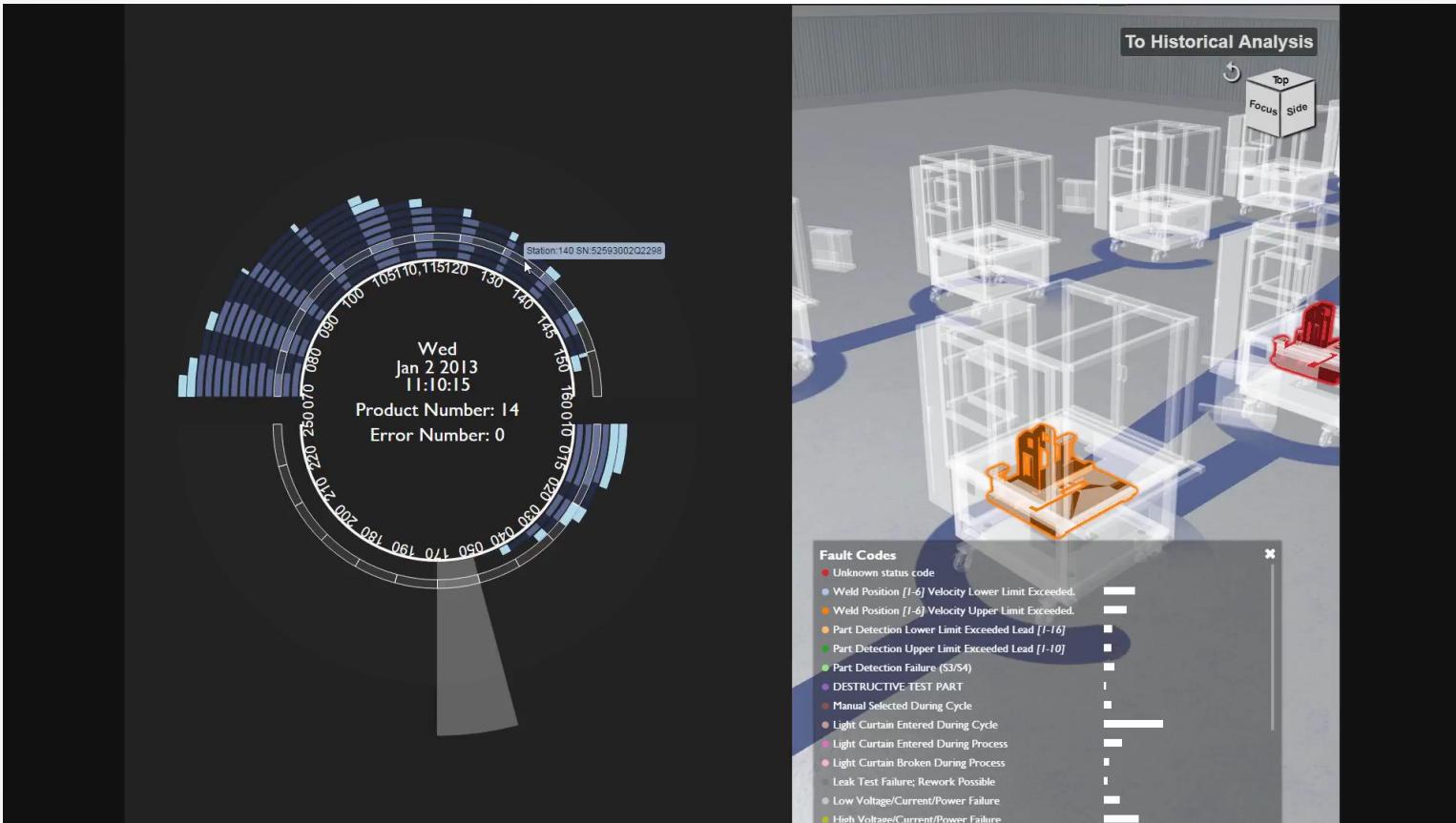
Method 2: Mouse Selection

Clicking on an item selects it and attributes of the data point are shown



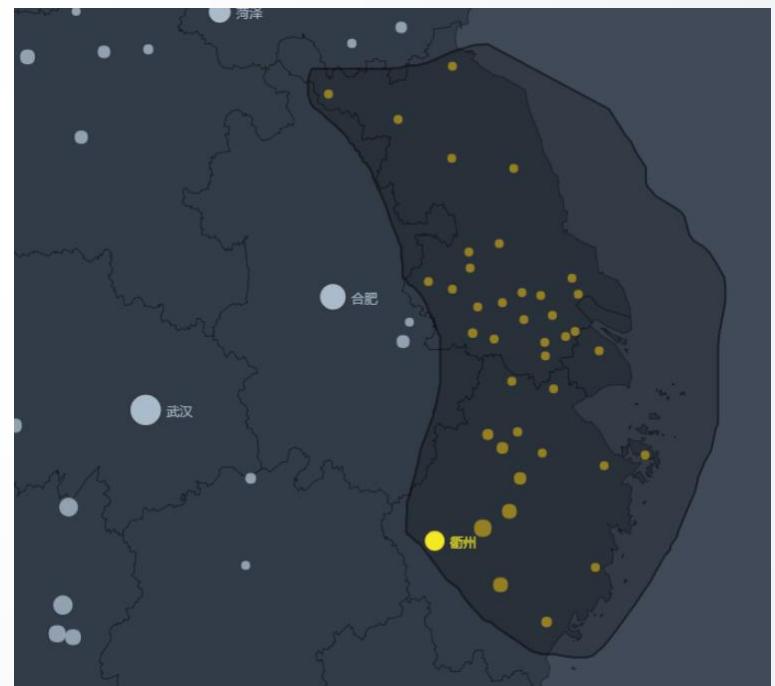
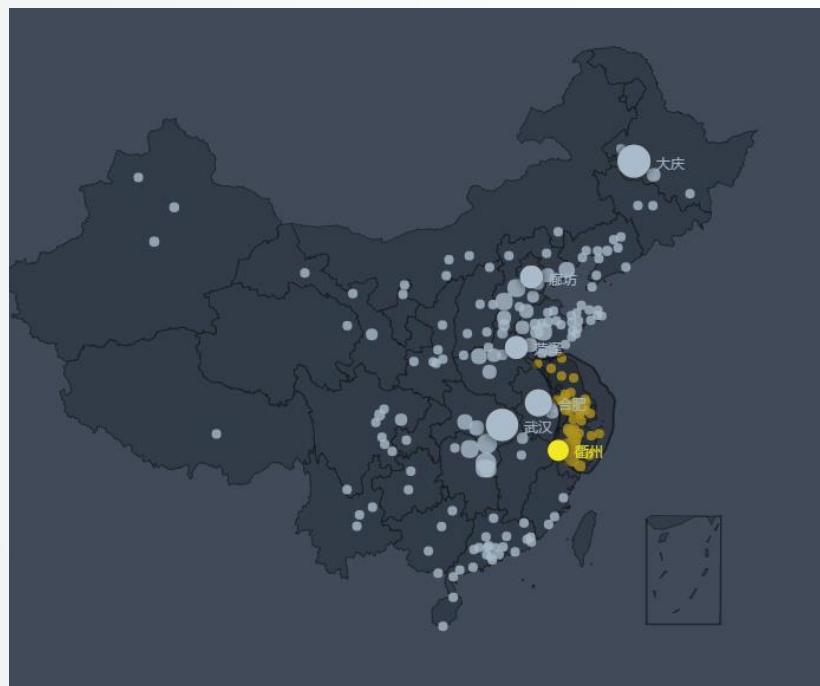
Method 2: Mouse Selection

Click on an item, selects it and detail of the data are shown.



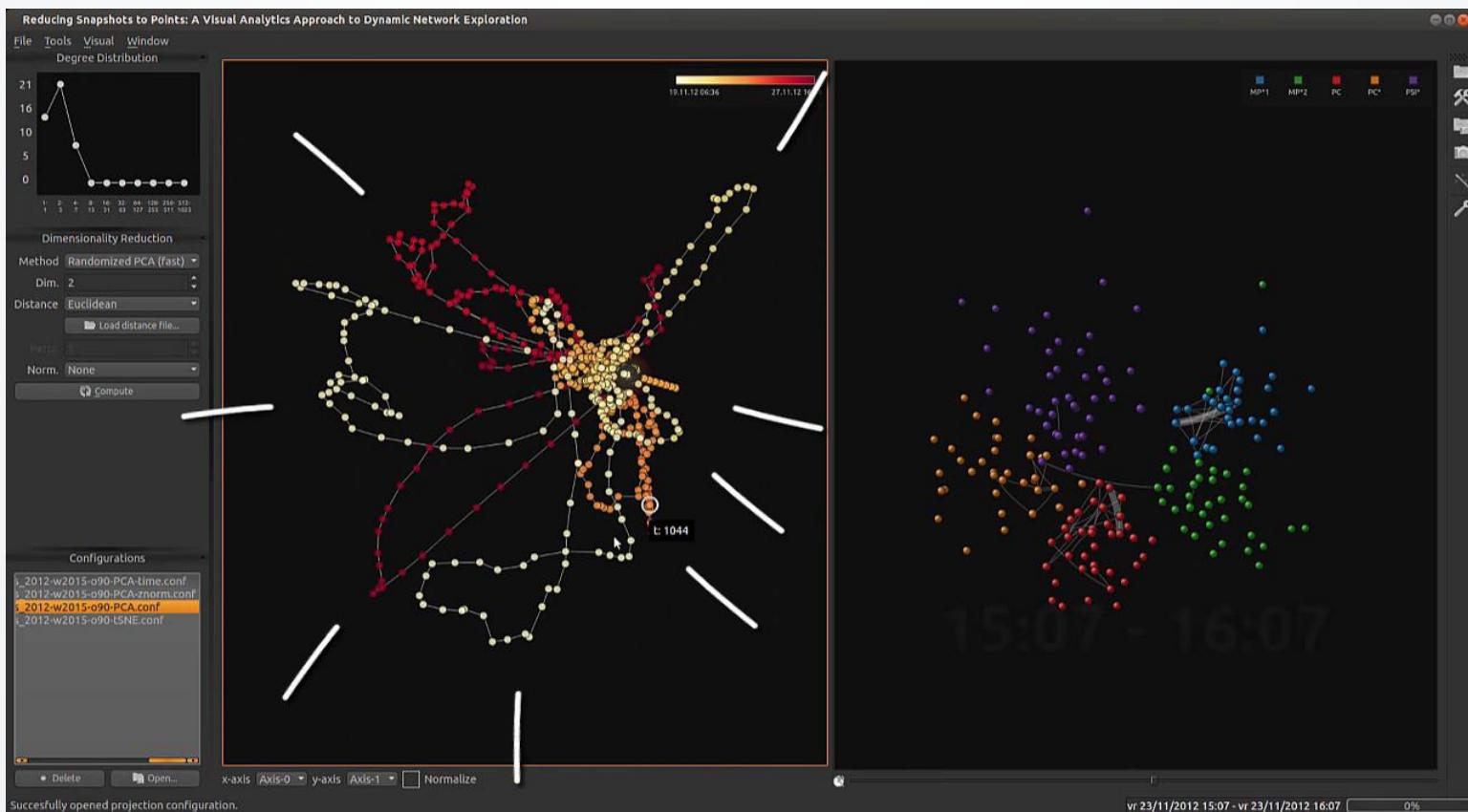
Method 2: Mouse Selection

Select a region on the map and use amplification technology to visualize clusters in the selection.



Method 2: Mouse Selection

Select a region on the map and use amplification technology to visualize clusters in the selection.

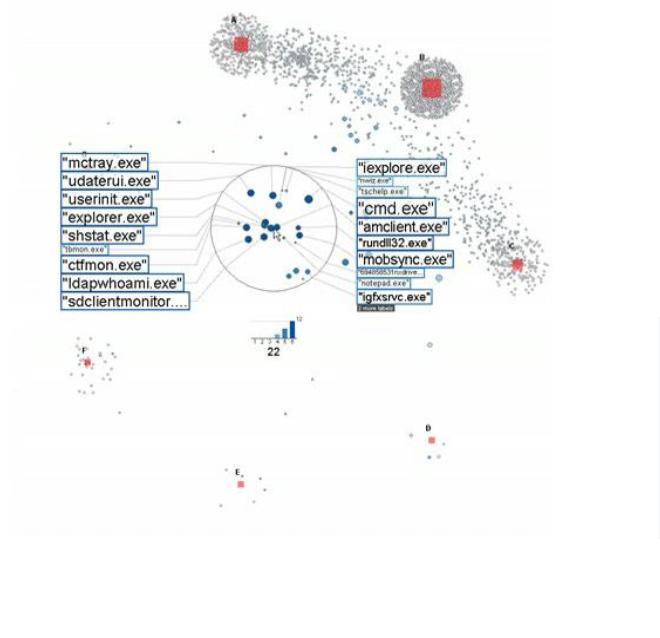
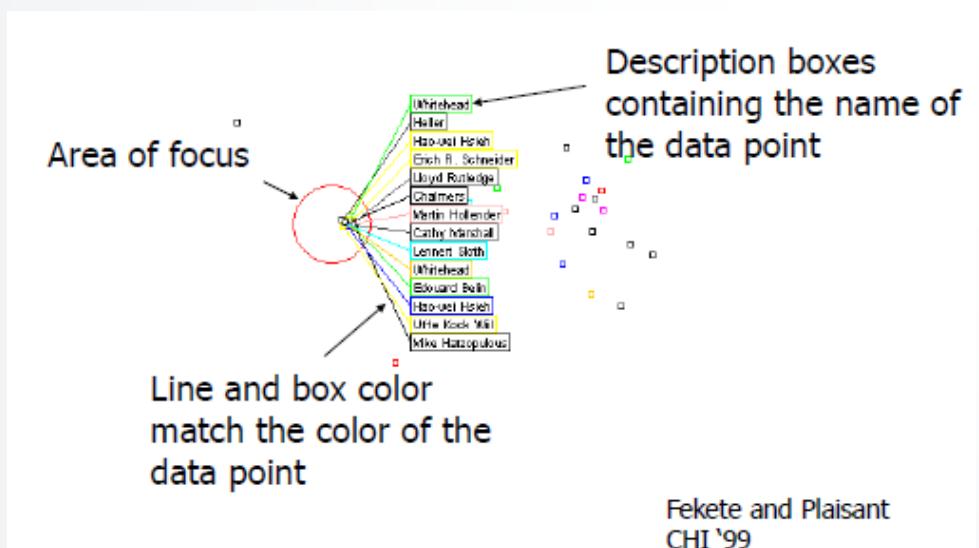


Problems and Goals of Label Selection

- Where are the labels?
 - Labeling is difficult to do when so many entities exist.
 - Can add to ball of string problem.
- Each label for a data point should:
 - Be readable,
 - Non-ambiguously relate to its graphical object, and
 - Not hide other pertinent information.
- Completeness (labeling of all objects) is desired but not always possible.

Excentric Labeling

- “Invisible” – Do not appear until user hovers over data points.
- Describe data points using the name field.
- Visually connect labels with data points.
- Order labels to indicate graph position.



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Types of Interactions

- Select
- Explore
- Reconfigure
- Encode
- Abstract/Elaborate
- Filter
- Connect

OUTLINE

Explore

- “Show me something different.”
 - Exploration enable users to examine a different subset of data.
 - Exploration overcome the limitation of display size
- Examples
 - Panning in Google Earth
 - Direct Walking in Visual Thesaurus

Direct Walk

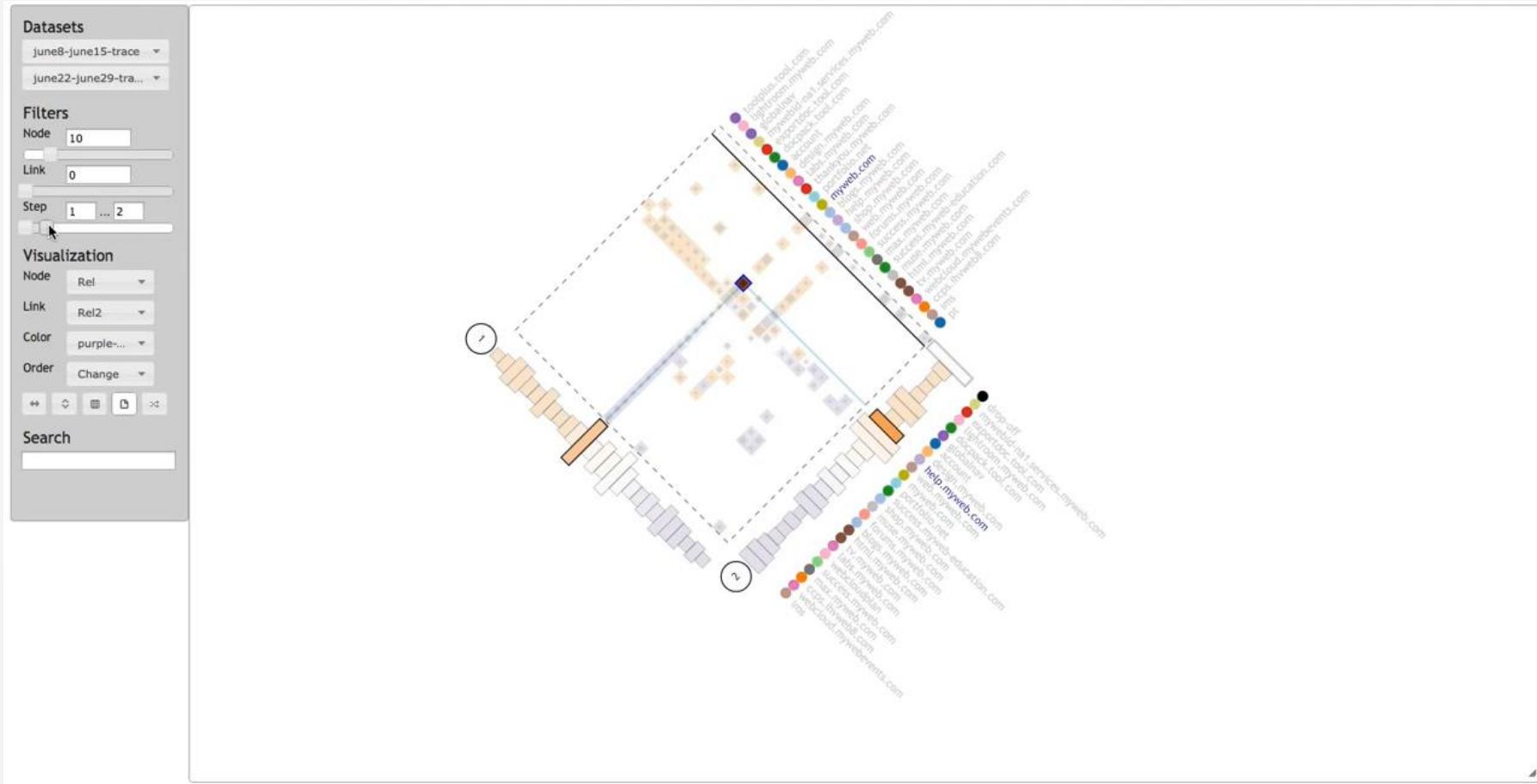
Linkages between cases : Exploring one may lead to another.

- Follow the hyperlinks on web pages.



<http://www.zju.edu.cn/>

2D Navigation



Zhao et al. MatrixWave: Visual comparison of event sequence data. ACM HFCS, 2015.
https://www.youtube.com/watch?v=HranxBG9F_w

2D Navigation

GeneaQuilts

A System for Exploring
Large Genealogies

A. Bezerianos P. Dragicevic J.-D. Fekete J. Bae B. Watson

3D Navigation



https://www.youtube.com/watch?v=tl_sJuA2LWg

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OUTLINE

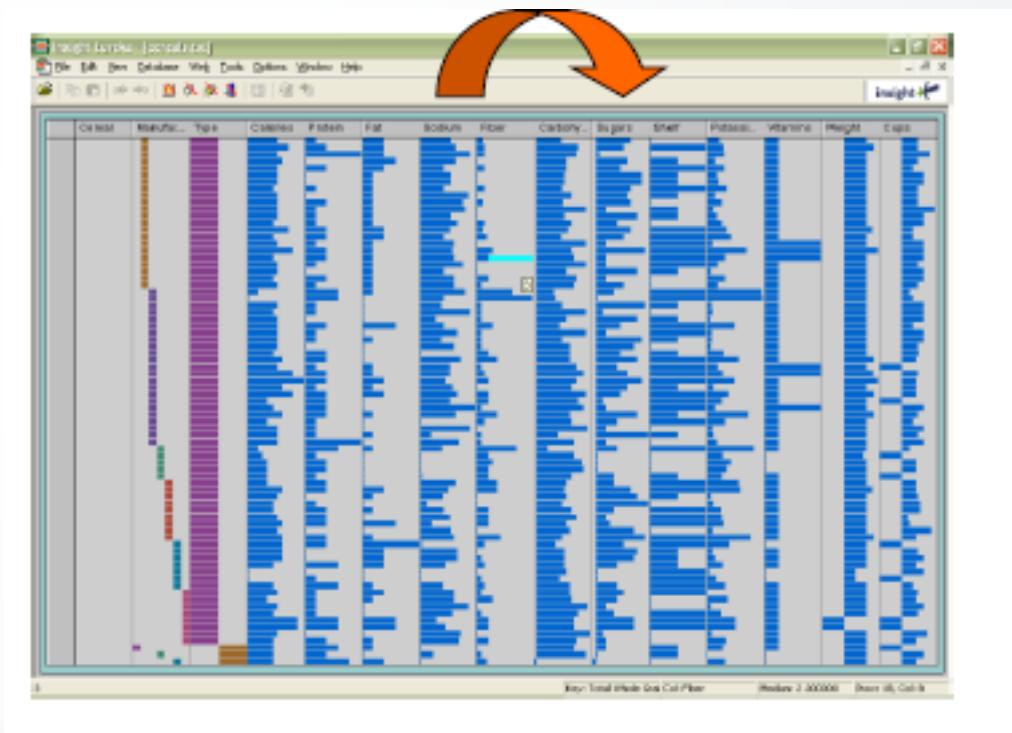
Reconfigure

- “Show me a different arrangement.”
- Reconfiguring provides different perspectives by changing the spatial arrangement of representation.
- Examples
 - Sorting and rearranging columns in TableLens.
 - Changing the attributes in a scatter plot.
 - The baseline adjustment feature in Stacked Histogram.
 - The “Spread Dust” feature in Dust & Magnet.

Method 1: Rearrange View

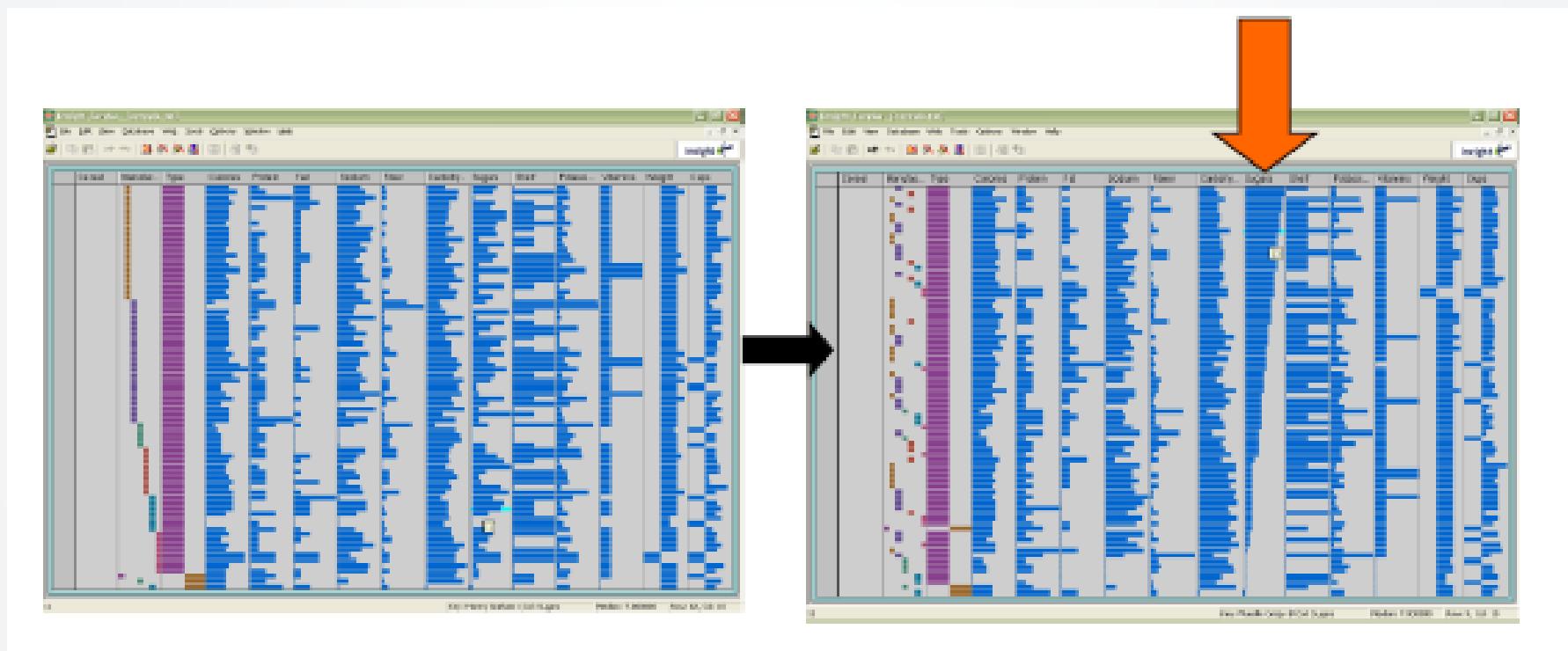
- Keep same fundamental representation and what data is being shown, but rearrange elements by:
 - Alter positioning
 - Sort

You can move columns
(attributes) left and right



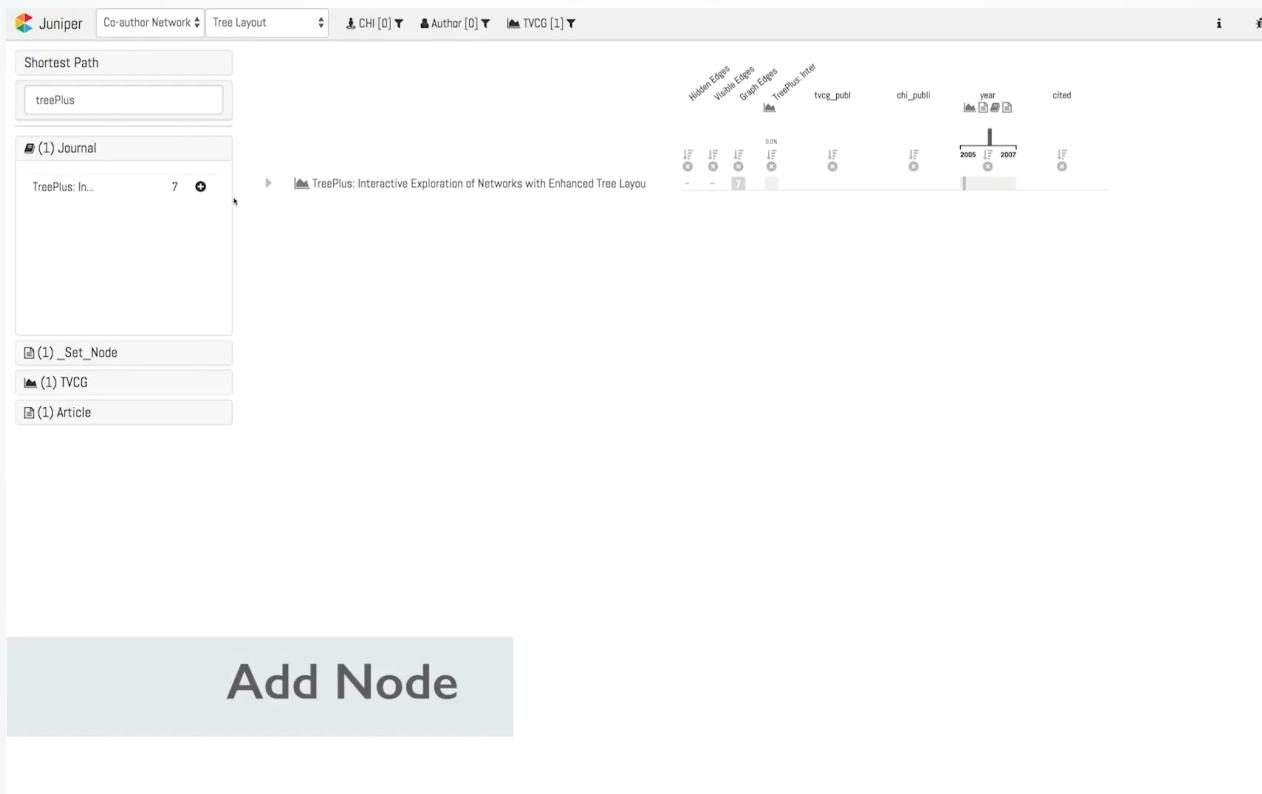
Method 2: Sorting

- Sort data with respect to a particular attribute.



Method 2: Sorting

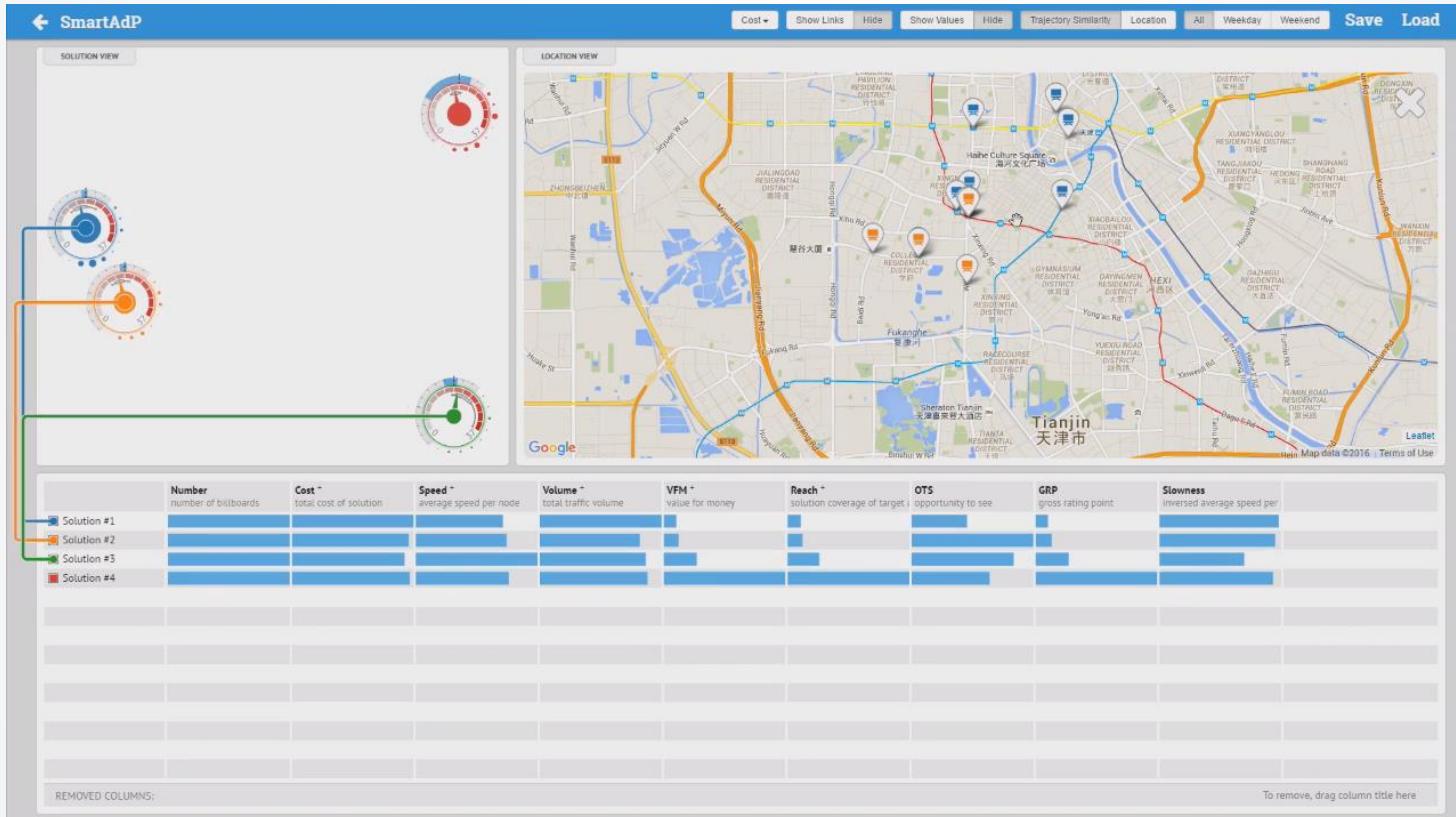
- Sort data with respect to a particular attribute.



Nobre et al. Juniper: A Tree+ Table Approach to Multivariate Graph Visualization. arXiv 2018.
<https://www.youtube.com/watch?v=EAjNxFgsJ58>

Method 2: Sorting

- Sort data with respect to a particular attribute.

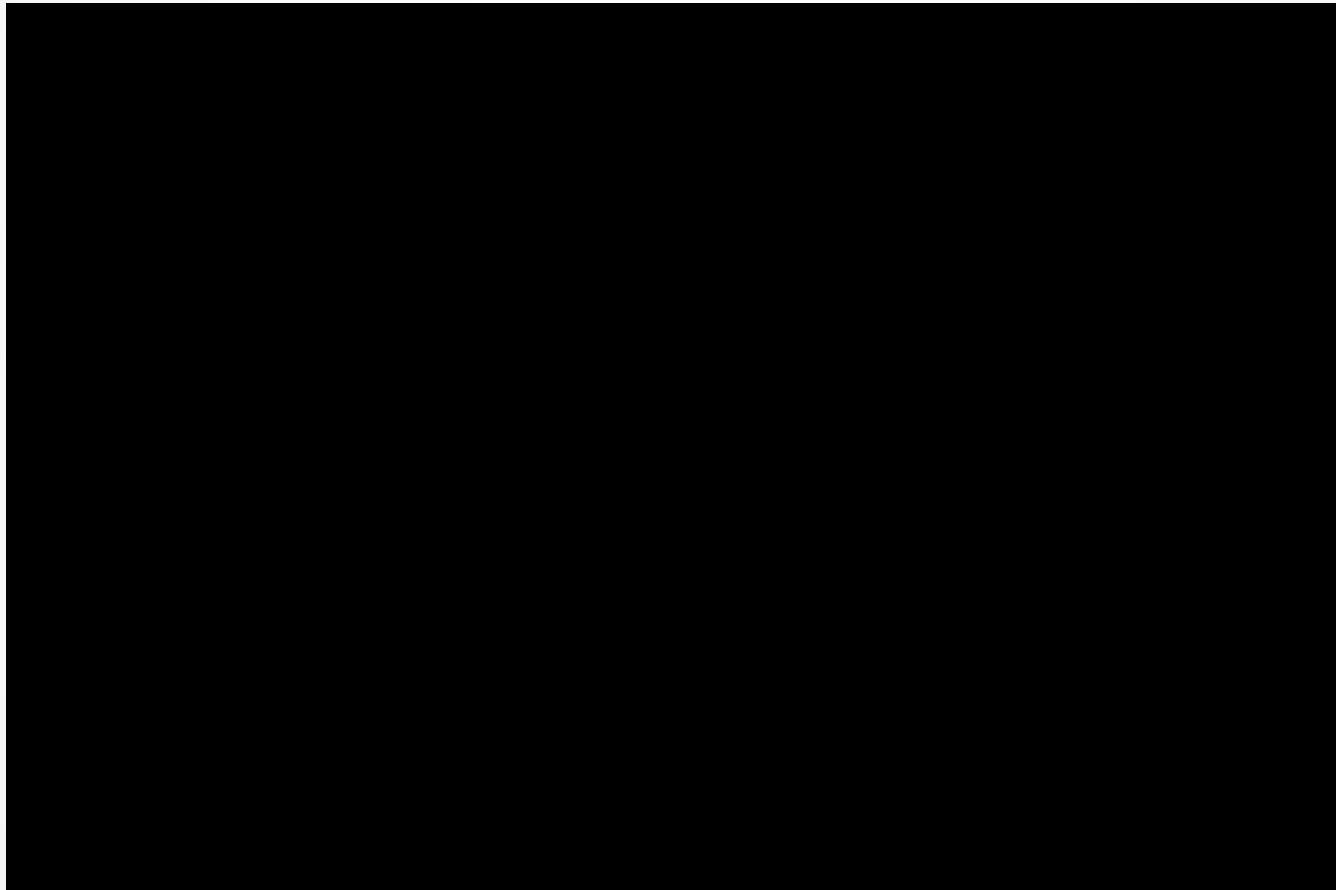


Liu, Dongyu, et al Smartadp: Visual analytics of large-scale taxi trajectories for selecting billboard locations. IEEE TVCG 2017

<https://www.youtube.com/watch?v=7vkYubfIVuo>

Method 3: Reposition

- Dust & Magnet



<https://www.youtube.com/watch?v=laGJ4v7DEU0>

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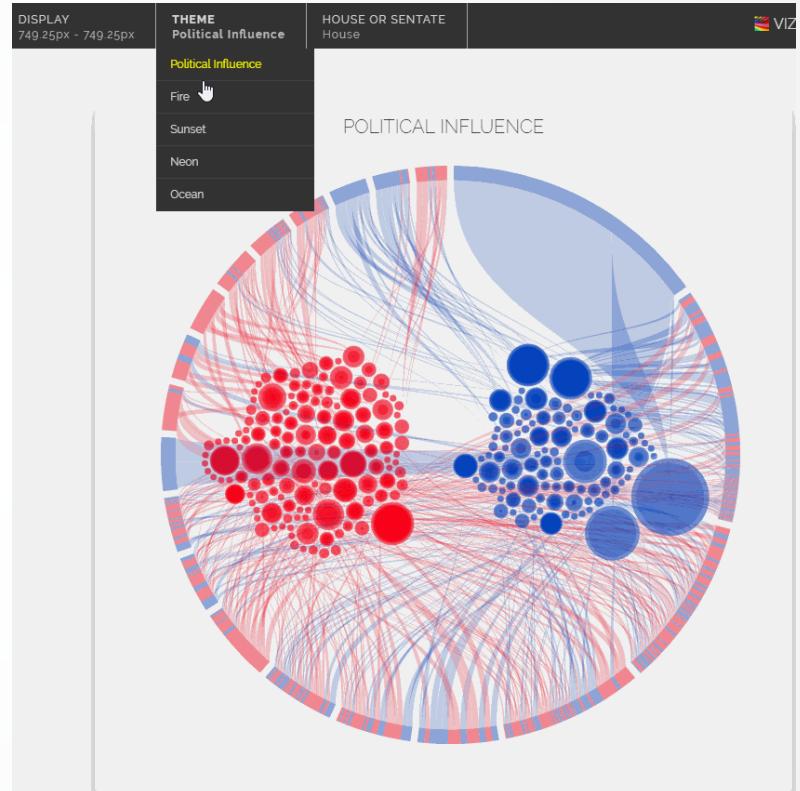
Types of Interactions

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OUTLINE

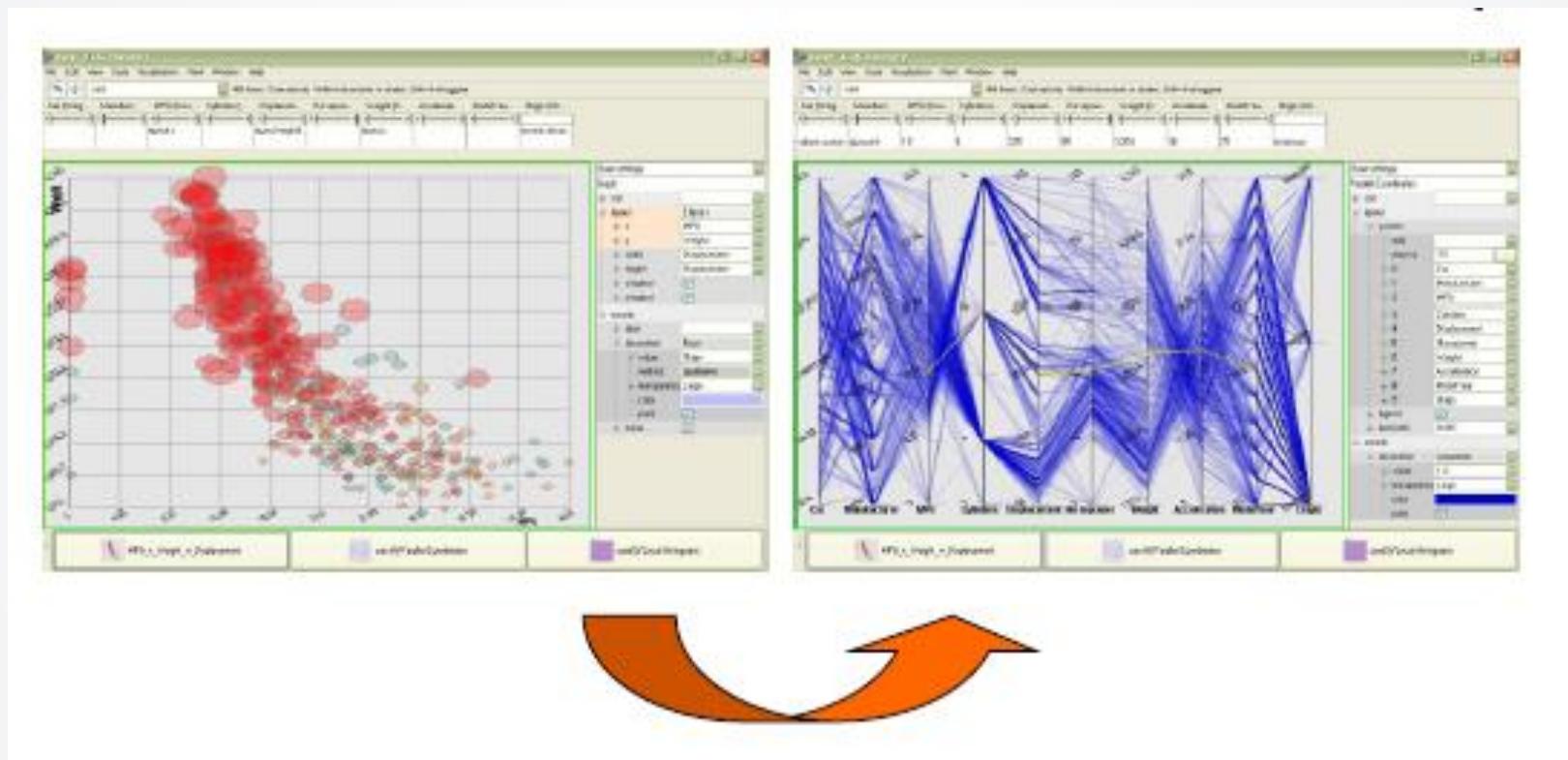
Encode

- “Show me a different representation.”
- Change visual appearances.
- Examples
 - Changing color encoding
 - Changing size
 - Changing orientation
 - Changing font
 - Changing shape



<https://github.com/d3/d3/wiki/Gallery>

Examples



Selecting different representation from options at the bottom

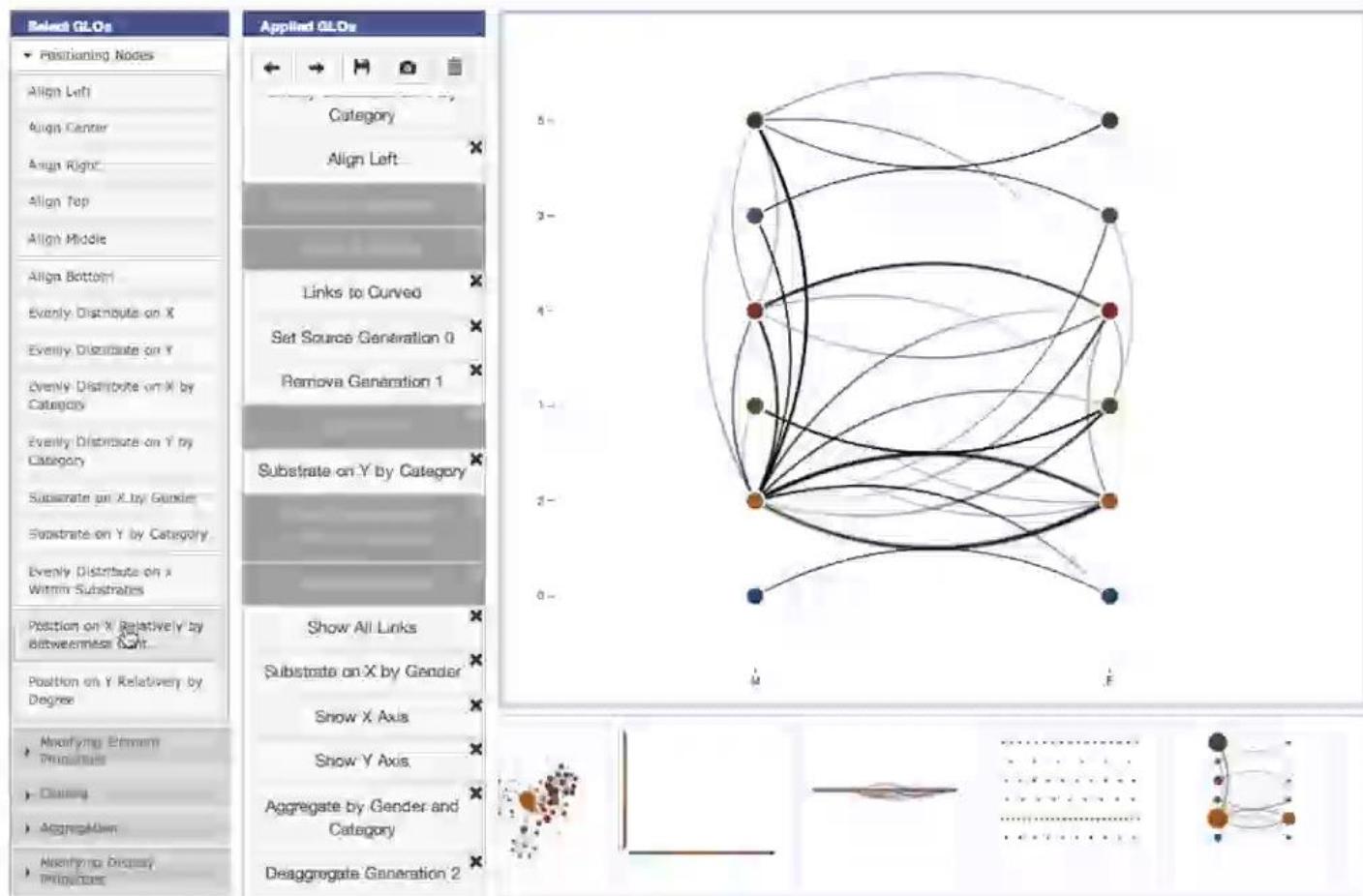
Examples



<https://www.tableau.com/>

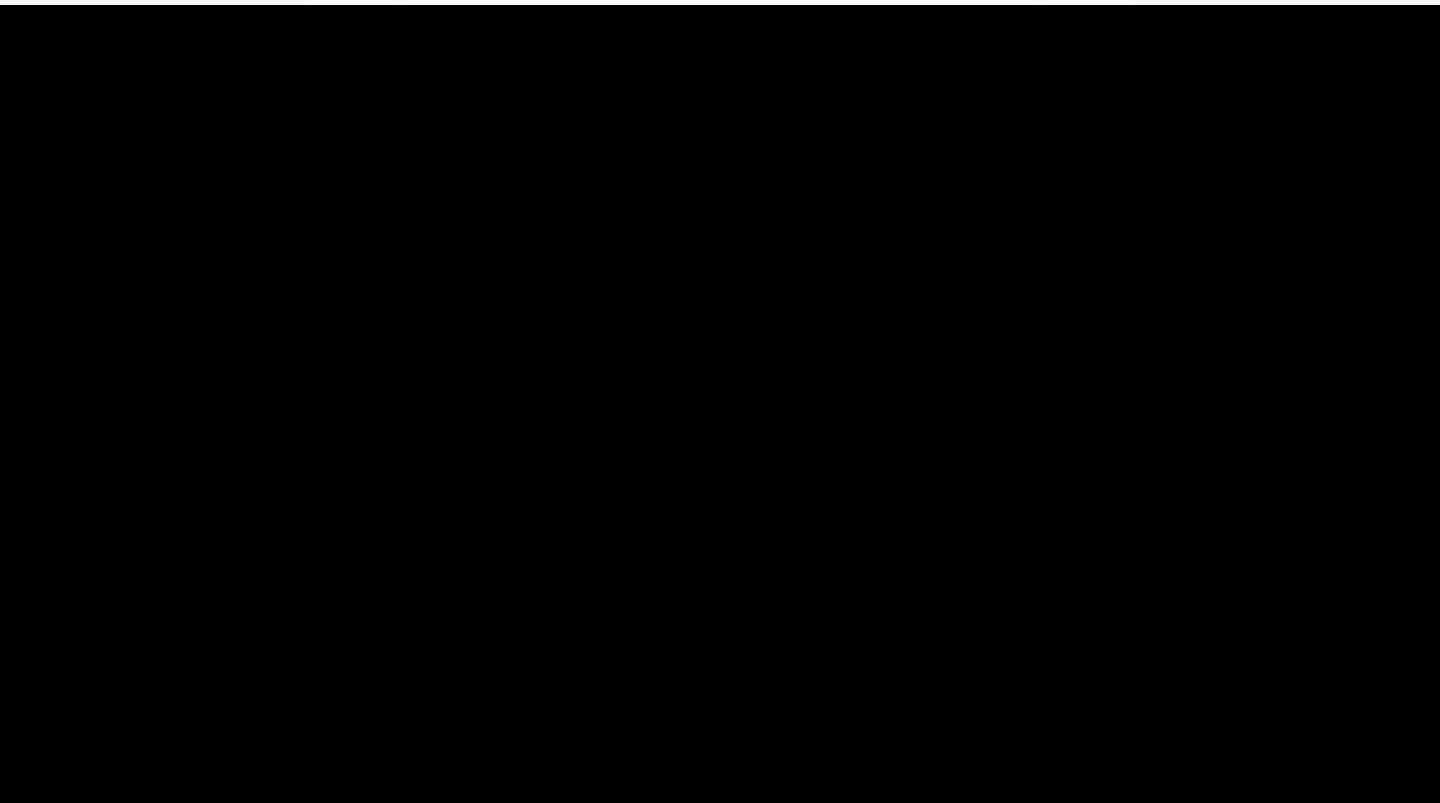
Examples

GLO-STIX: Graph-Level Operations for Specifying Techniques and Interactive exploration



Stolper et al. Glo-stix: Graph-level operations for specifying techniques and interactive exploration. IEEE TVCG, 2014.
<https://www.youtube.com/watch?v=a7ZkZRU6VBM>

Examples



UNIVERSITÉ
PARIS-SUD 11



The University of Sydney



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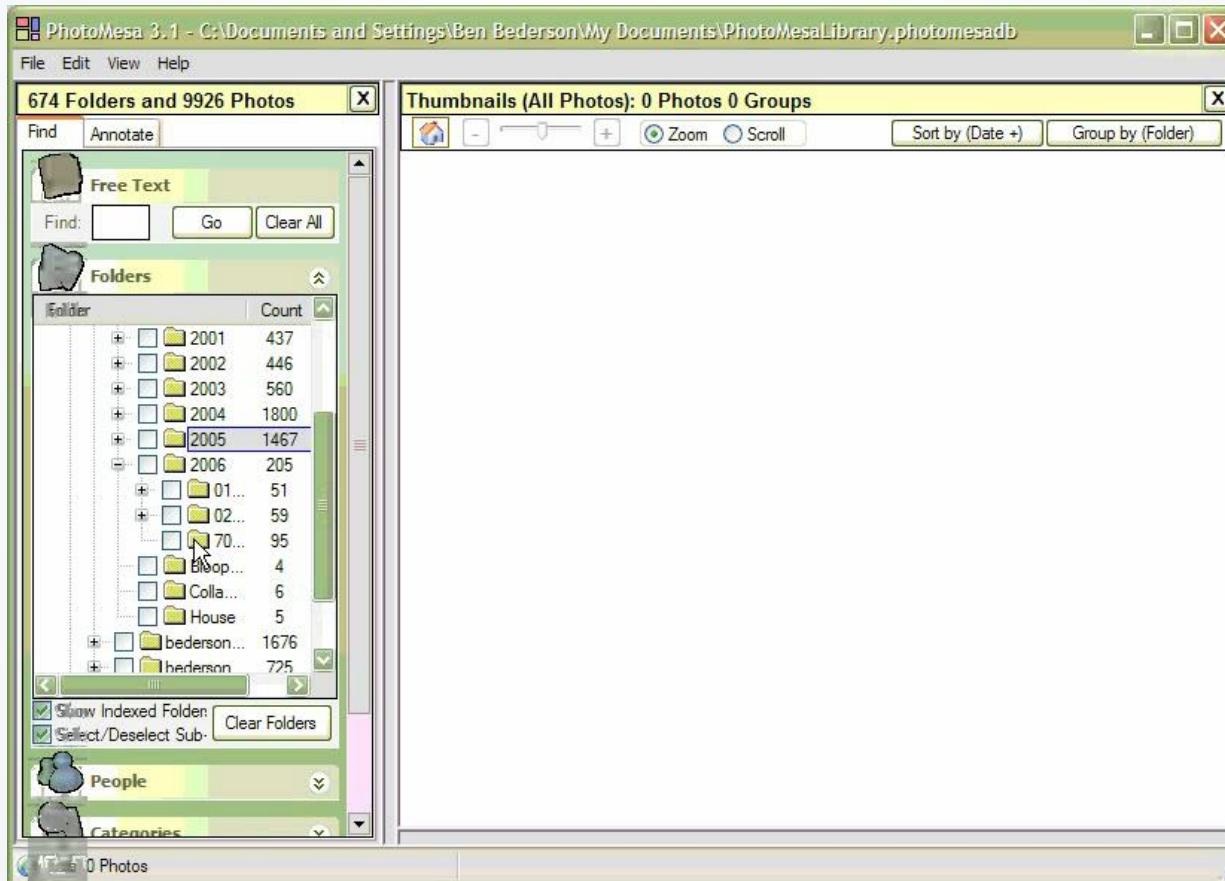
OUTLINE

Abstract/Elaborate

- “Show me more or less detail”
- Adjust the level of abstraction (overview and details)
- Examples
 - Unfolding sub-categories in an interactive pie chart
 - Drill-down in Treemap
 - Details-on-demand in Sunburst
 - The tool-tip operation in SeeIT
 - Zooming (geometric zooming)

Examples

- Photo set abstraction



<https://www.youtube.com/watch?v=CQYDhnBMoF0>

Details-on-Demand

- Term used in infovis when providing viewer with more information/details about data case or cases.
- May just be more info about a case.
- May be moving from aggregation view to individual view.
 - May not be showing all the data due to scale problem.
 - May be showing some abstraction of groups of elements.
 - Expand set of data to show more details, perhaps individual cases.

Examples

SmartAdp

Save Load

Data Set
Using: Tianjin Taxi Trajectory

Target Area
OD Heatmap Road

- 39.1072, 117.1676
- 39.1071, 117.1828
- 39.1166, 117.1691

Solution Area
Mark favorite places

- 39.1083, 117.1899
- 39.1081, 117.1794
- 39.1097, 117.1796
- 39.1146, 117.1842
- 39.1146, 117.1841
- 39.1097, 117.1795
- 39.1127, 117.1889
- 39.1034, 117.1787
- 39.1072, 117.1936

Solution Parameters

Number of Billboards: 8

Normal Trajectory Weight: 1

Target Trajectory Weight: 1,000

Temporal Filter: All

Coordinate Filter: N/A

Generate Solution

Solution Explorer

SOLUTION PREVIEW

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 5
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 8
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 8
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 8
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 8
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

Number of Billboards: 8
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

N	C	S	V	M	R	O	G
✓	✓	✓	✓	✓	✓	✓	✓

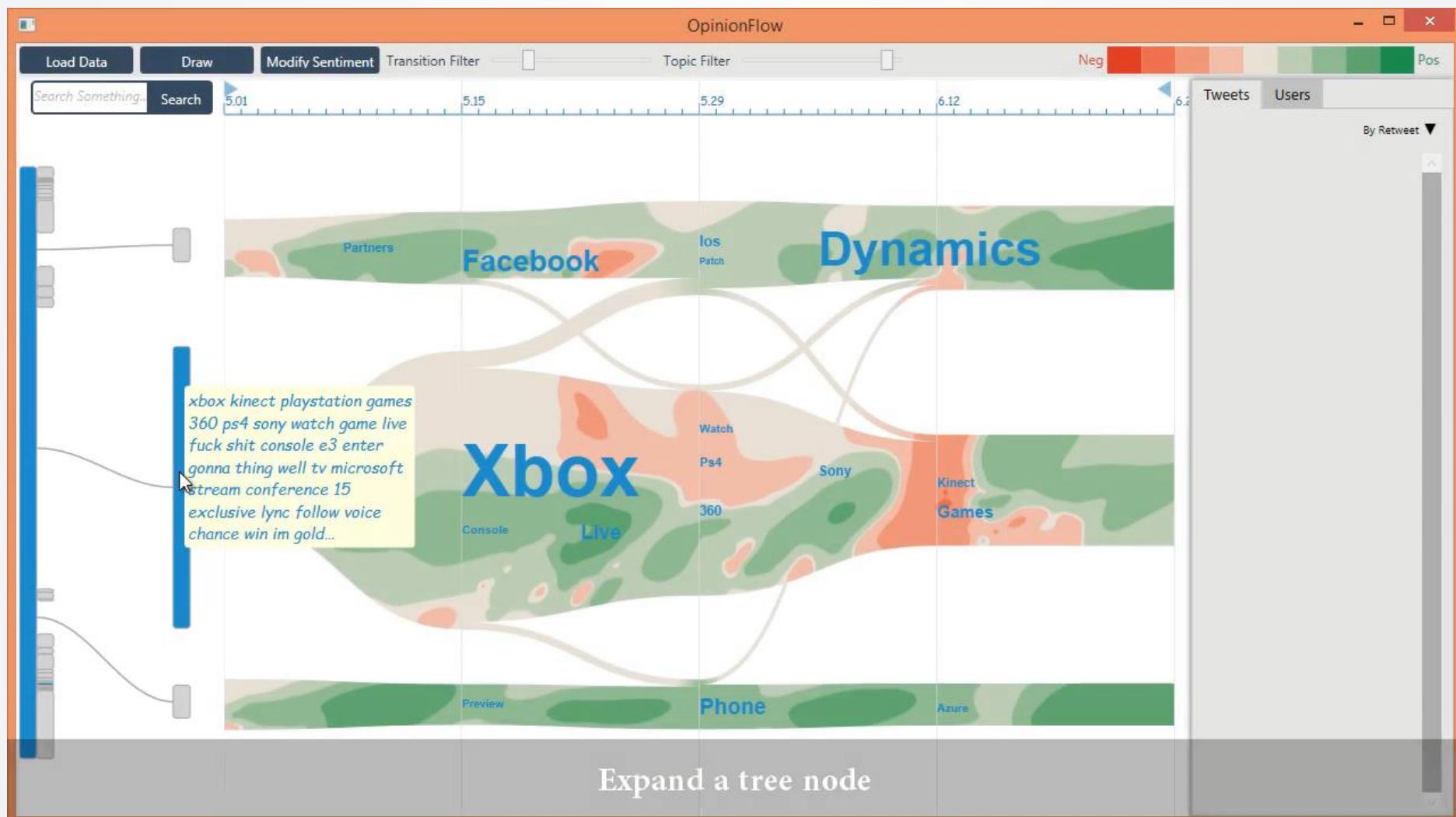
Number of Billboards: 5
Target to Normal: 1000
Temporal Filter: none
Speed Less Than: N/A

« »

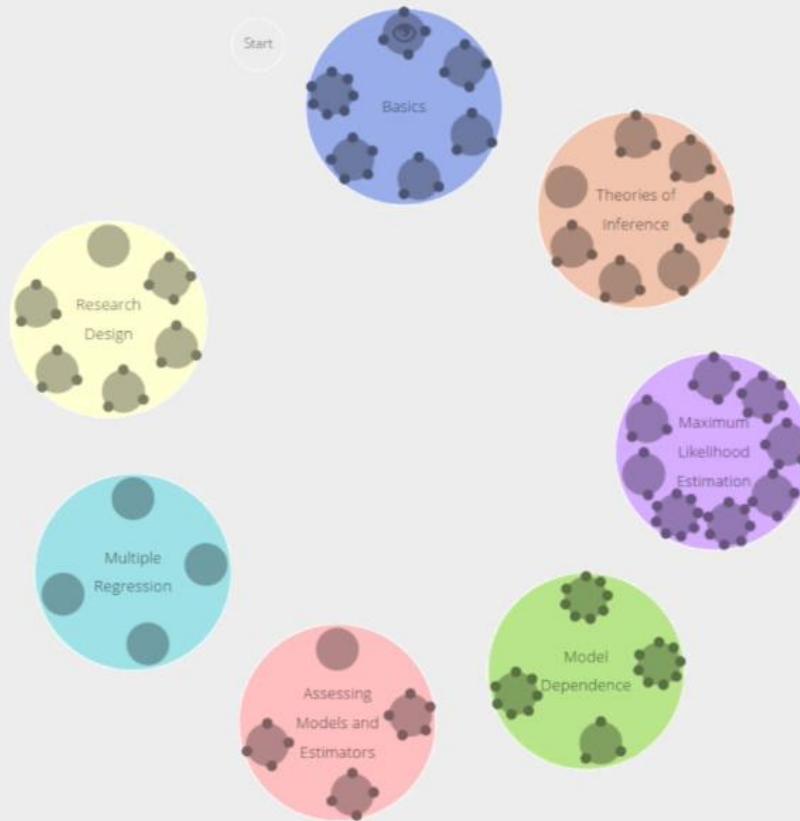
Examples

Interaction

Examples



Examples



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Types of Interactions

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Filter

- “Show me something conditionally.”
- Change the set of data items being presented based on some specific conditions.
- Examples
 - Dynamic query
 - Attribute Explorer
 - Keystokebased filtering in NameVoyager
 - QuerySketch

Method 1: Filtering/Limiting

- Fundamental interactive operation in infovis is changing the set of data cases being presented.
 - Focusing
 - Narrowing/widening

Method 1: Filtering/Limiting

The screenshot shows the Baby Name Wizard website interface. At the top, there's a navigation bar with links for NameVoyager Expert, Expert NameFinder, Name MatchMaker, Logout, Manage my Account, and a search bar. Below the navigation is a toolbar with buttons for View, History, and Edit.

1. Names You Like: Enter one or more names that appeal to you to get suggestions with a similar style. There are three input fields labeled "Type name and select sex:" followed by radio buttons for boy (blue) and girl (red).

MATCH NAMES

2. Control Panel: You can adjust factors you care about to help the MatchMaker understand your personal taste.

Show Me: girl boy both **APPLY**

I prefer names with these qualities...

Current Popularity Level: Rare Popular

All-Time Peak Popularity: Rare Popular

Length (in letters): Short Long

3. Style and Culture Preferences

	Prefer	Avoid		Prefer	Avoid
African	<input type="radio"/>	<input checked="" type="radio"/>	Traditional	<input type="radio"/>	<input checked="" type="radio"/>
African-American	<input checked="" type="radio"/>	<input type="radio"/>	Contemporary	<input type="radio"/>	<input checked="" type="radio"/>
Celtic	<input type="radio"/>	<input checked="" type="radio"/>	Unexpected	<input type="radio"/>	<input checked="" type="radio"/>
French	<input checked="" type="radio"/>	<input type="radio"/>	Creative Spelling	<input type="radio"/>	<input checked="" type="radio"/>
German/Dutch	<input type="radio"/>	<input checked="" type="radio"/>	Androgynous	<input type="radio"/>	<input checked="" type="radio"/>
Greek	<input checked="" type="radio"/>	<input type="radio"/>	Nickname	<input type="radio"/>	<input checked="" type="radio"/>

MatchMaker Suggestions **Symbols Key**

Name	Rank	Graph	Trend	Celeb	Book	Fave This!
[Placeholder]						

Method 2: Dynamic Query

- Probably best-known and one of most useful infovis techniques
- Let's explore more details...

DB Query

Query language

```
- Select house-address  
From atl-realty-db  
Where price >= 200,000 and  
    price <= 400,000 and  
    bathrooms >= 3 and  
    garage == 2 and  
    bedrooms >= 4
```

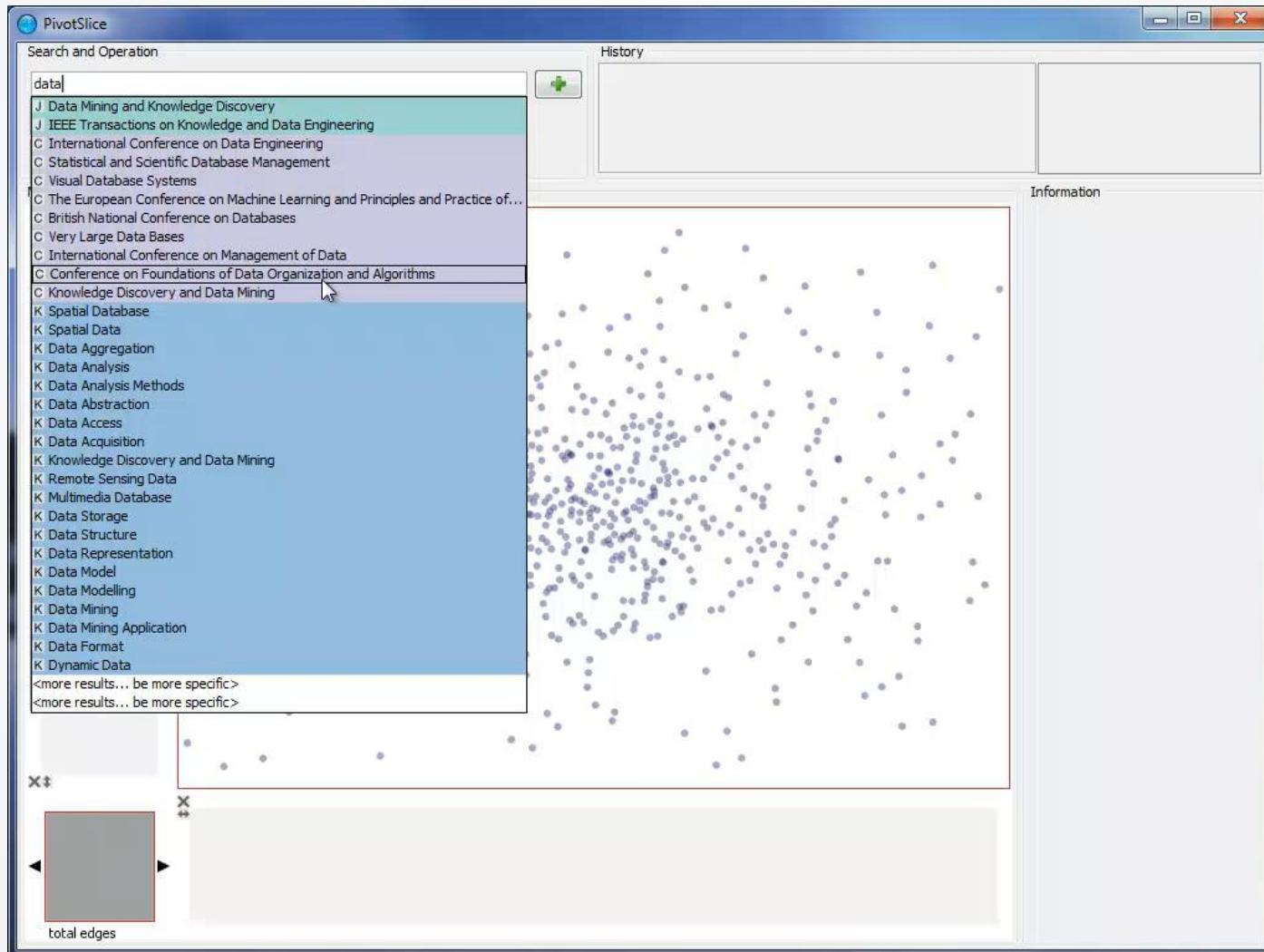
Usually we will get

- 124 hits found
 - 1. 748 Oak St. - a beautiful ...
 - 2. 623 Pine Ave. -
 - ...
- 0 hits found

Method 2: Dynamic Query

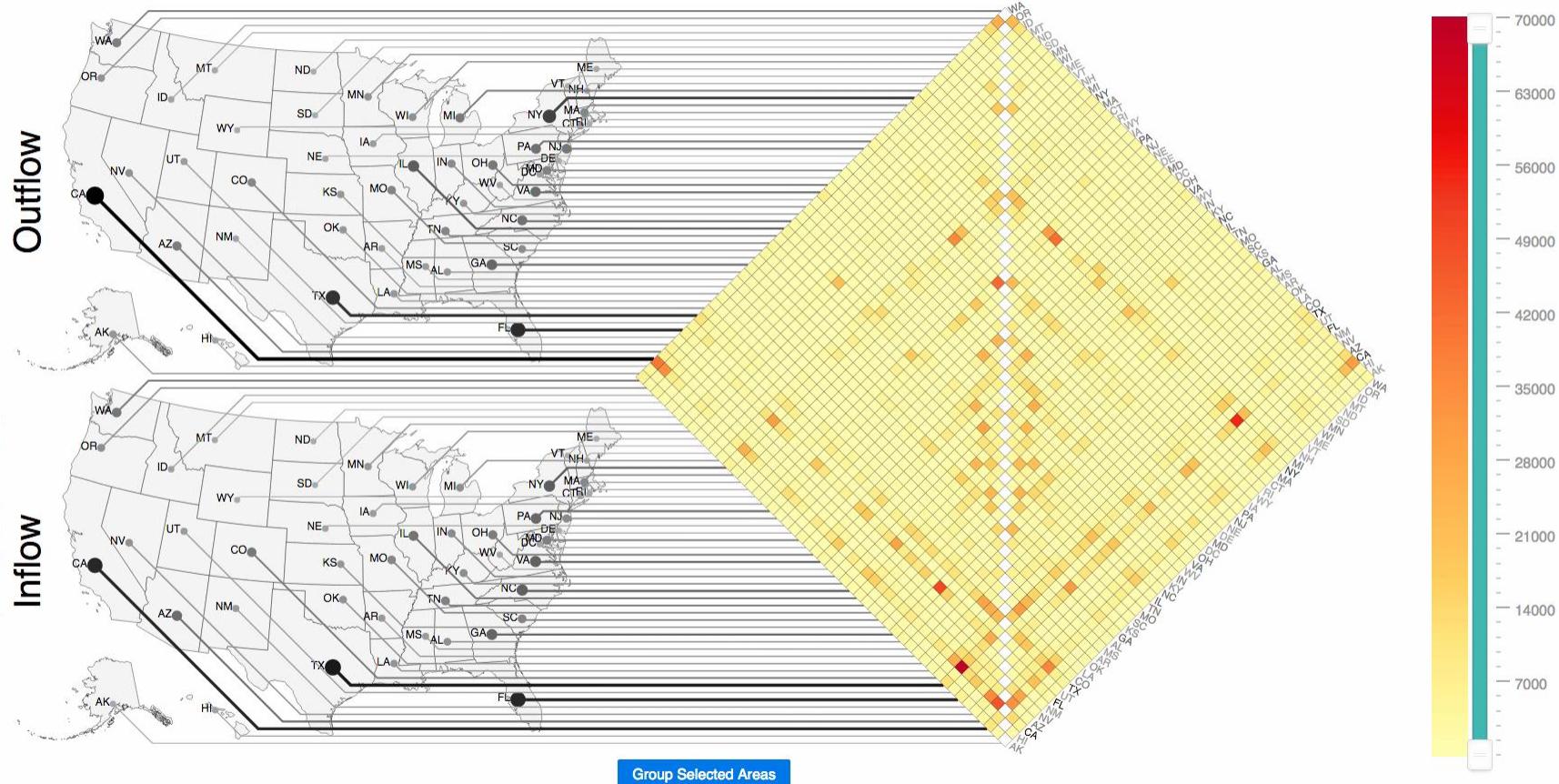
- Dynamic queries continuously update the data that is filtered from the database and visualized.
- An interface that allows **dynamic queries** has these properties ([Williamson and Shneiderman, 1992]):
 - Graphical representation of the request
 - the graphical visualization of the database and searching results
 - delivers results immediately when several parameters are changed
 - visualizes result borders (min-max)
 - allows beginners a faster entrance without having much practice, and still offers experts some mighty functions

Method 2: Dynamic Query

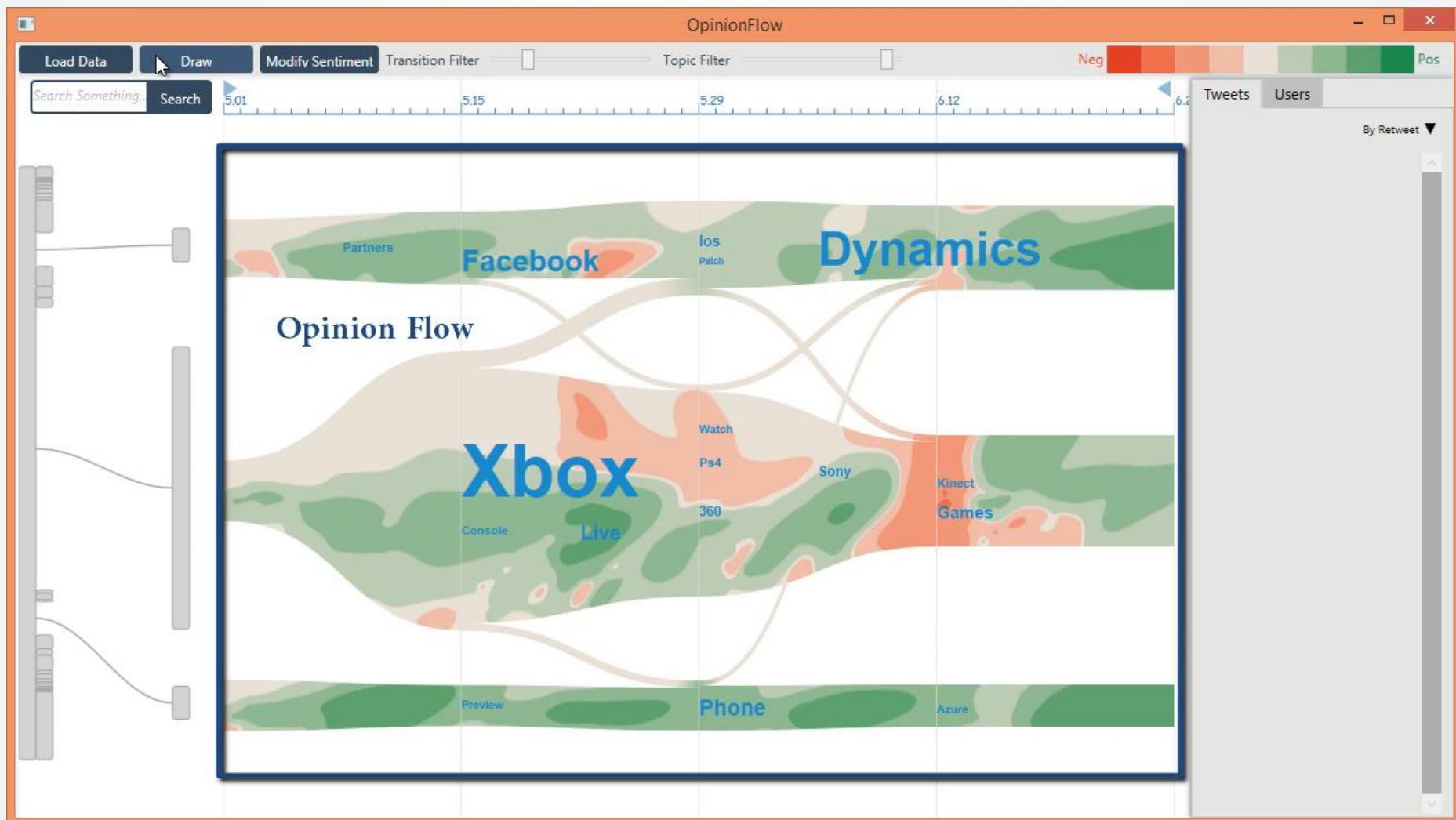


Method 2: Dynamic Query

MapTrix Demo

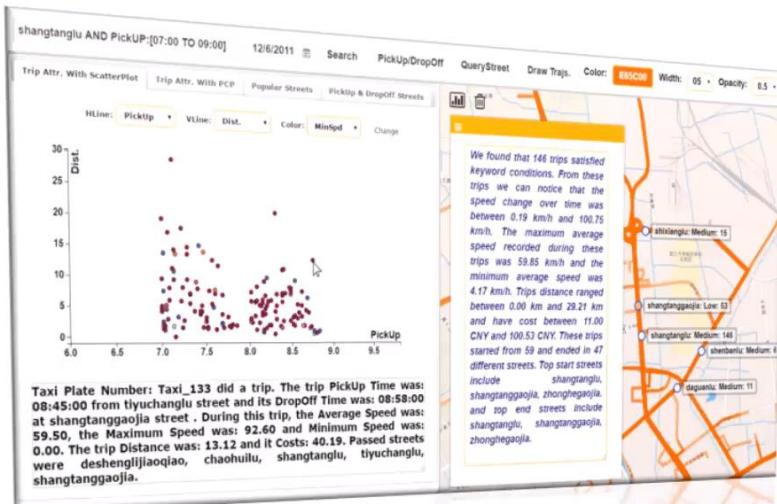


Method 2: Dynamic Query



Method 2: Dynamic Query

SemanticTraj: A New Approach to Interacting with Massive Taxi Trajectories



Shamal Al-Dohuki, Farah Kamw, Ye Zhao,
Jing Yang, Chao Ma, Yingyu Wu, Xinyue Ye,
Fei Wang, Xin Li, Wei Chen



DQ Strengths

- Work is faster.
- Promote reversing, undo, exploration.
- Very natural interaction.
- Directly shows the data.

DQ Weaknesses

- Operations are fundamentally conjunctive.
- Can you formulate an arbitrary boolean expression?

$$! (A_1 \cup A_2) \cap A_3 \cup (A_4 \cup A_5 \cap A_6) \cup \dots \dots$$

- Controls are global in scope.
- They affect everything.
- Controls must be fixed in advance.

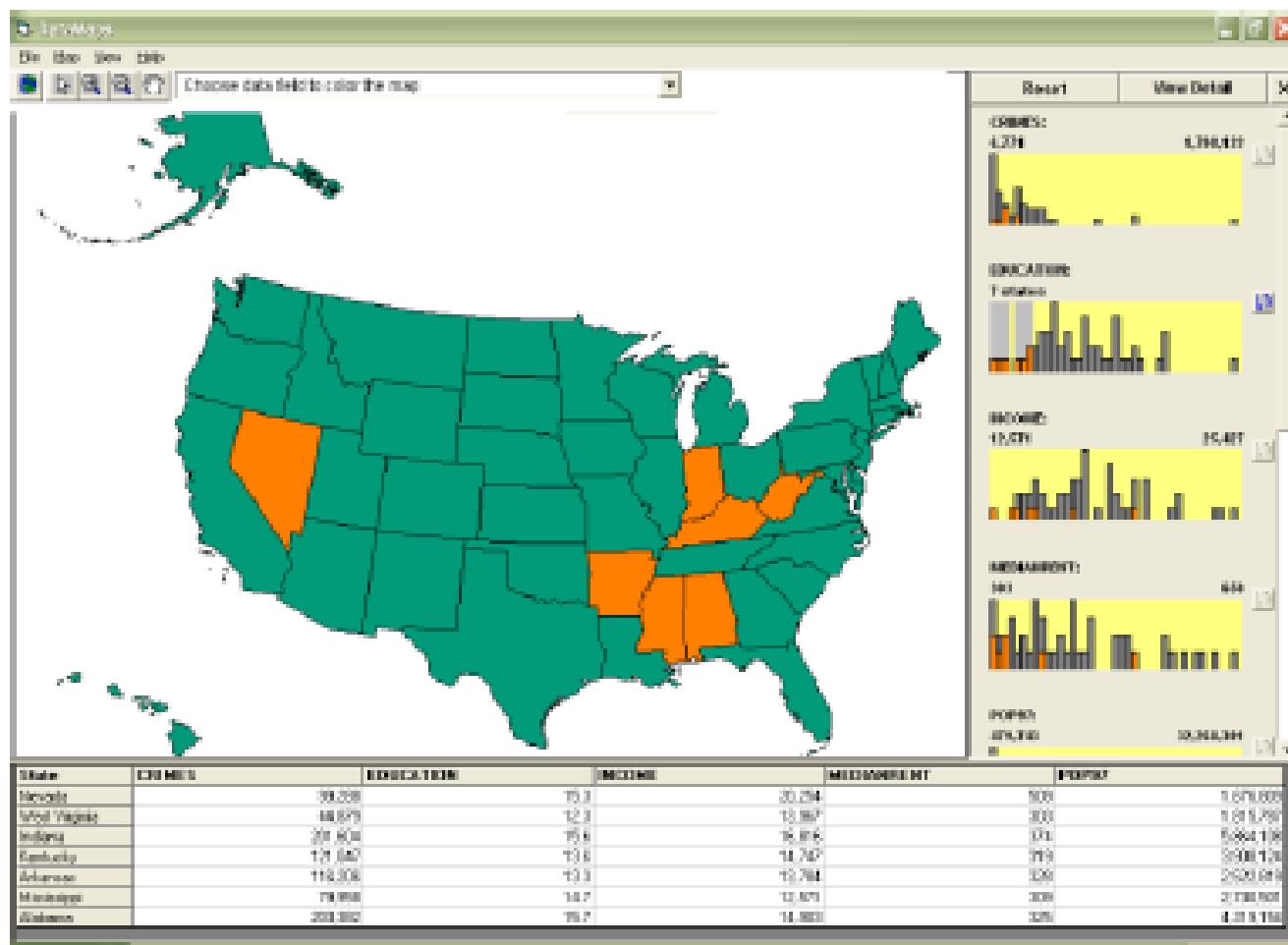
DQ Weaknesses

- As data set gets larger, real-time interaction becomes increasingly difficult.
- Storage -Data structures:
 - Linear array
 - Grid file
 - Quad, k-d trees
 - Bit vectors

Brushing Histogram

- Special case of brushing.
- Data values represented in histograms that can be clicked on and selected (controls region).
- When items selected there, the corresponding item(s) are highlighted in main view windows.
- Application:
 - Transfer function design of 3D volume data field.

Example



DataMaps
Maryland
&
Va Tech

Demo

Example

ReACH

Map data ©2017 Leaflet Terms of Use

	Total Price RMB	Floor Size sq m	Living Rooms number	Bedrooms number	Time Built year
江南水乡	14,000,000.53	443.00	2	6	2000
江南水乡	21,979,997.80	495.00	3	5	2010
荷韵江南苑	1,350,000.35	95.00	2	3	2009
绿都御景蓝湾	572,688.96	70.99	2	2	2014
绿都御景蓝湾	905,454.55	84.00	2	3	2015
绿都御景蓝湾	1,361,999.66	97.20	2	4	2012
金域兰庭	1,299,999.70	83.96	2	2	2014
金域兰庭	1,325,000.02	89.36	2	3	2013

No constraint yet

+ Add constraint

1927 FILTERS

Before creating reachability constraints

INSPECTOR

No candidate selected.

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Types of Interactions

- Select
- Explore
- Reconfigure
- Encode
- Abstract/Elaborate
- Filter
- Connect

OUTLINE

Connect

- “Show me related items.”
- Highlight associations and relationships.
- Show hidden data items that are relevant to a specified item.
- Examples:
 - Highlighting directly connected nodes in Vizster
 - Brushing in InfoScope

Explicit Connection



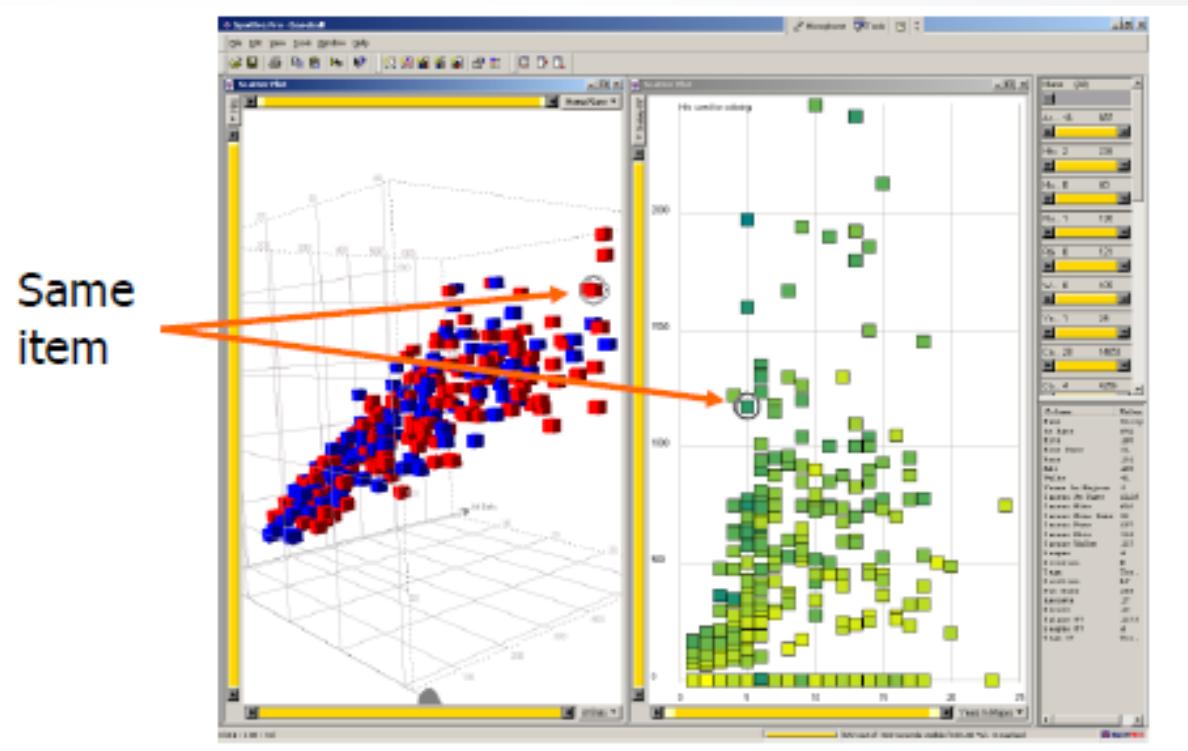
Highlighting Connections

- Viewer may wish to examine different attributes of a data case simultaneously.
- Alternatively, viewer may wish to view data case under different perspectives or representations.
- But need to keep straight where the data case is.

Brushing

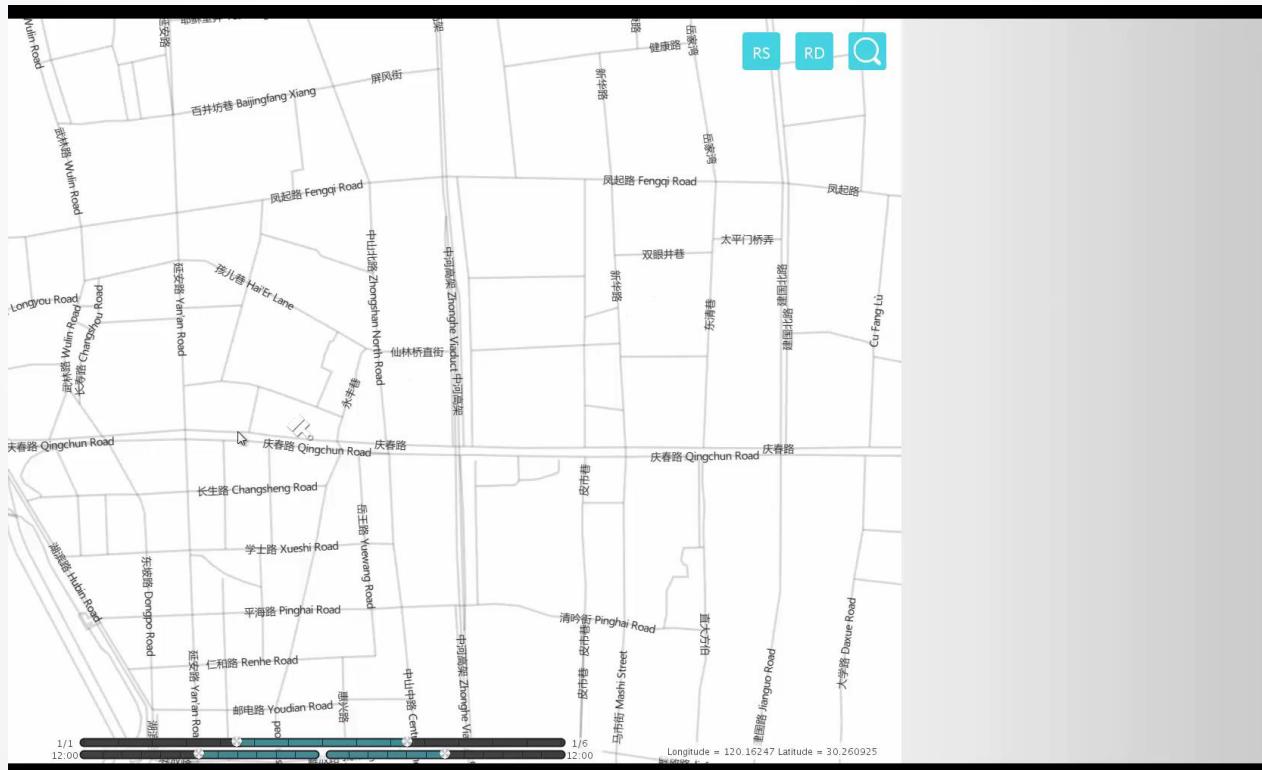
- Very common technique in InfoVis
- Applies when you have multiple views of the same data

Selecting or
highlighting a case in
one view generates
highlighting the case
in the other views



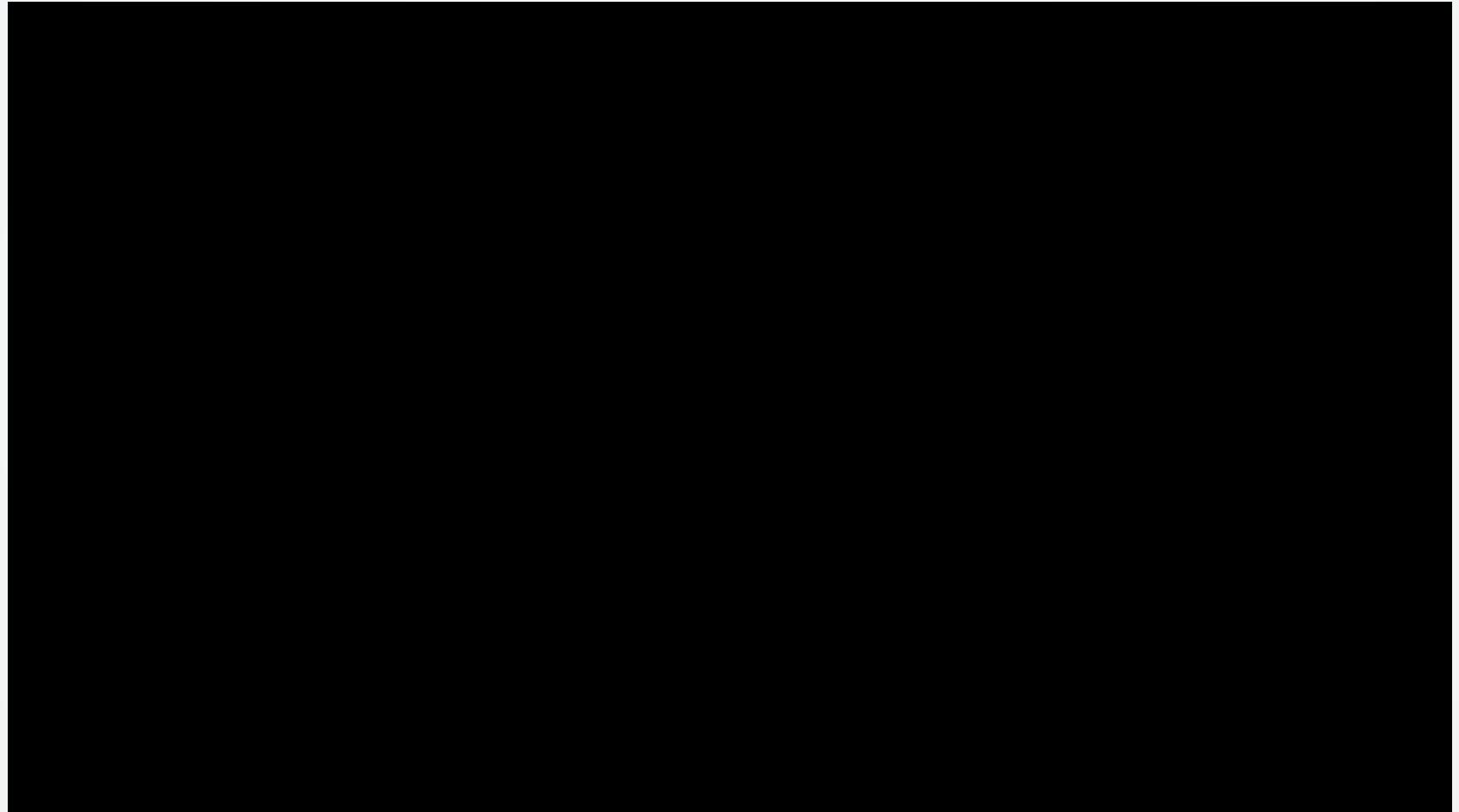
Example

- Very common technique in InfoVis
- Applies when you have multiple views of the same data



Wang et al. A visual reasoning approach for data-driven transport assessment on urban roads. IEEE TVCG 2014.

Example



Yalcin et al. AggreSet: Rich and scalable set exploration using visualizations of element aggregations. IEEE
TVCG 2016.

<https://www.youtube.com/watch?v=cSSAvDAre-E>

Example

Embedded Merge & Split : Visual Adjustment of Data Grouping

Ali Sarvghad *, Bahador Saket *, Alex Endert, Nadir Weibel
(* equal contribution)



UC San Diego

Overview + Details

Overview + Details

- Scale-Minified Images
 - May simply be scaled down
 - May be scaled down to fit viewer's screen
 - May only be scaled down to fit viewer's screen



<https://www.arcadevillage.com/>

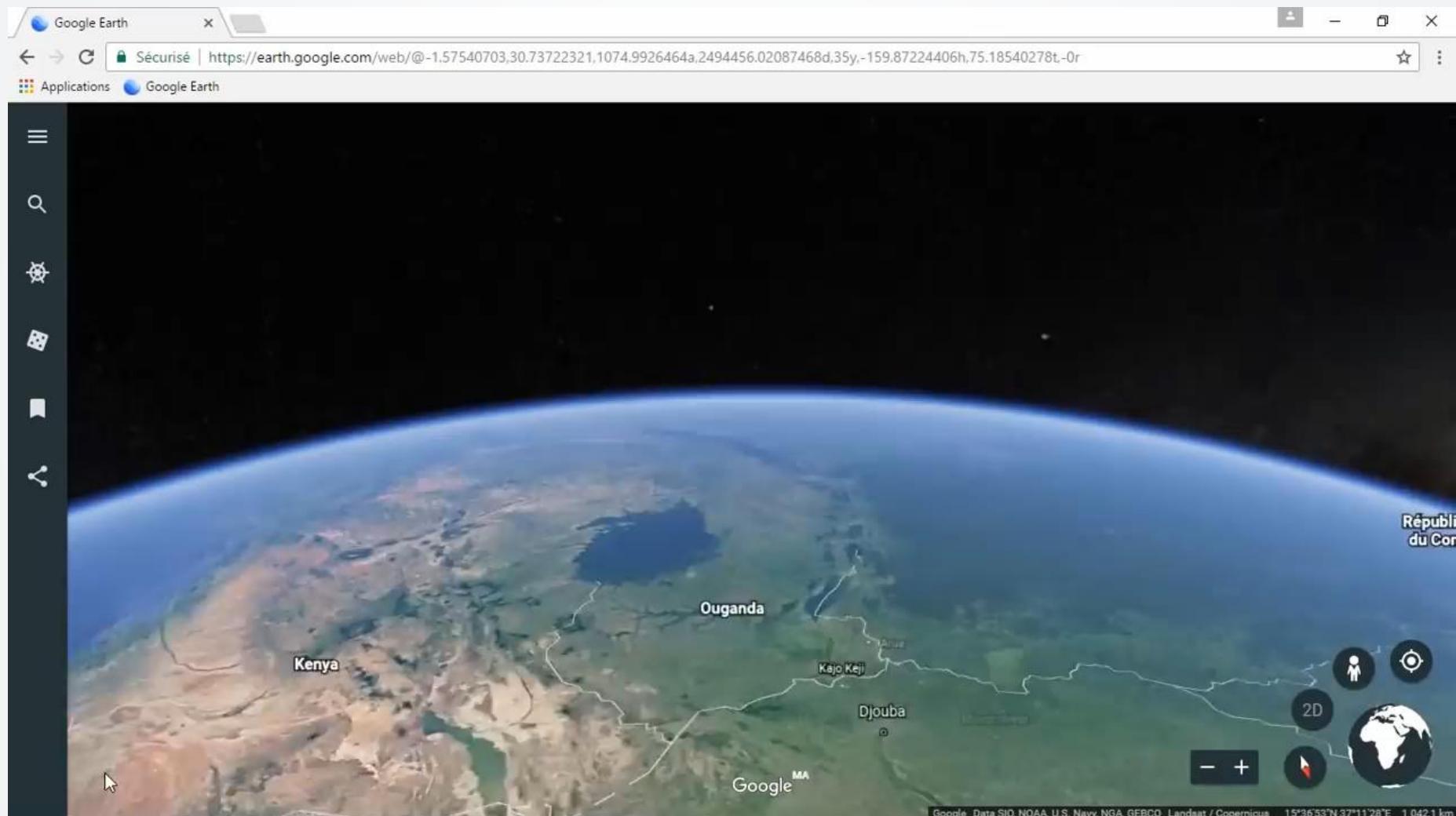
Overview + Details

- Potential solutions lie in:
 - Data representation,
 - Interaction,
 - Or both.

Common Solution

- Use scroll:
 - Provide a larger, virtual screen by allowing user to move to different areas.
- It is Still a problem:
 - Clunky interaction.
 - Only get to see one piece.

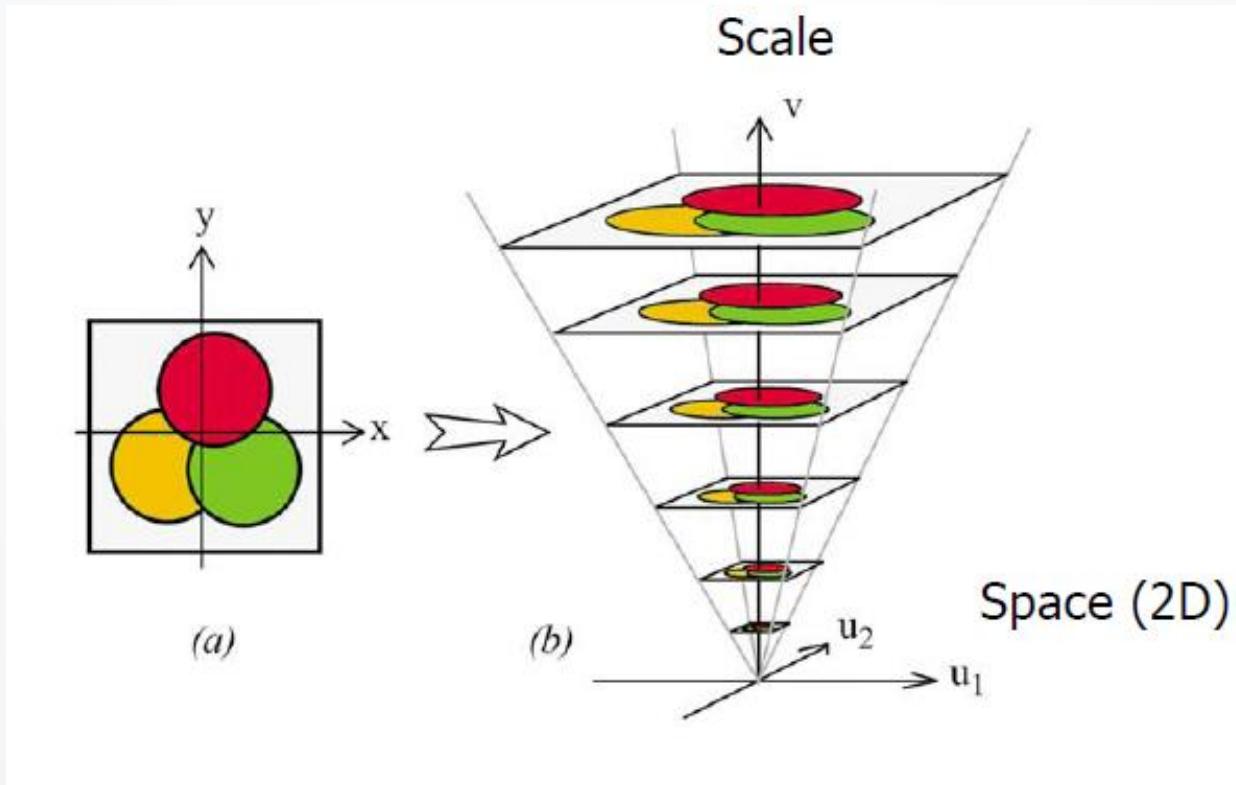
Example



<https://www.youtube.com/watch?v=paqB4FrJN0w>

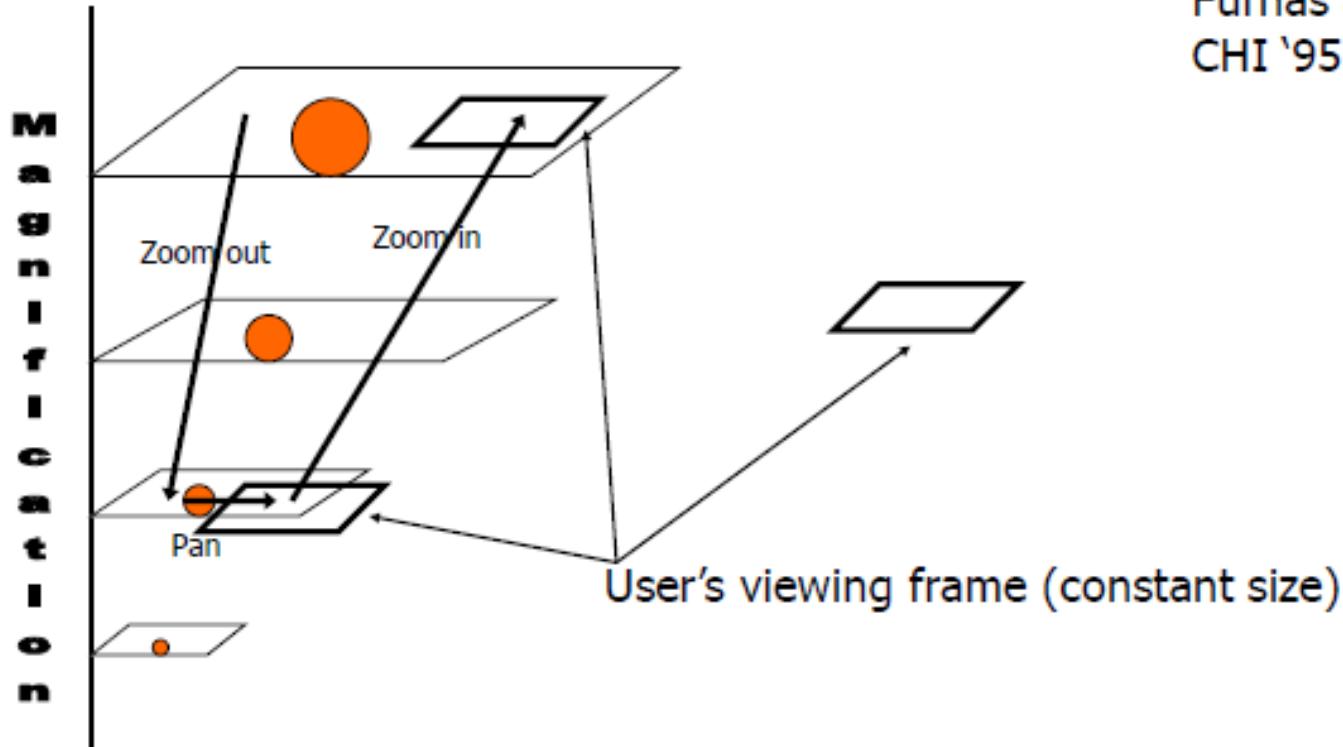
Understanding Zooming

- The space scale diagram
- Operations in zooming



Furnas et al. Space-scale diagrams: Understanding multiscale interfaces. SIGCHI ACM, 1995.

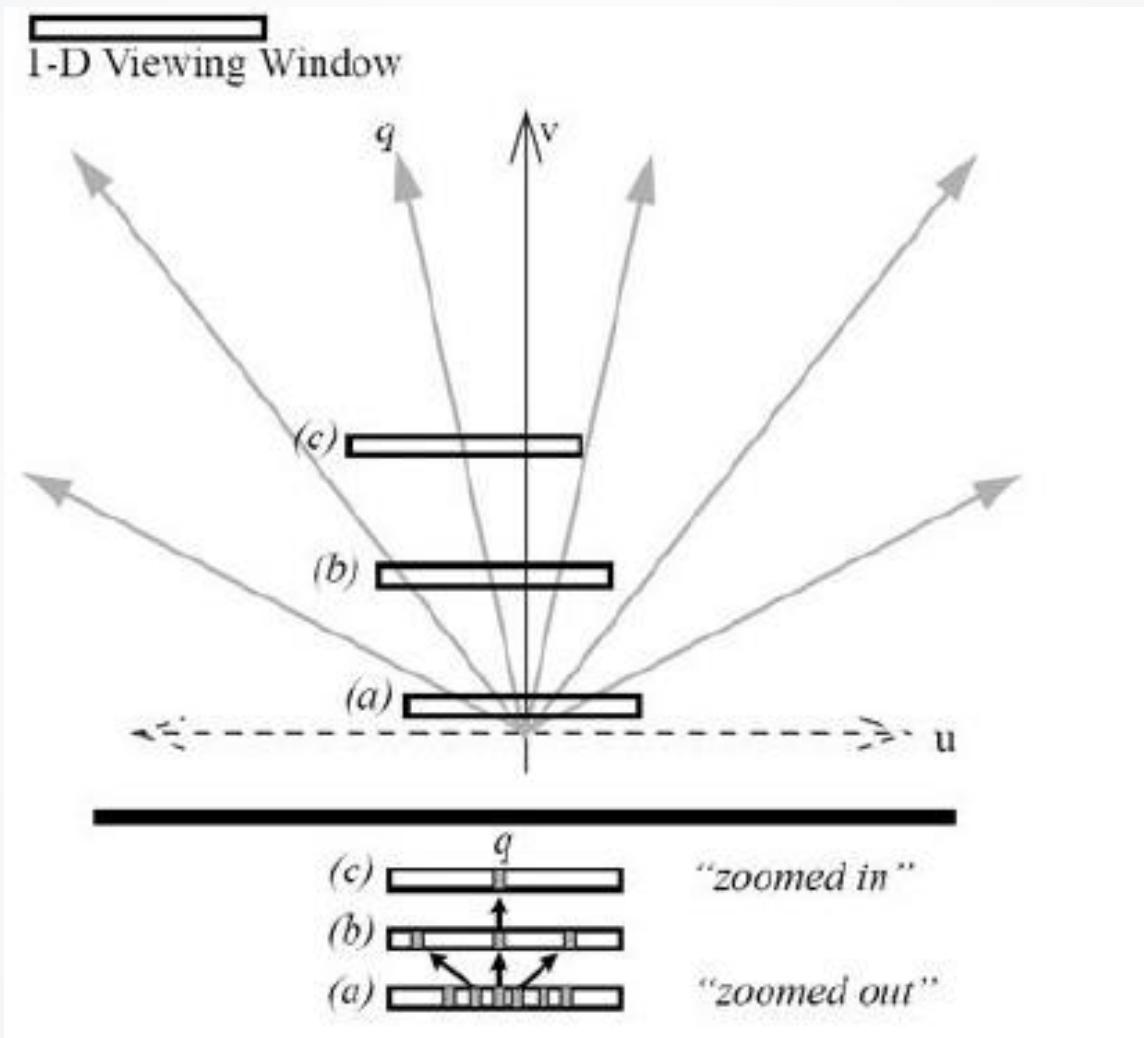
Space-Scale Diagram



Furnas and Bederson
CHI '95

Technique for describing panning and zooming interfaces

Simplification: 1D Space



Focus + Context

Why is it called Fisheye?

Fisheye Camera Lens



Fisheye 1992

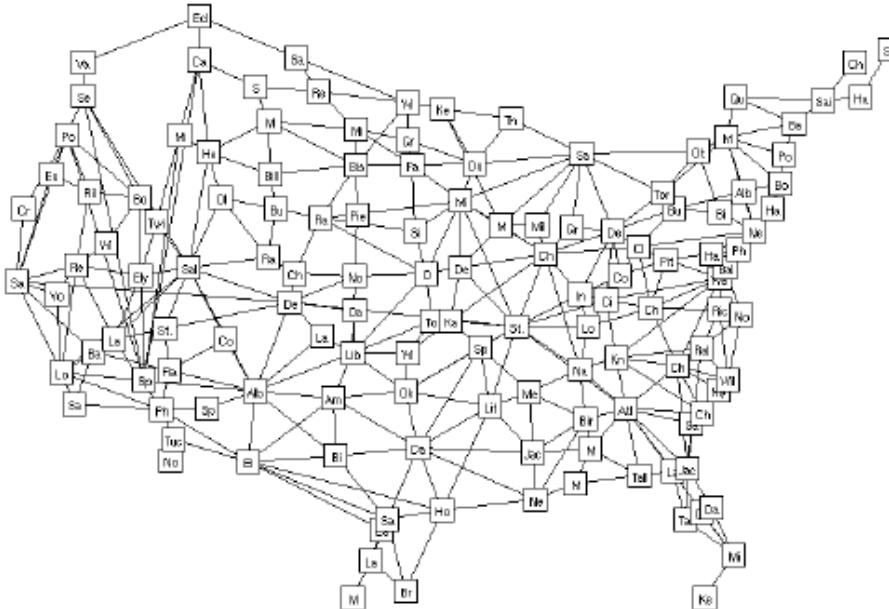


Figure 1: A graph with 134 vertices and 338 edges. The vertices represent major cities in the United States, and the edges represent paths between neighboring cities. (Typically, the edges would be annotated with the distance and driving time between the cities.) The *a priori importance* value assigned to each vertex is proportional to the population of the corresponding city. Fisheye views of this graph appear in Figures 2–6

Fisheye 1992

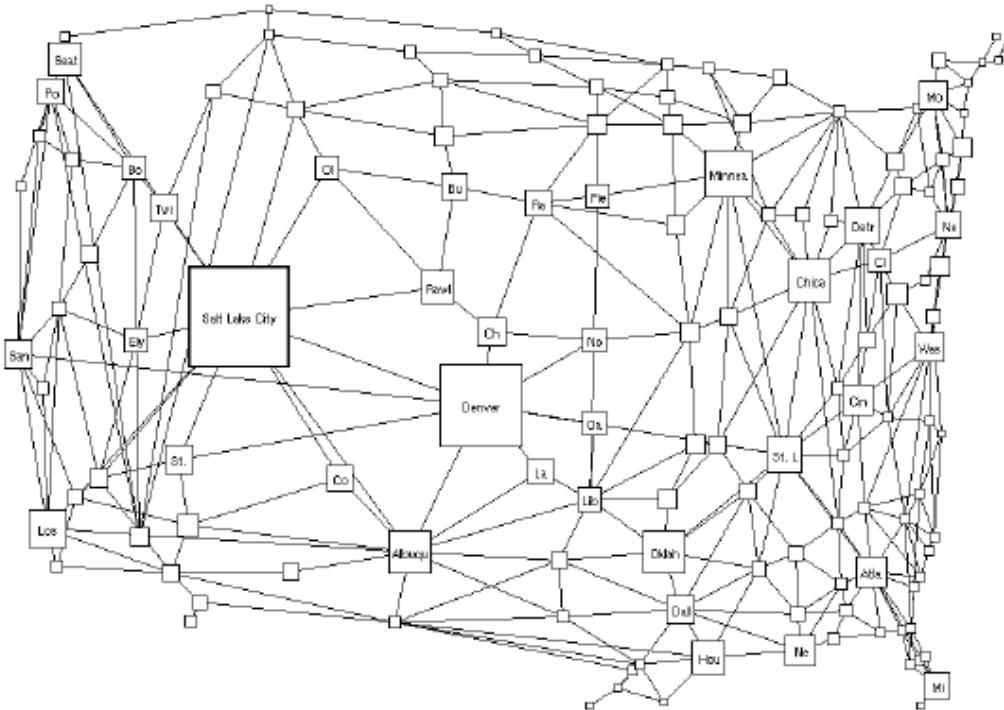
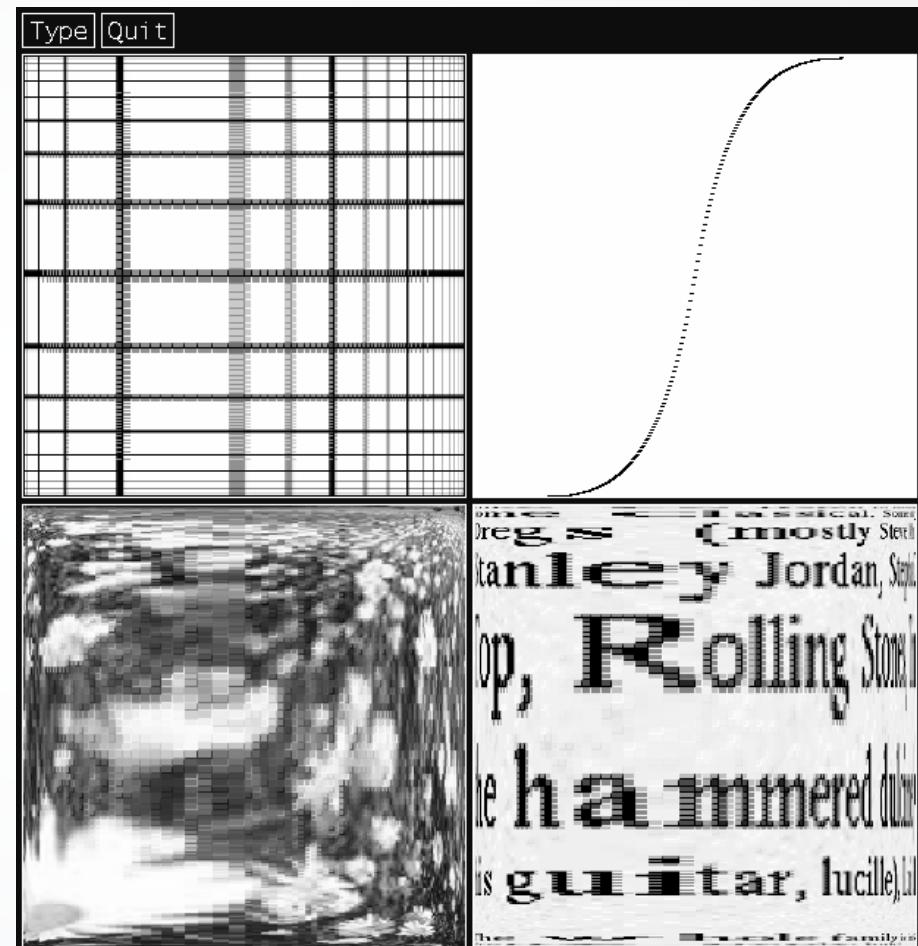
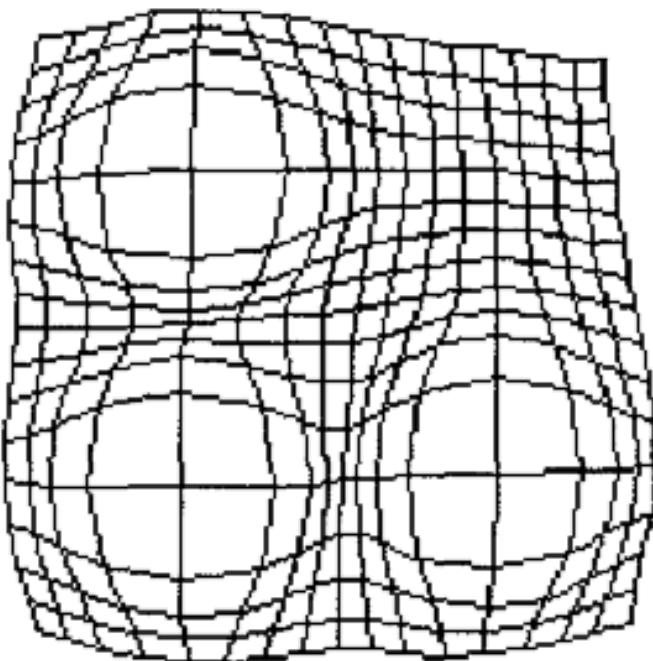


Figure 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City. The level of distortion is the same as in Figure 3; only the location of the focus has changed. The values of the fisheye parameters are $d = 2$, $c = 0.5$, $e = 0.5$, $VWcutoff = 0$.

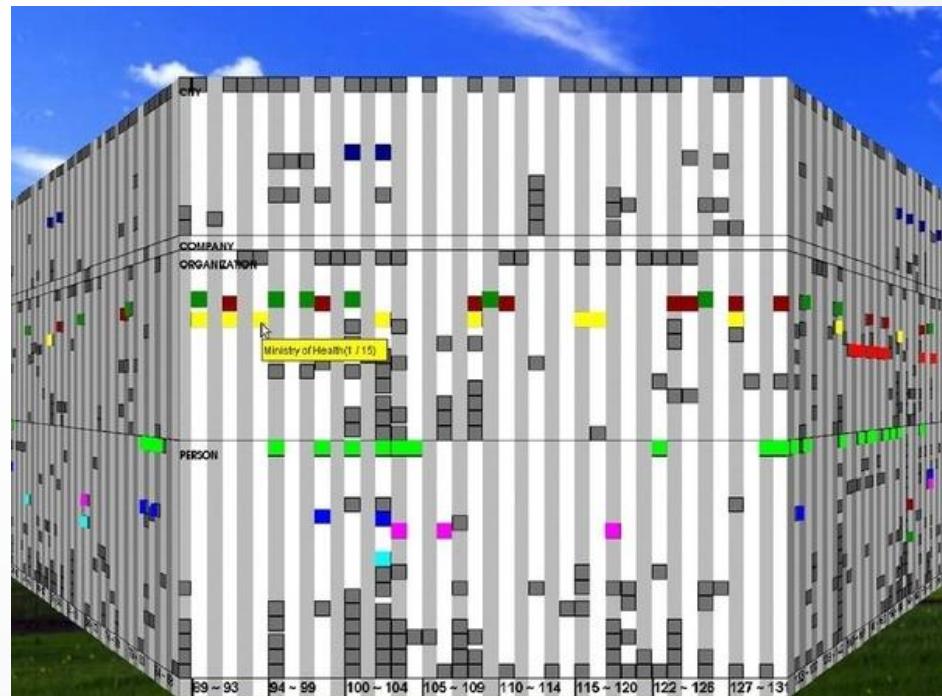
Example

- Multifocal Display



Example

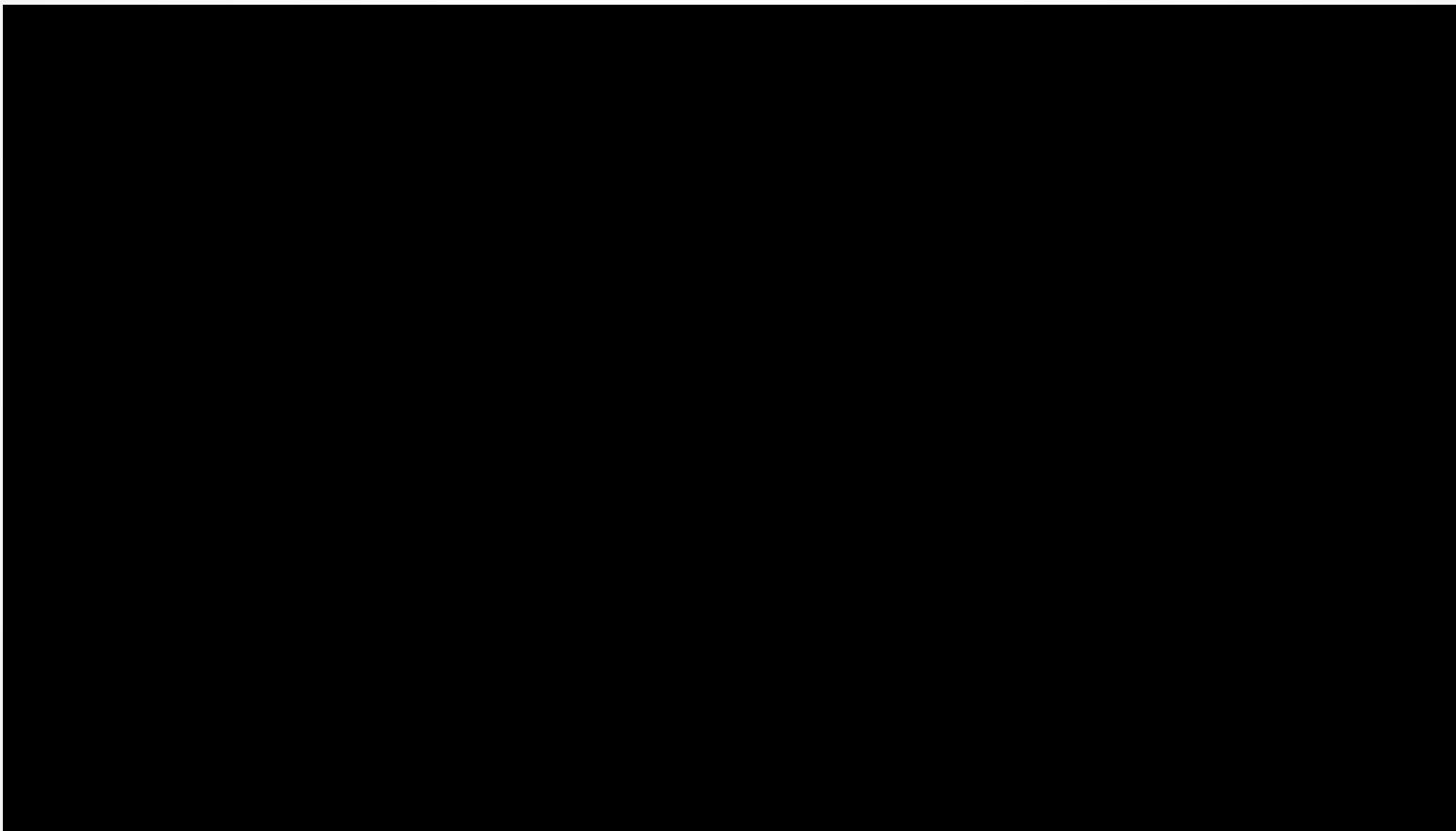
- Computerized, automated 3D implementation of Bifocal display.
- Map work charts onto diagram.
- X-axis is time.
- Y-axis is project.



Mackinlay et al. The perspective wall: Detail and context smoothly integrated. SIGCHI ACM, 1991.

Example

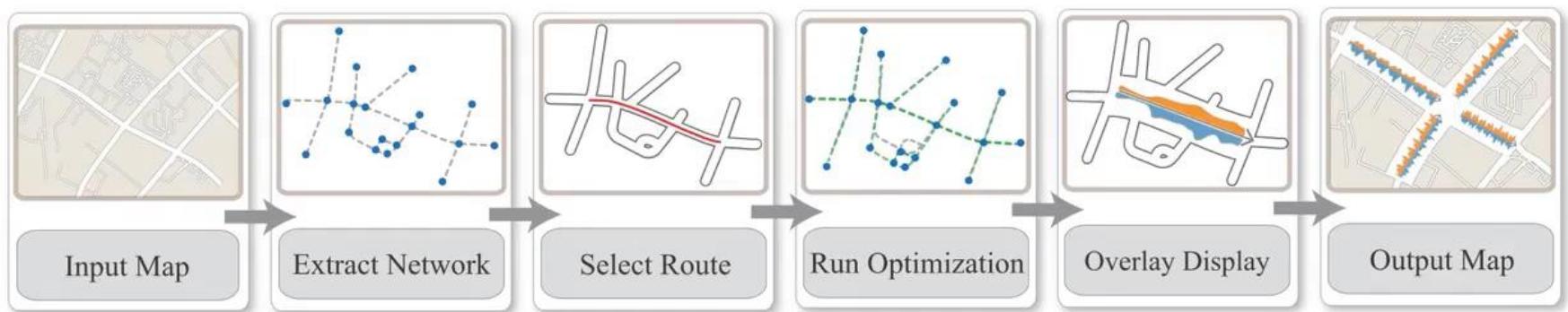
- Maps



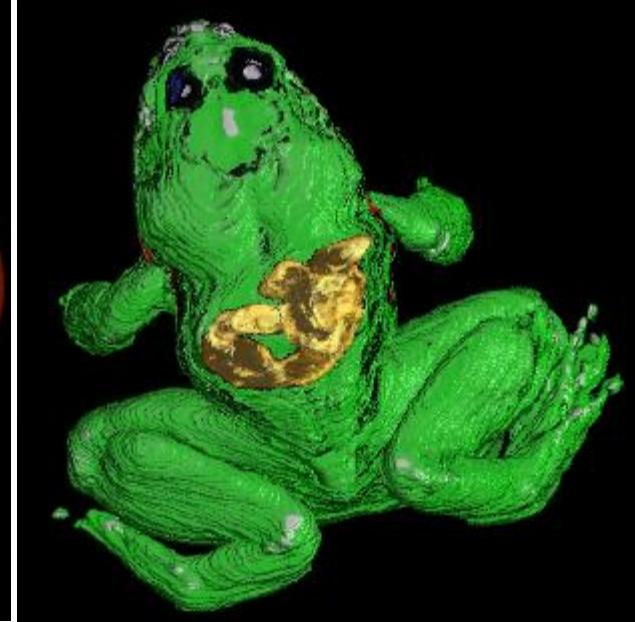
Tominski et al. 3d information visualization for time dependent data on maps. International Conference on Information Visualisation , 2005.

Example

System Overview

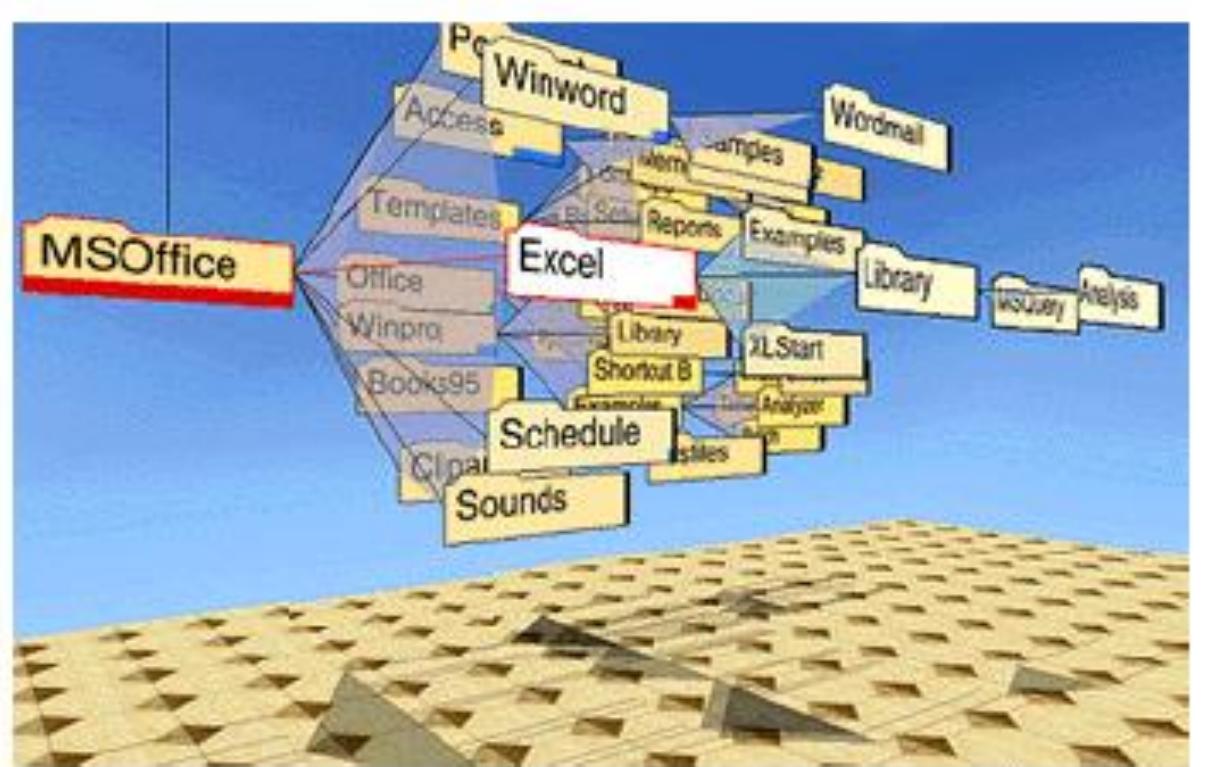


The magic volume lens



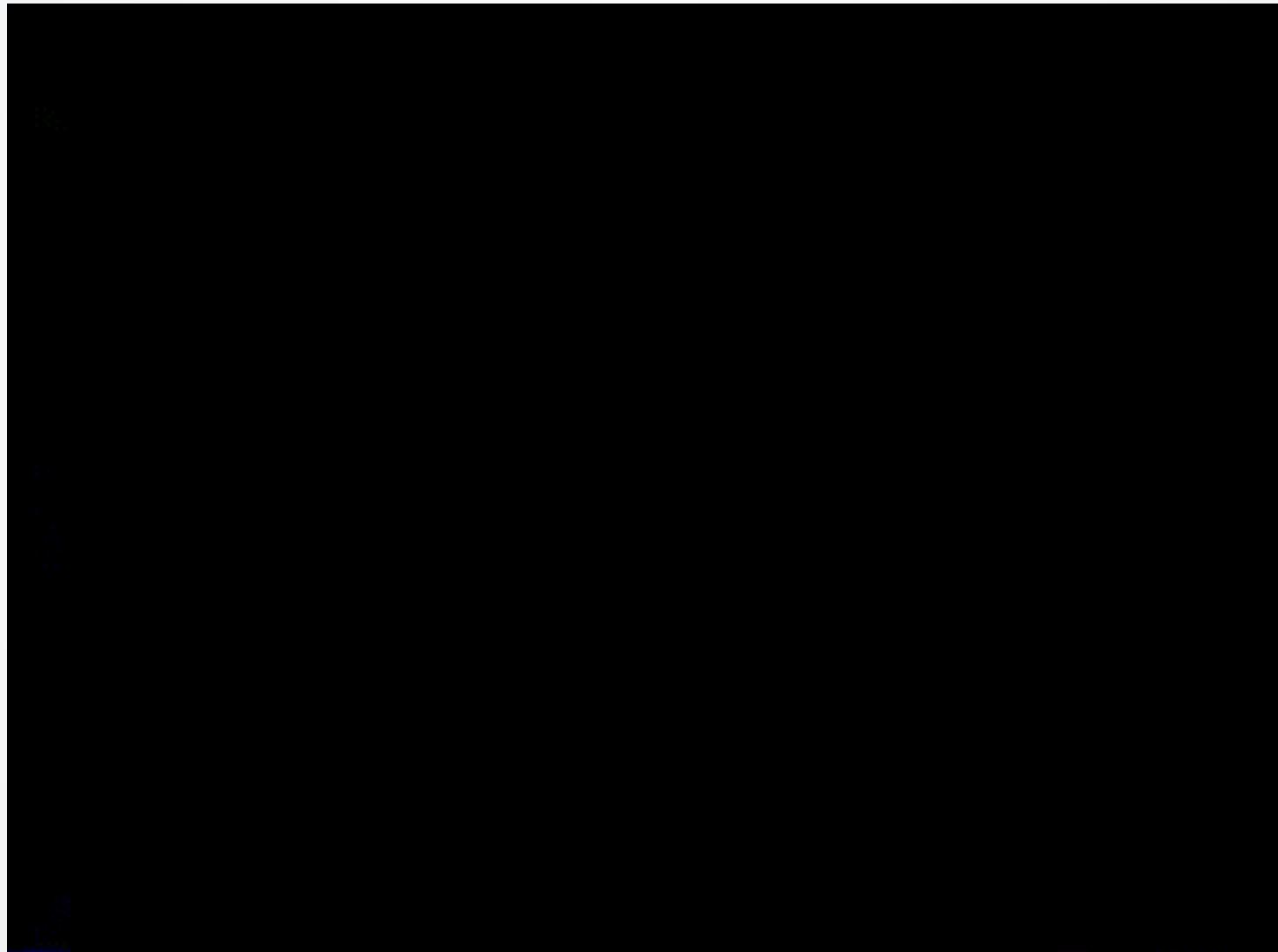
3D Approaches

- 3D views of hierarchies, such as file systems
- Cone Trees



Robertson et al. Cone trees: animated 3D visualizations of hierarchical information. SIGCHI ACM, 1991.

Hyperbolic Tree



Focus & Context Screen

**Focus Plus Context
Screens**

Animation



Animation

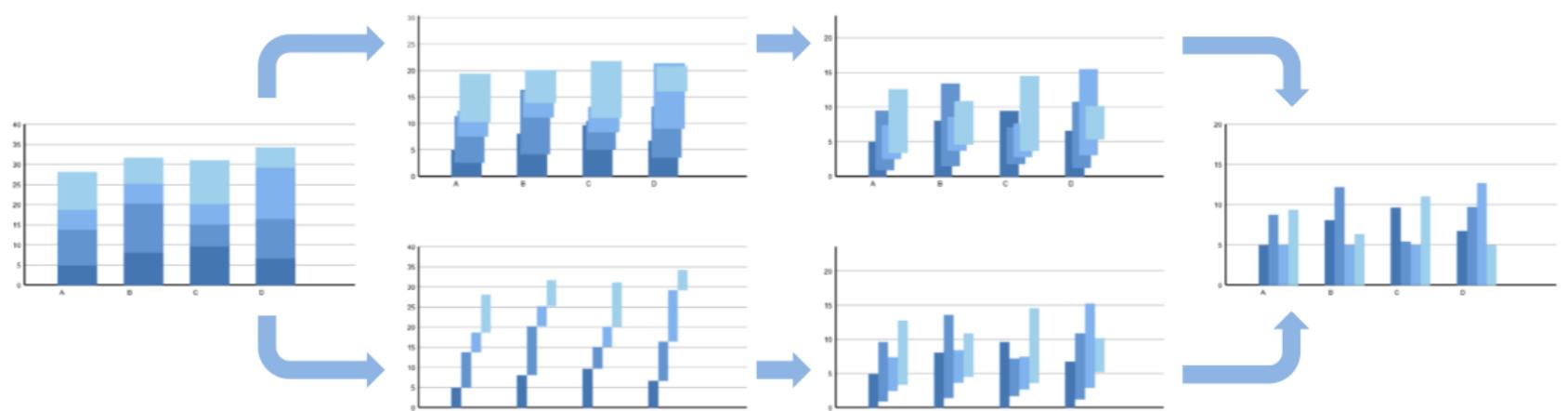


Figure 2. Animating from stacked bars to grouped bars. The top path directly interpolates between the starting and ending states. The bottom path is staged: the first stage changes the widths and x-coordinates of bars, the second stage drops the bars down to the baseline.

Animation

Heer et al. Animated transitions in statistical data graphics. IEEE TVCG 2007.
<https://www.youtube.com/watch?v=vLk7mlAtEXI>

FocusChange

Animated Exploration of Graphs with Radial Layout

IEEE InfoVis 2001

Ka-Ping Yee
Rachna Dhamija
Danyel Fisher
Marti Hearst

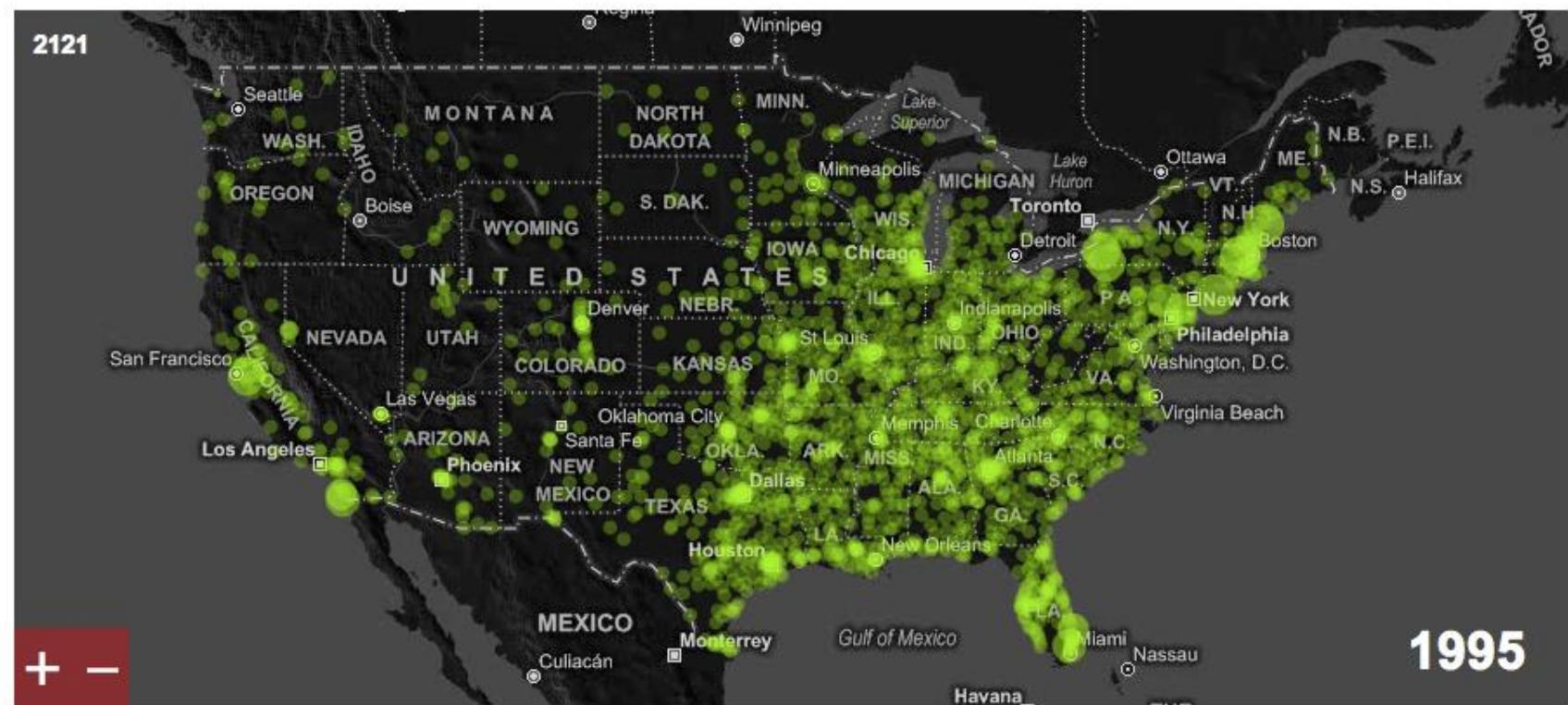
University of California, Berkeley

Yee, Ka-Ping. "Animated Exploration of Graphs with Radial Layout" 2001.
https://www.youtube.com/watch?v=OPX5iGro_lA

Narrative Animation

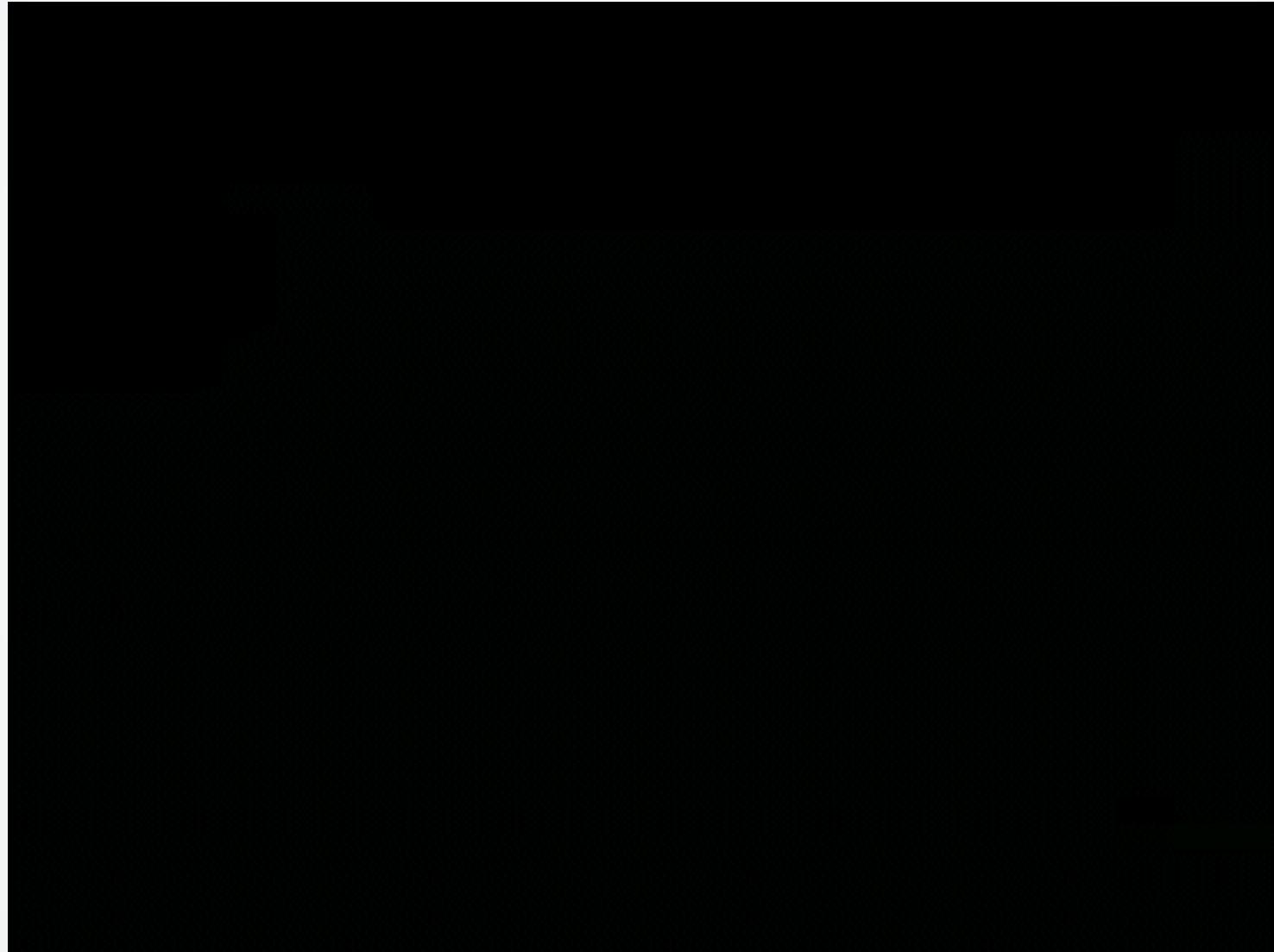
Watching the Growth of Walmart Across America

Over the weekend, I mapped the spread of Walmart using [Modest Maps](#). It starts slow and then spreads like wildfire in the southeast and makes its way towards the west coast.  [Subscribe to FlowingData](#) / [Read more...](#)



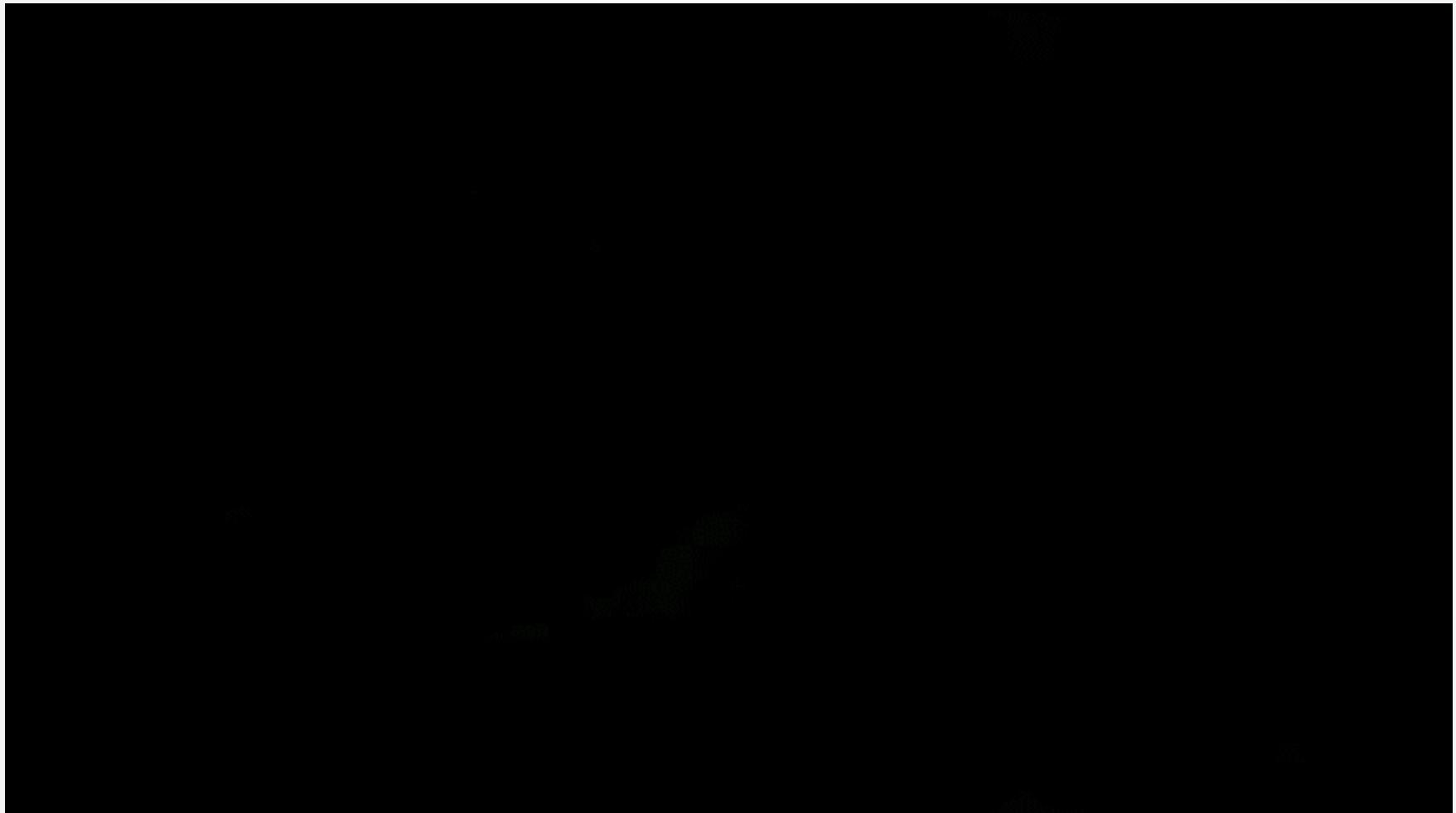
<https://flowingdata.com/2010/04/07/watching-the-growth-of-walmart-now-with-100-more-sams-club/>

HansRosling



https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen?language=en

200 Countries, 200 Years, In 4 Minutes

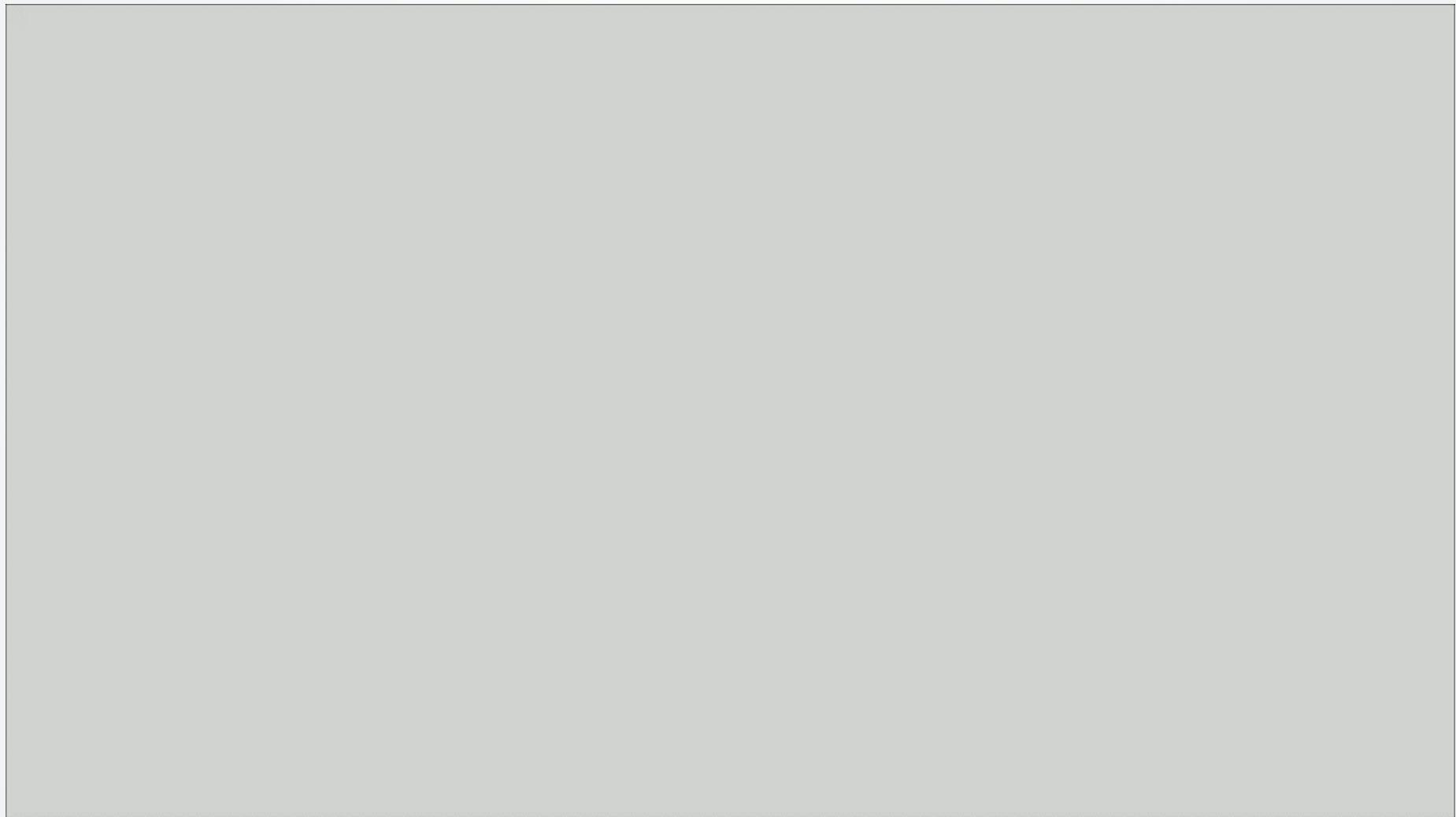


<https://www.youtube.com/watch?v=jbkSRLYSoj0>

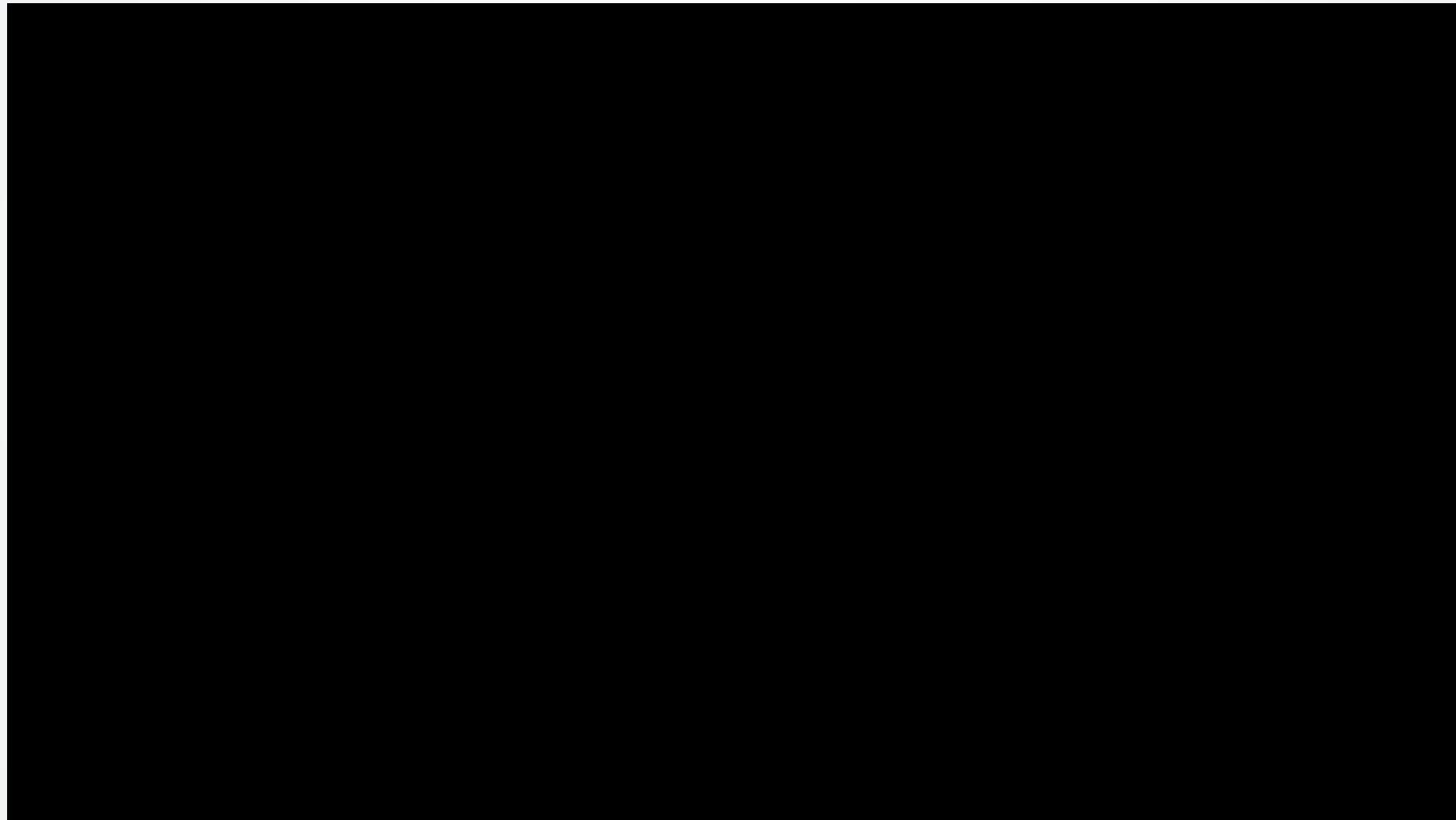
Interaction Hardware Design



Leap Motion



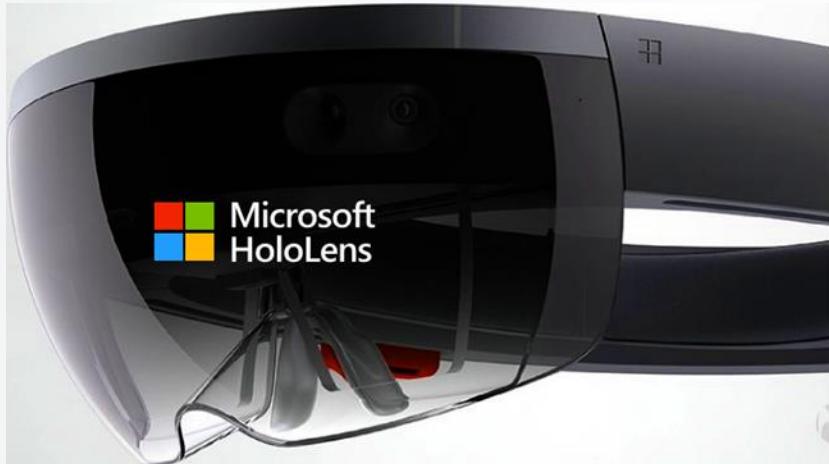
Multi-touch



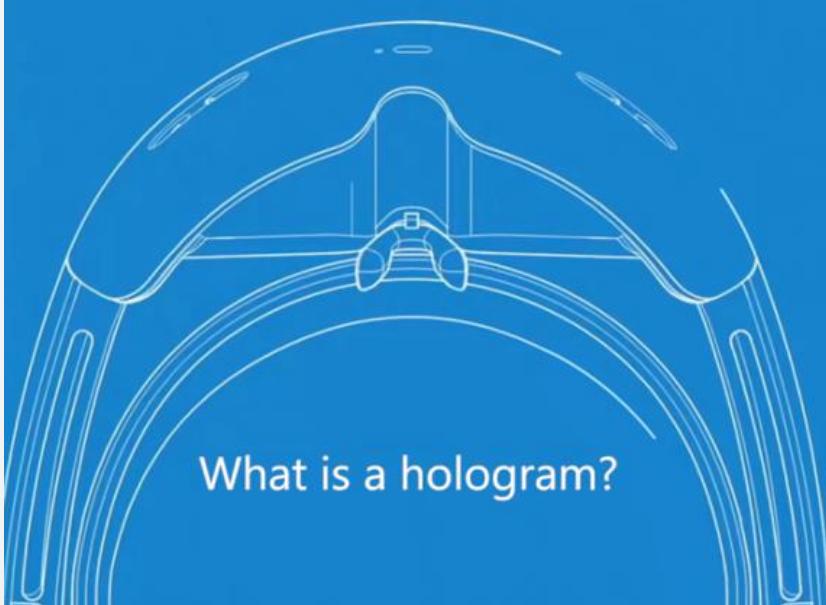
Microsoft Kinect

<https://www.youtube.com/watch?v=FjY5aqz3Abg>

Microsoft HoloLens



Microsoft HoloLens



What is a hologram?



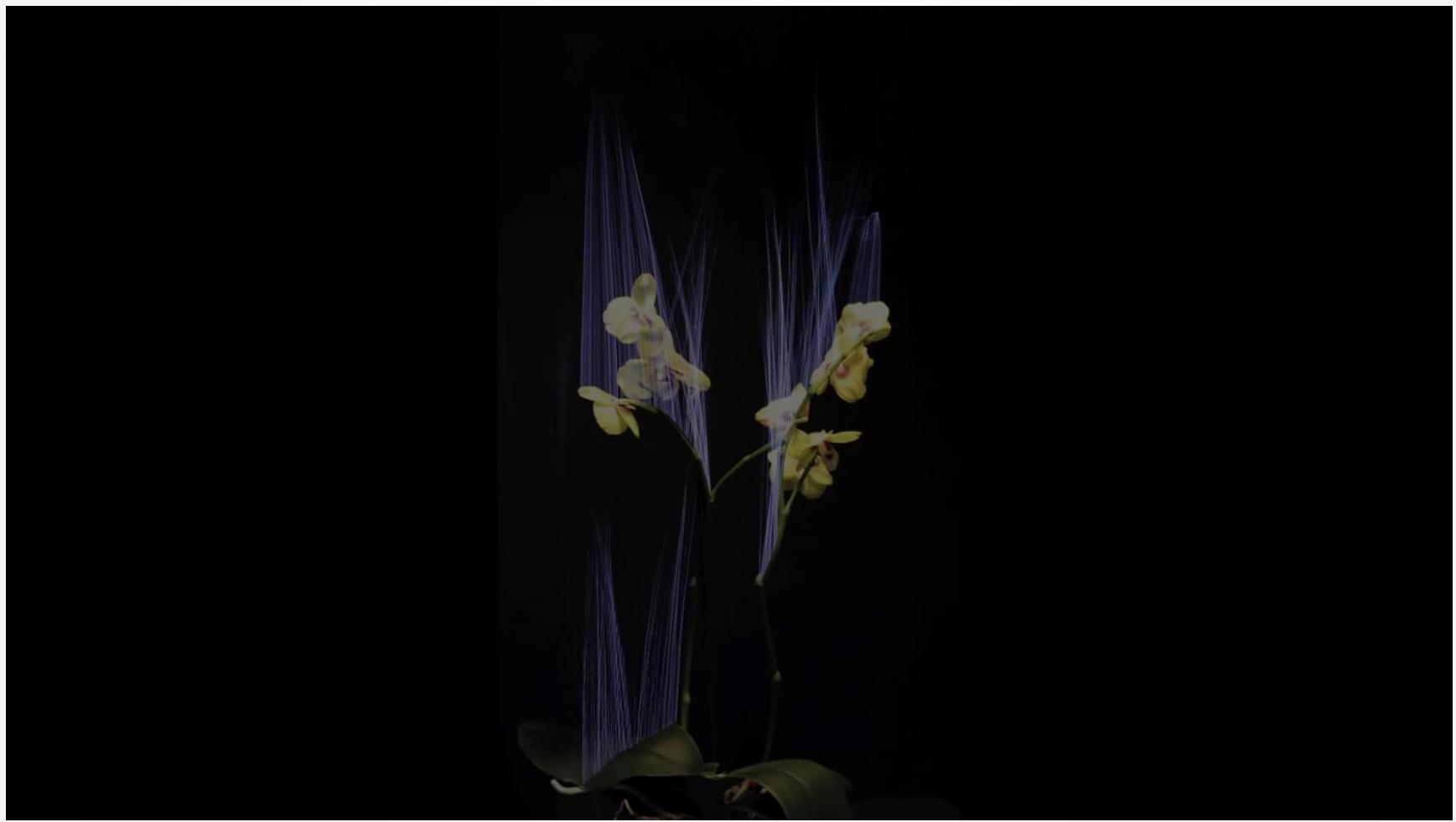
Microsoft HoloLens

Google Glass

Welcome to Glass

<https://www.youtube.com/watch?v=4EvNxWhskf8>

Interact with Plants



Poupyrev et al. "Botanicus Interacticus: interactive plants technology." ACM SIGGRAPH 2012
https://www.youtube.com/watch?v=_uTJiEYI1ik

Wearable Technology

When David Meets Goliath:

Combining Smartwatches with a
Large Vertical Display for Visual Data Exploration

Tom Horak*, Sriram Karthik Badam*, Niklas Elmquist, Raimund Dachselt

**The first two authors contributed equally to this work.*

ACM CHI 2018
Montreal, Canada





浙江大學
ZHEJIANG UNIVERSITY

2019 ZJU
International Summer School on Visual Analytics

Thank You!

