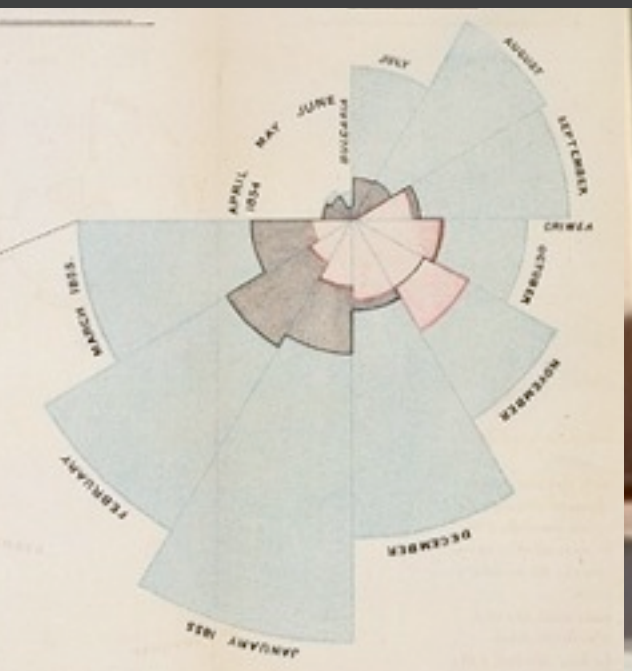
CSE512 :: 30 Jan 2014

Interaction



Jeffrey Heer University of Washington

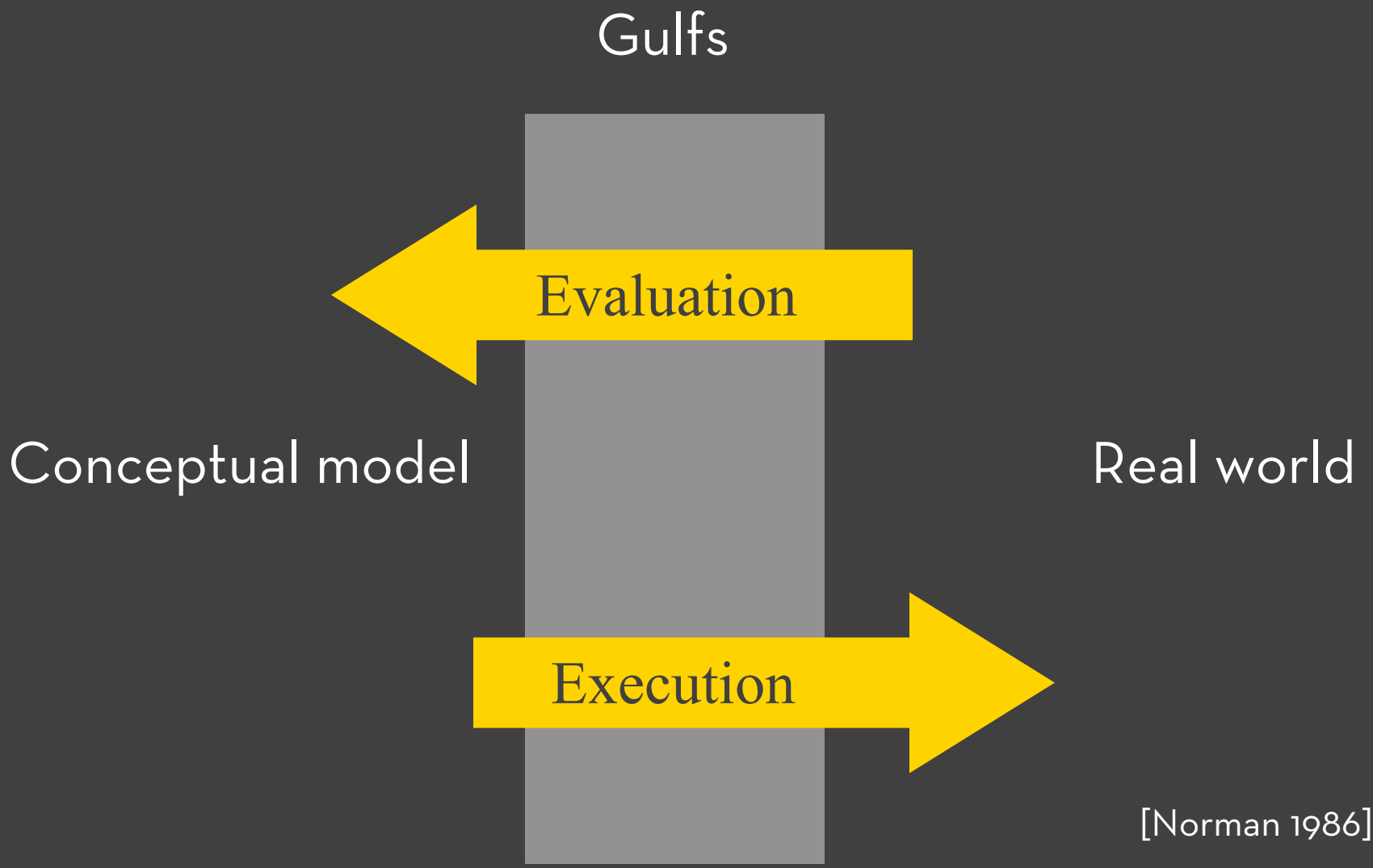
[There is an] apparent challenge that computational artifacts pose to the longstanding distinction between the physical and the social, in the special sense of those things that one designs, builds, and uses, on the one hand, and those things with which one communicates, on the other.

"Interaction"– in a sense previously reserved for describing a uniquely interpersonal activity – seems appropriately to characterize what goes on between people and certain machines as well.

Lucy Suchman, *Plans and Situated Actions*

Interaction between people and machines requires *mutual intelligibility* or *shared understanding*.

Gulfs of Execution & Evaluation



[Norman 1986]

Gulf of Execution

The difference between the user's intentions and the allowable actions.

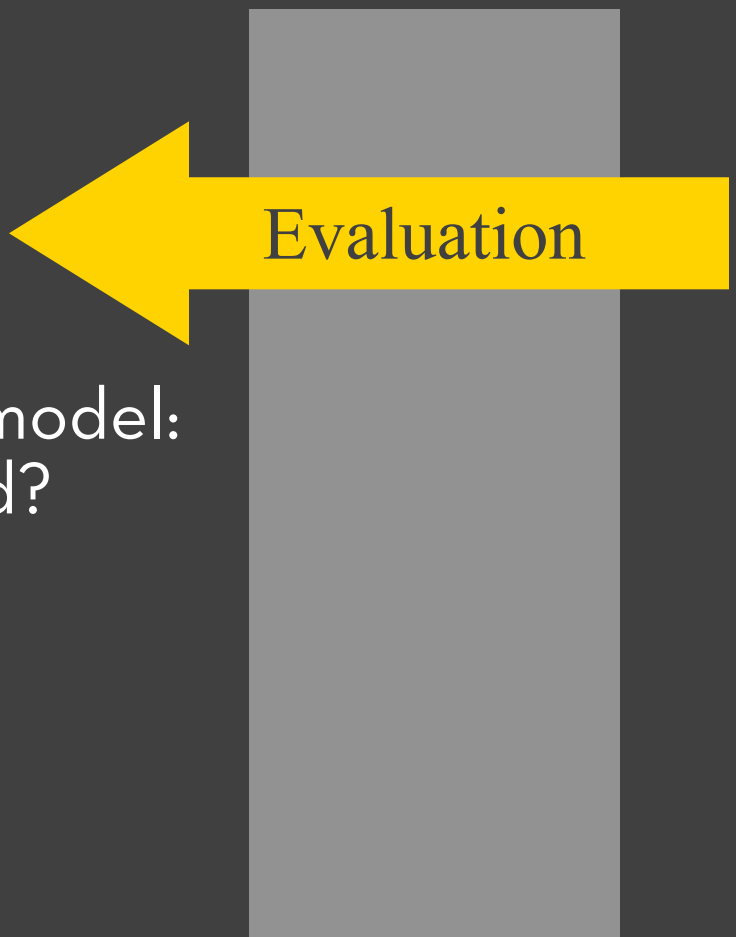
Gulf of Evaluation

The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

[Norman 1986]

Gulf of Evaluation

Gulf



Conceptual model:
x,y correlated?

Real world:

X	Y
0.67	0.79
0.32	0.63
0.39	0.72
0.27	0.85
0.71	0.43
0.63	0.09
0.03	0.03
0.20	0.54
0.51	0.38
0.11	0.33
0.46	0.46

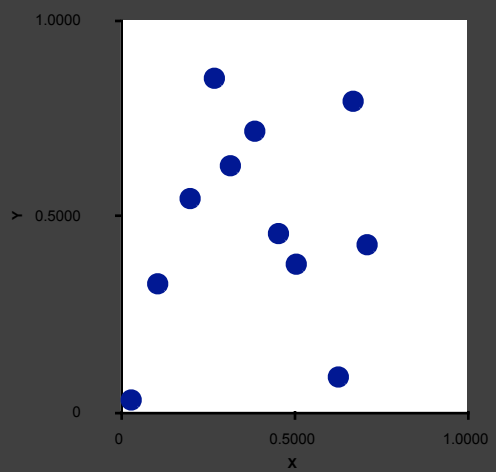
Gulf of Evaluation

Gulf

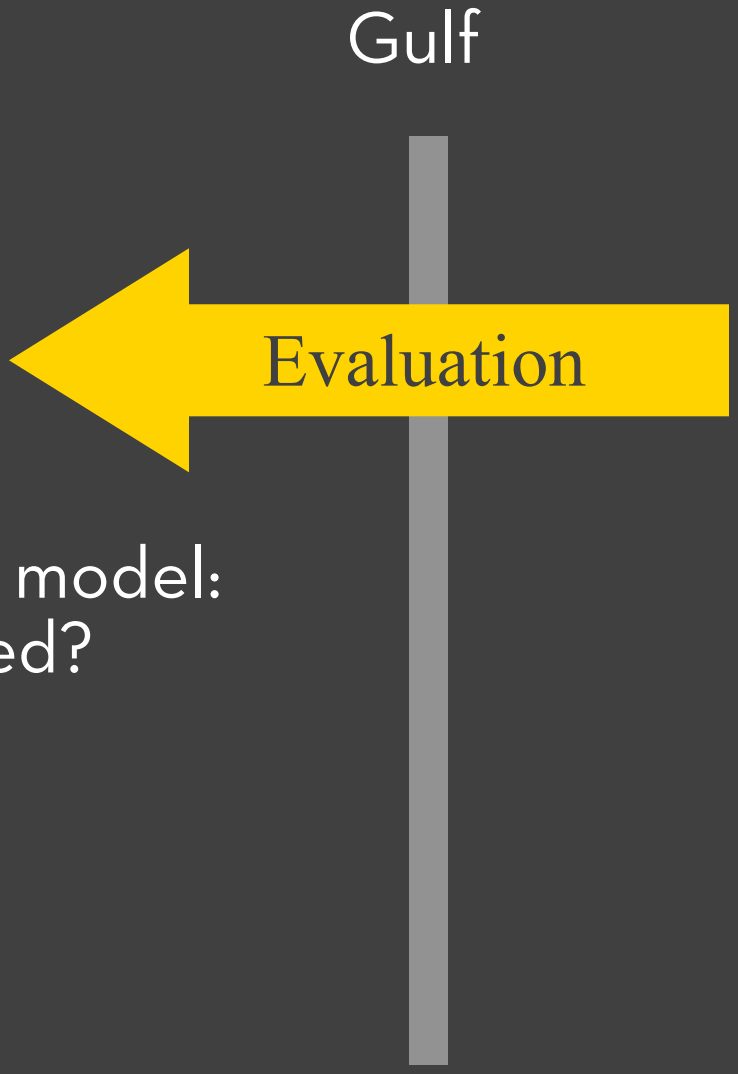
Evaluation

Conceptual model:
x,y correlated?

Real world:



Gulf of Evaluation



Conceptual model:
x,y correlated?

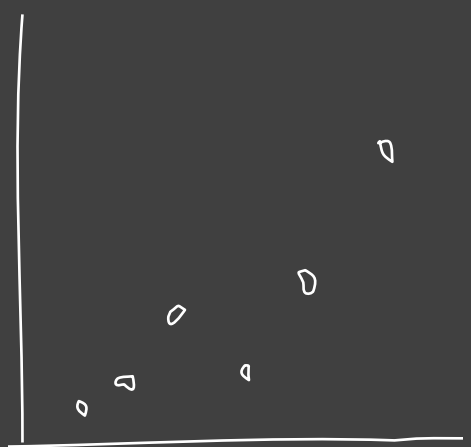
Real world:

$\rho = -.29$

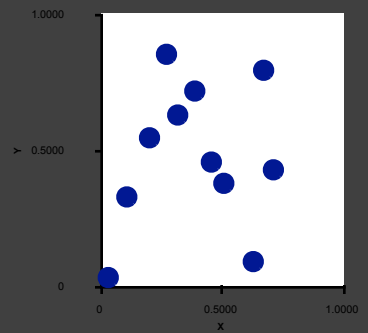
Gulf of Execution

Gulf

Conceptual model:
Draw a scatterplot



Execution



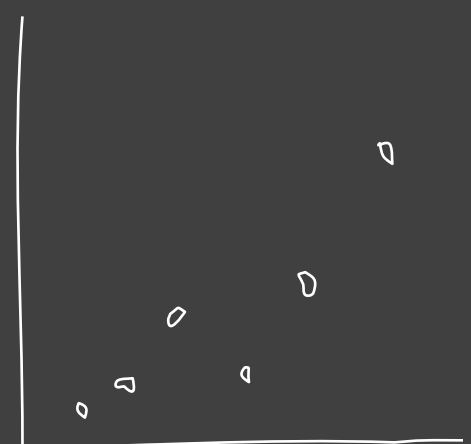
Real world

Move 90 30
Rotate 35
Pen down
…

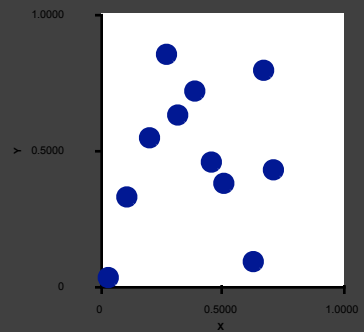
Gulf of Execution

Gulf

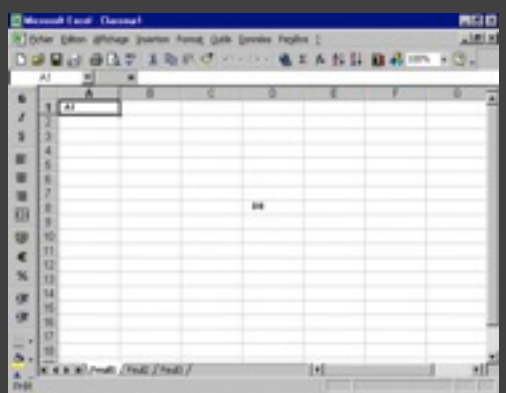
Conceptual model:
Draw a scatterplot



Execution



Real world



Interaction Techniques

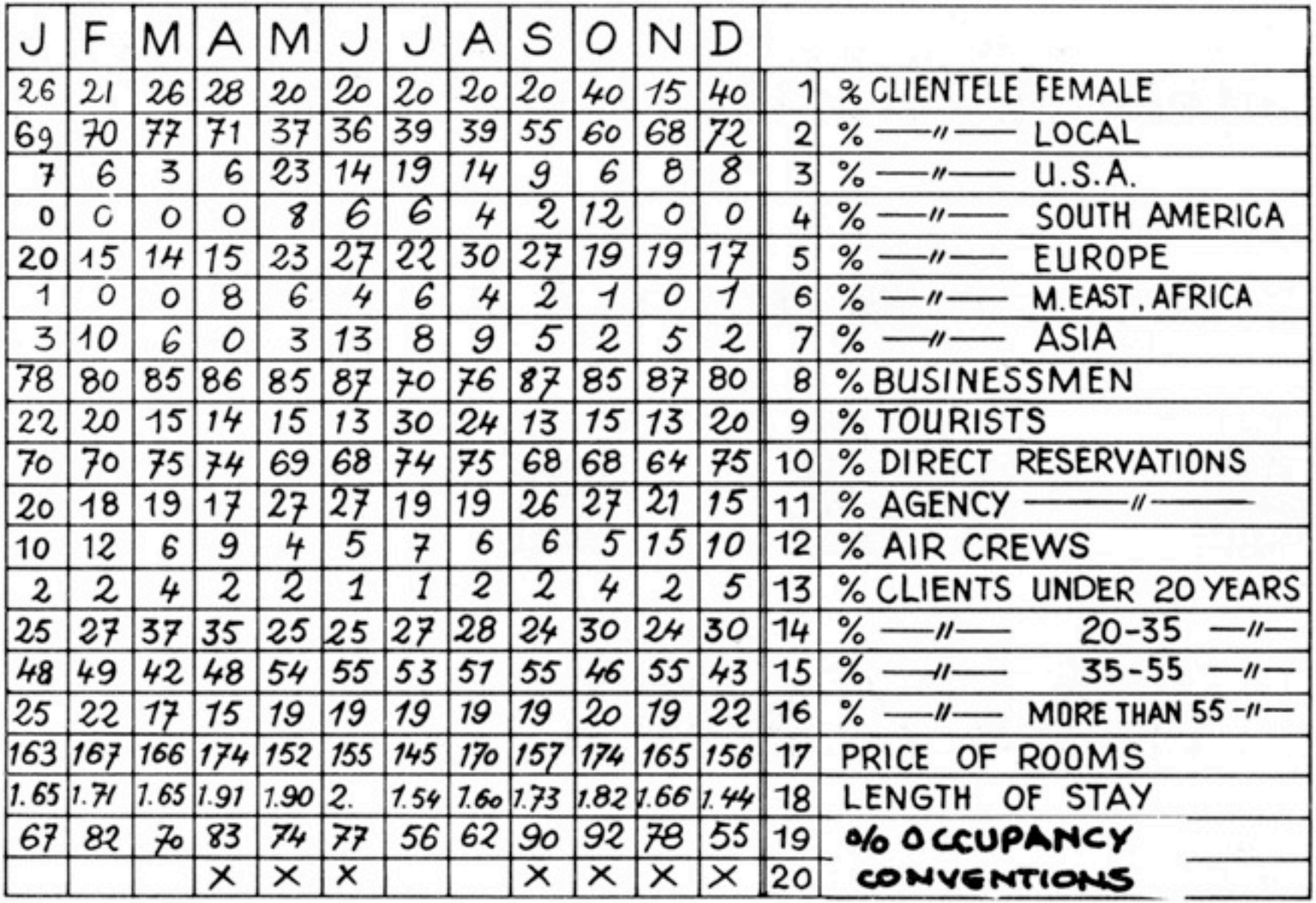
Are there “essential” interactive operations for supporting exploratory data visualization?

Interaction Techniques

Are there “essential” interactive operations for supporting exploratory data visualization?

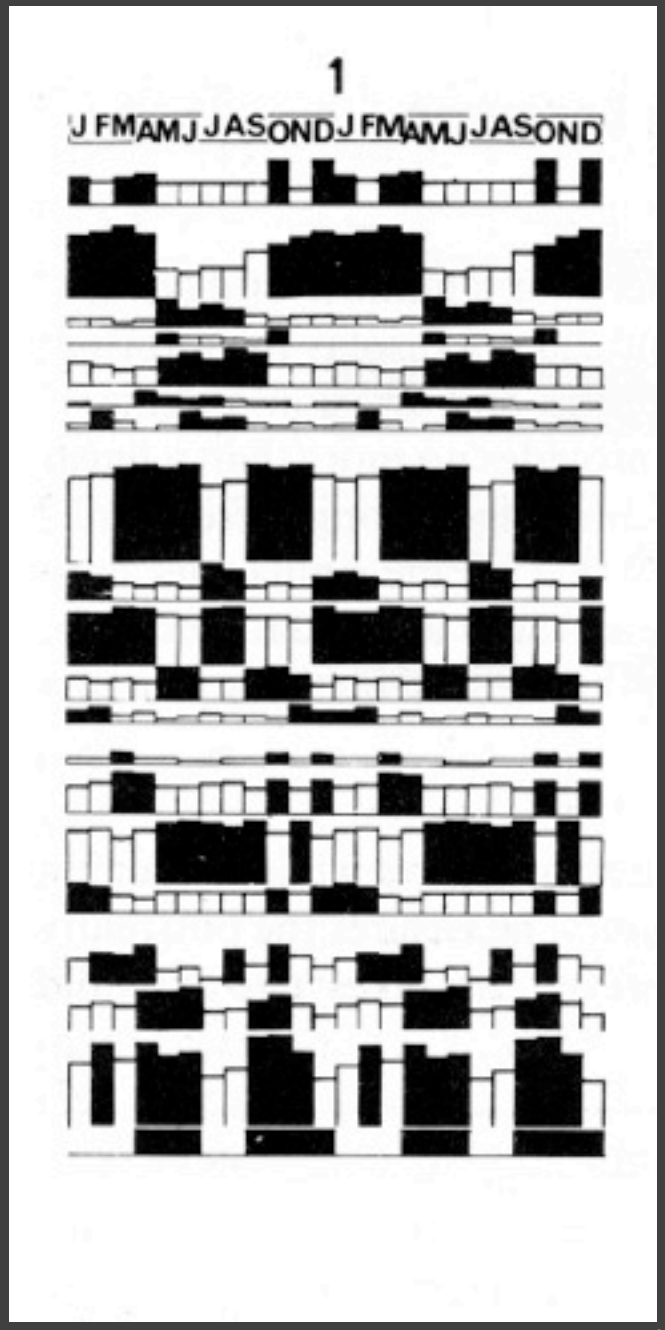
- View Specification (map data to visual vars)
- Navigation (pan, zoom, scale, rotate)
- Selection / Highlighting
- Filtering
- Sorting
- Extract Data

Interactive Visualization

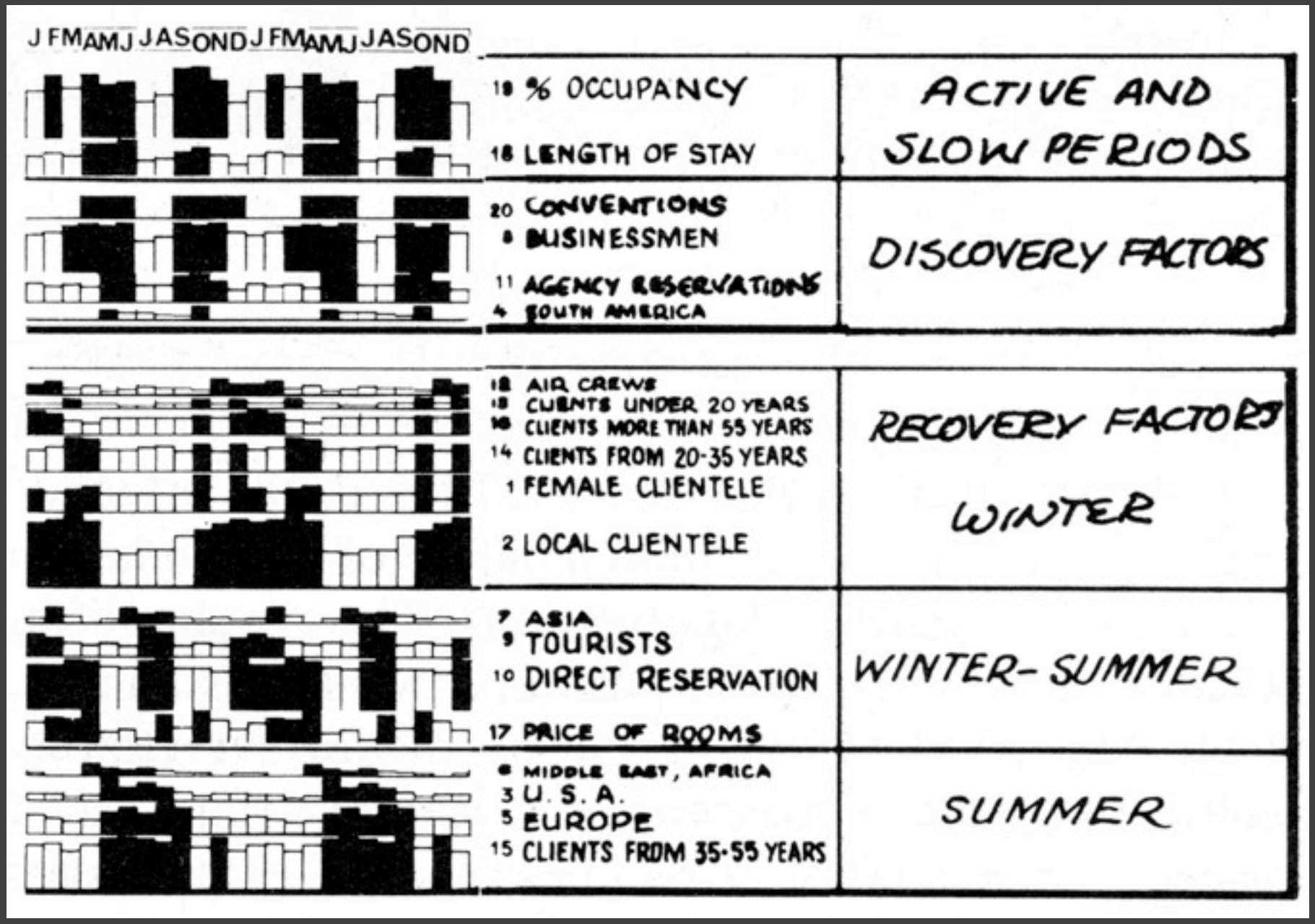


J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —〃— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —〃— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —〃— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —〃— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —〃— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —〃— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY ——〃——
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —〃— 20-35 —〃—
48	49	42	48	54	55	53	51	55	46	55	43	15	% —〃— 35-55 —〃—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —〃— MORE THAN 55 —〃—
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS

[Graphics and Graphic Information Processing, Bertin 81]



[Graphics and Graphic Information Processing, Bertin 81]



[Graphics and Graphic Information Processing, Bertin 81]

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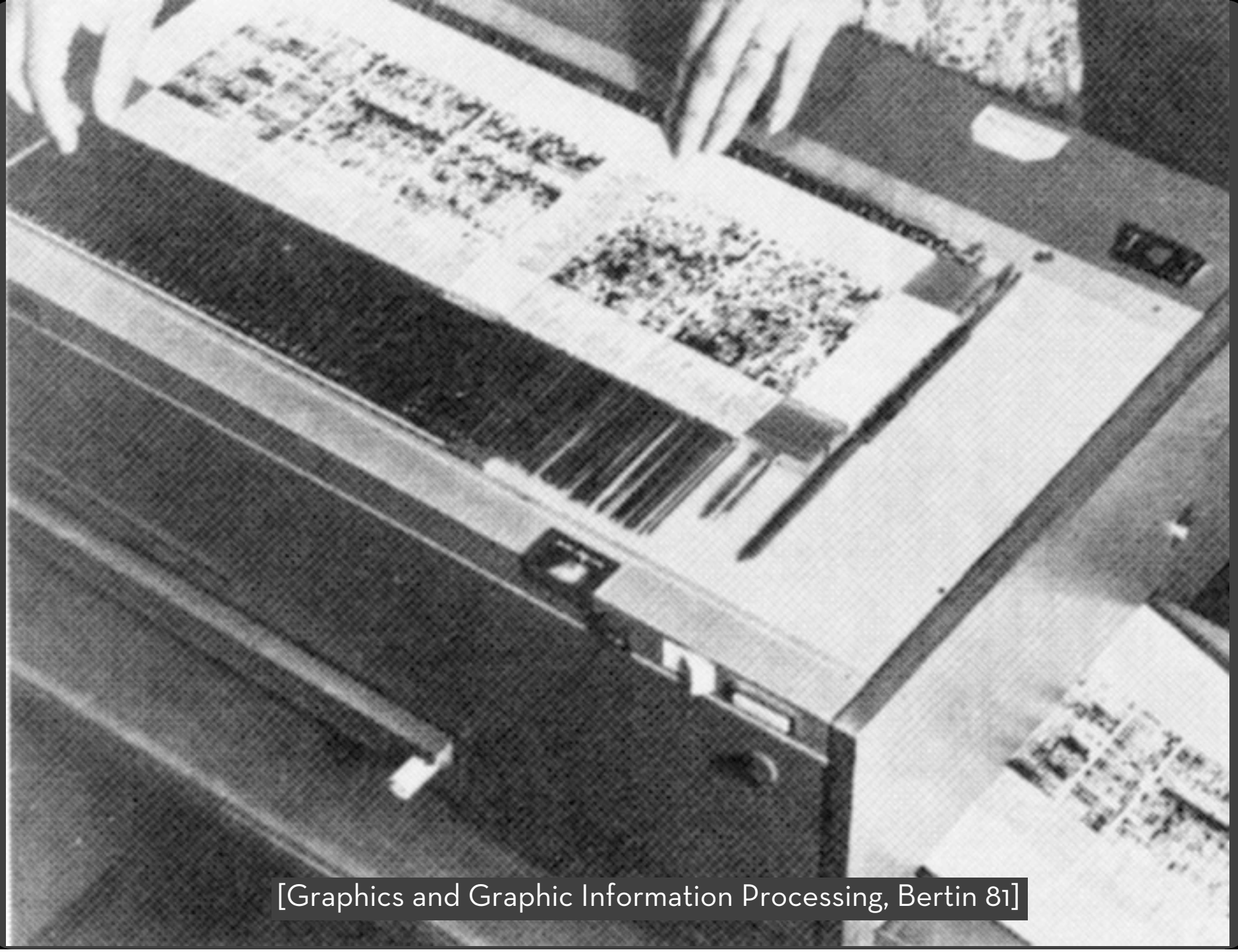
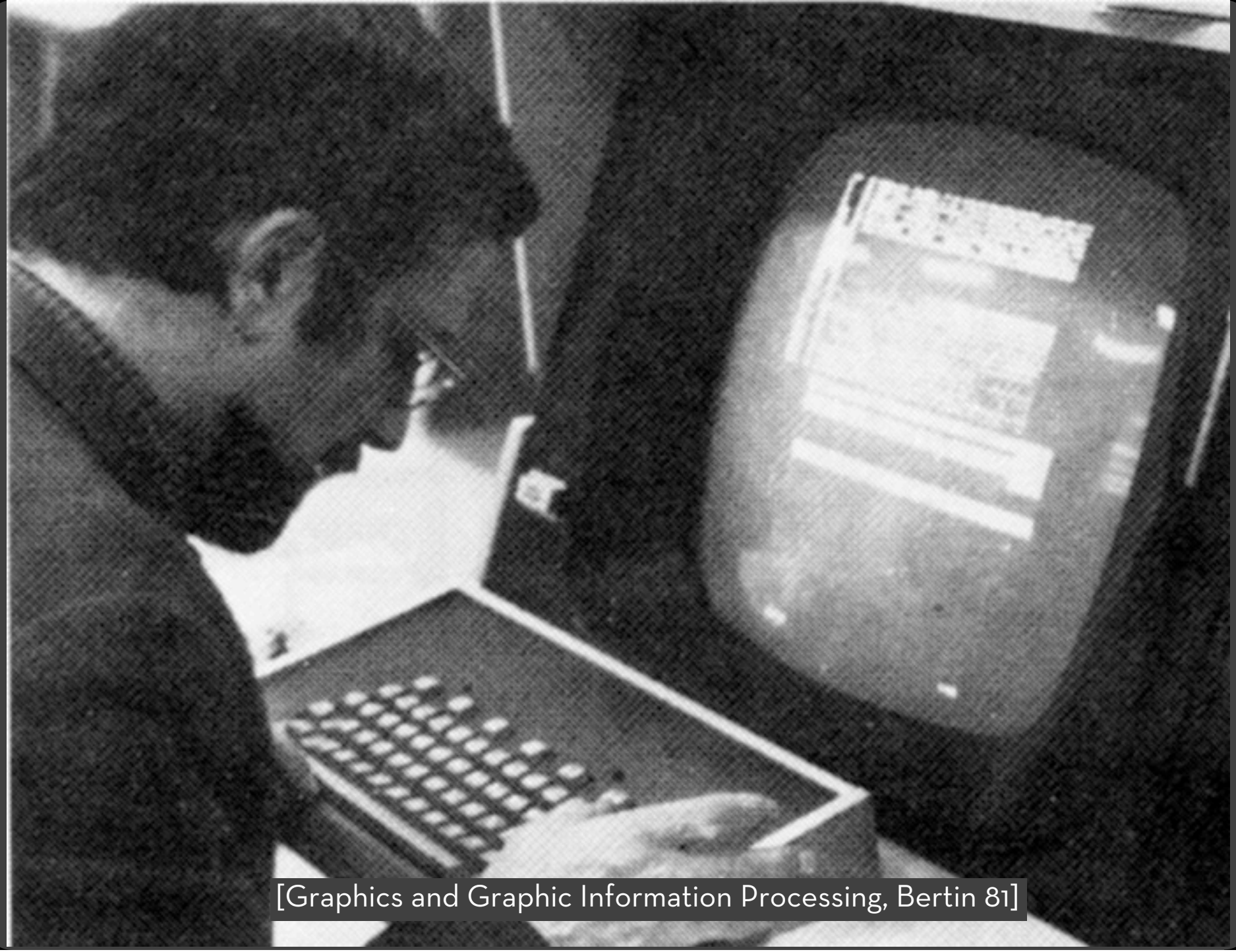
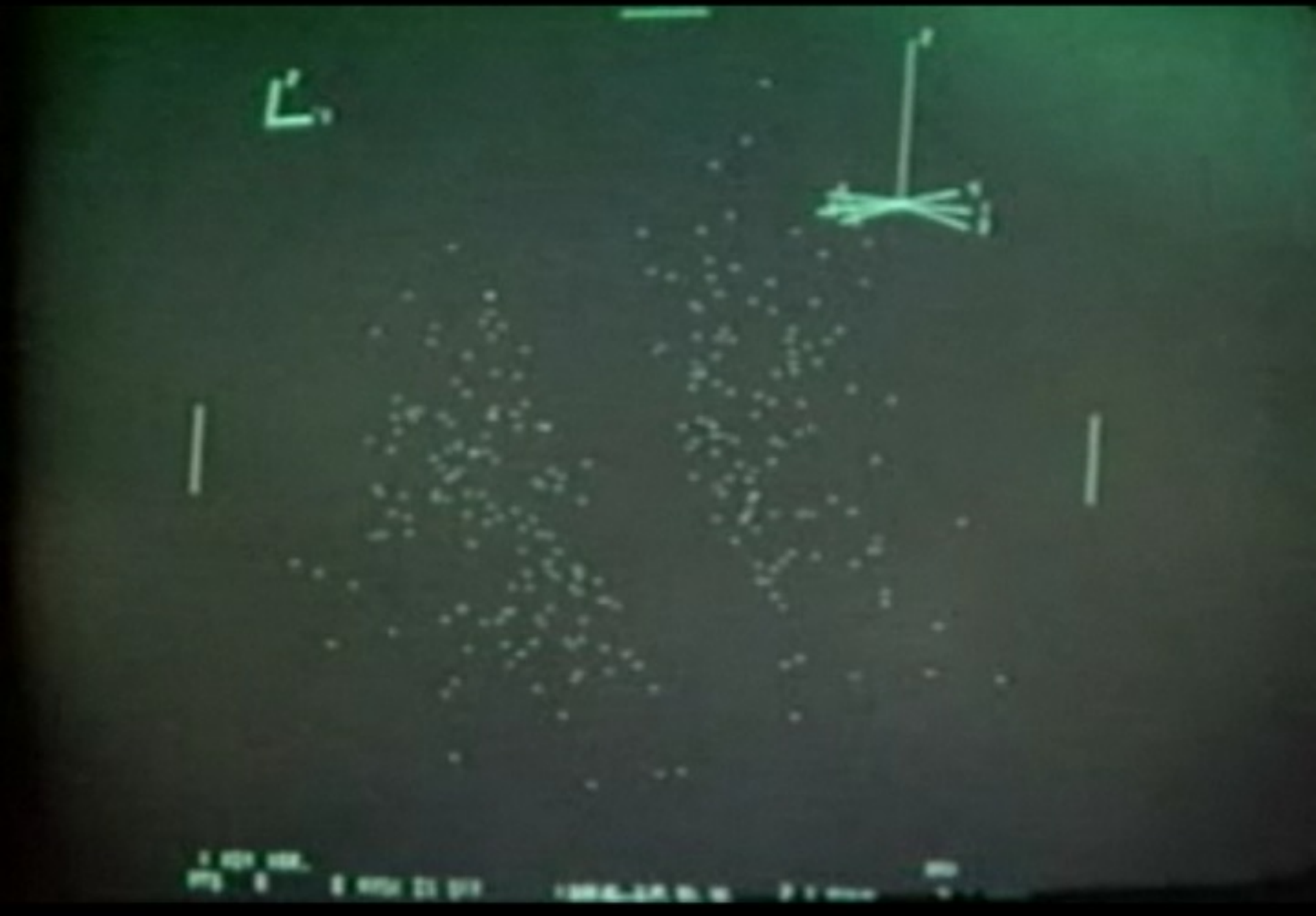


[Graphics and Graphic Information Processing, Bertin 81]



[Graphics and Graphic Information Processing, Bertin 81]

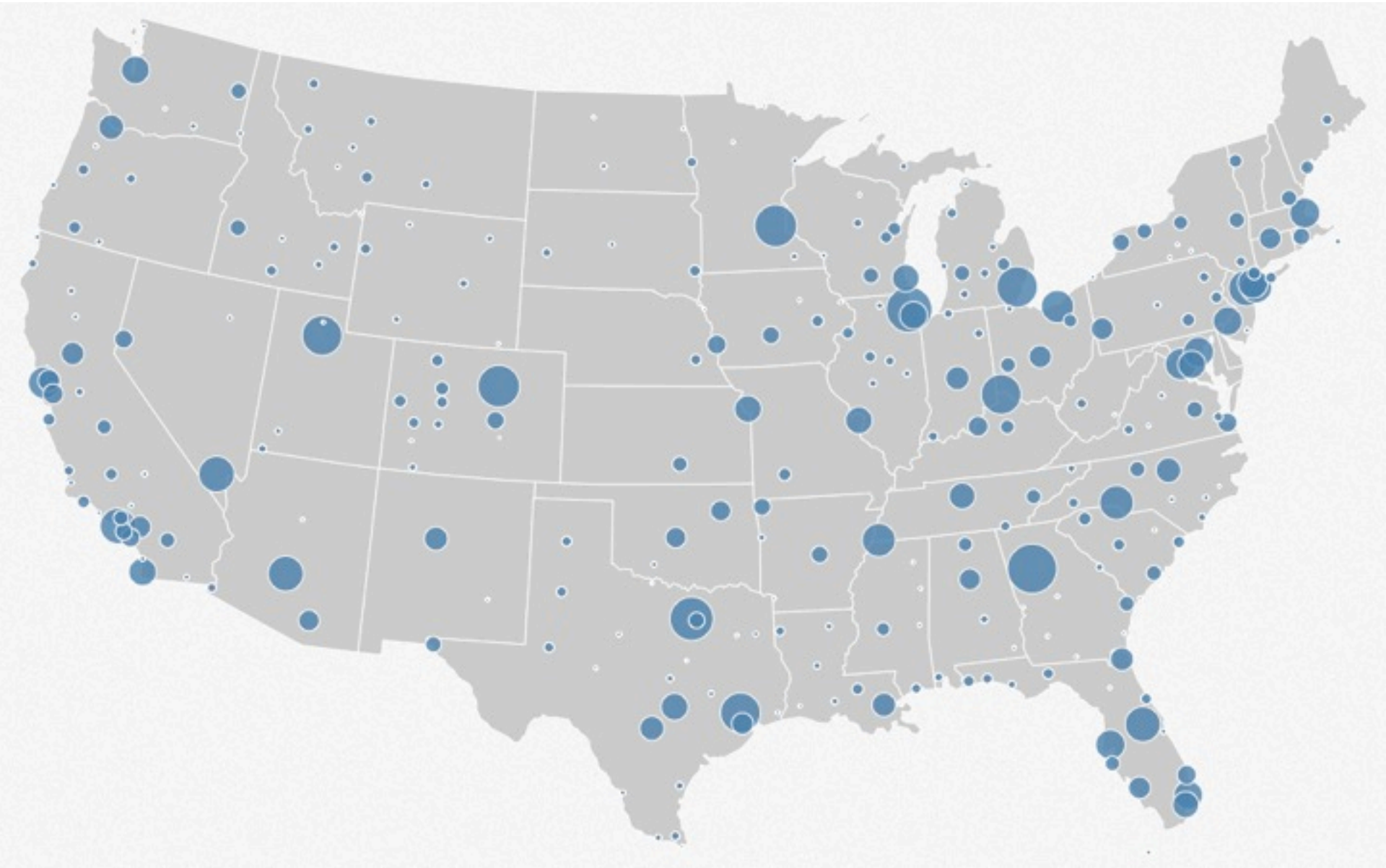
PRIM-9, Tukey, Fisherkeller, Friedman 1972

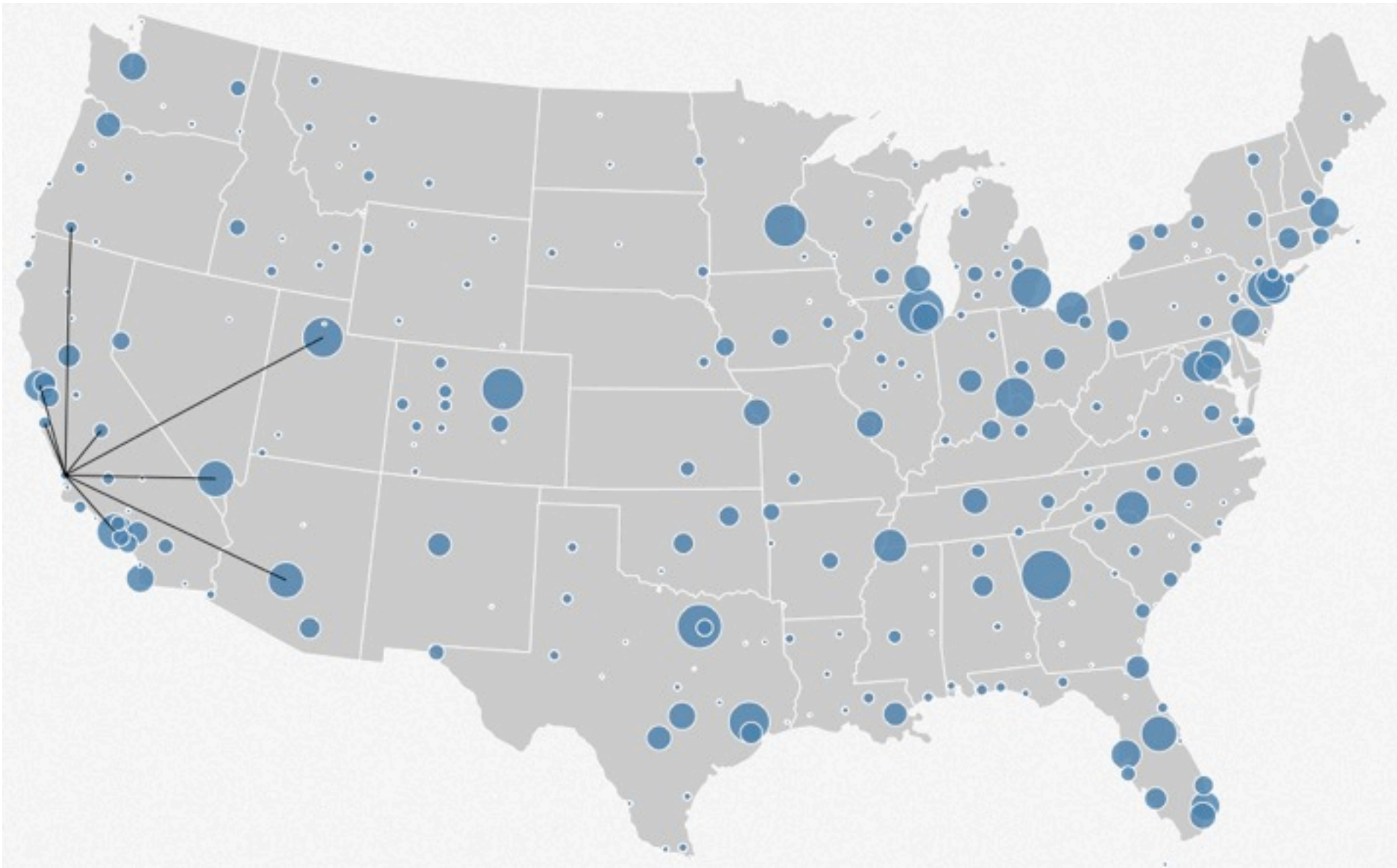


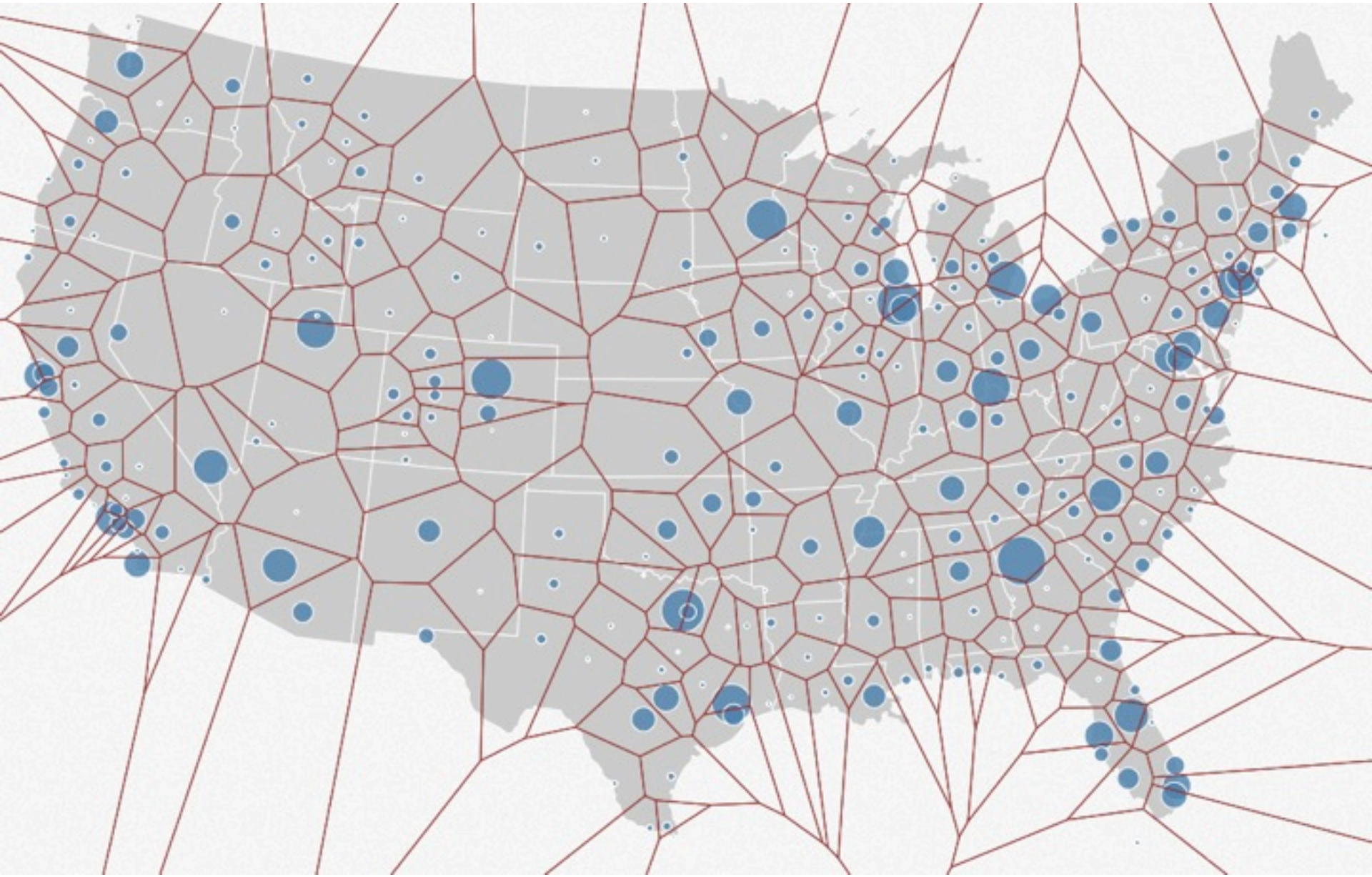
Pointing

Basic Pointing Methods

Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)







Basic Pointing Methods

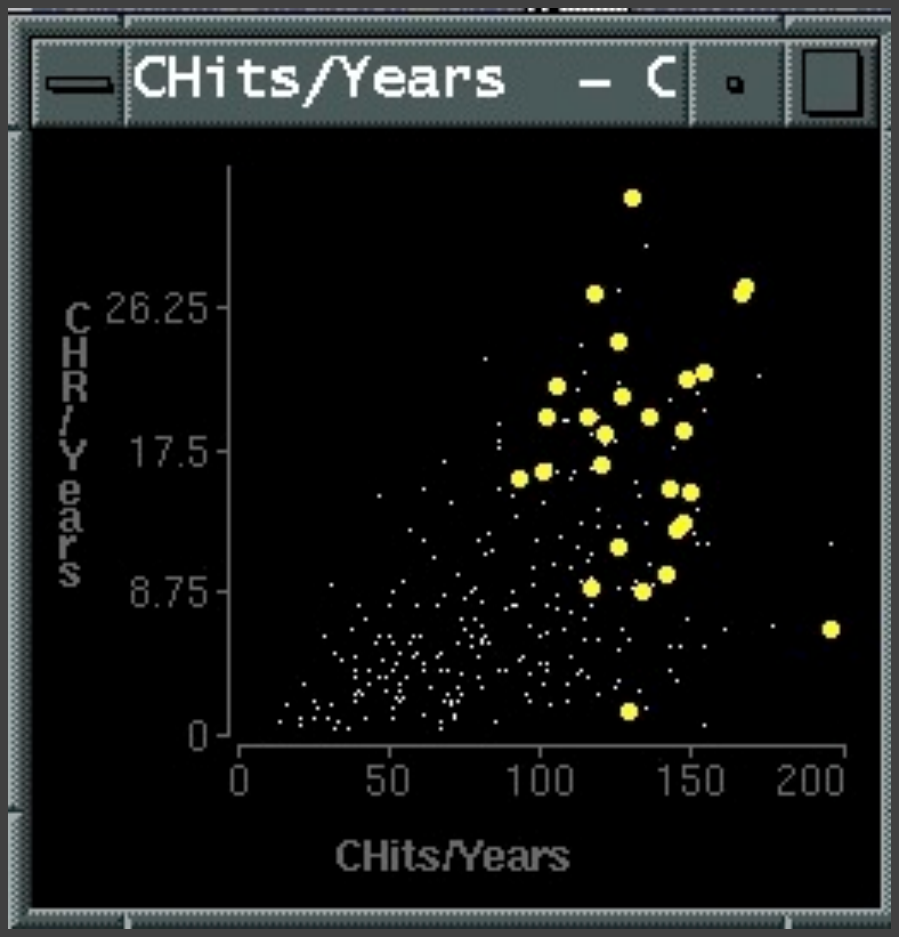
Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)

Region Selection
Rubber-band or Lasso
Area Cursors (“Brushes”)

Brushing and Linking

Highlighting / Brushing

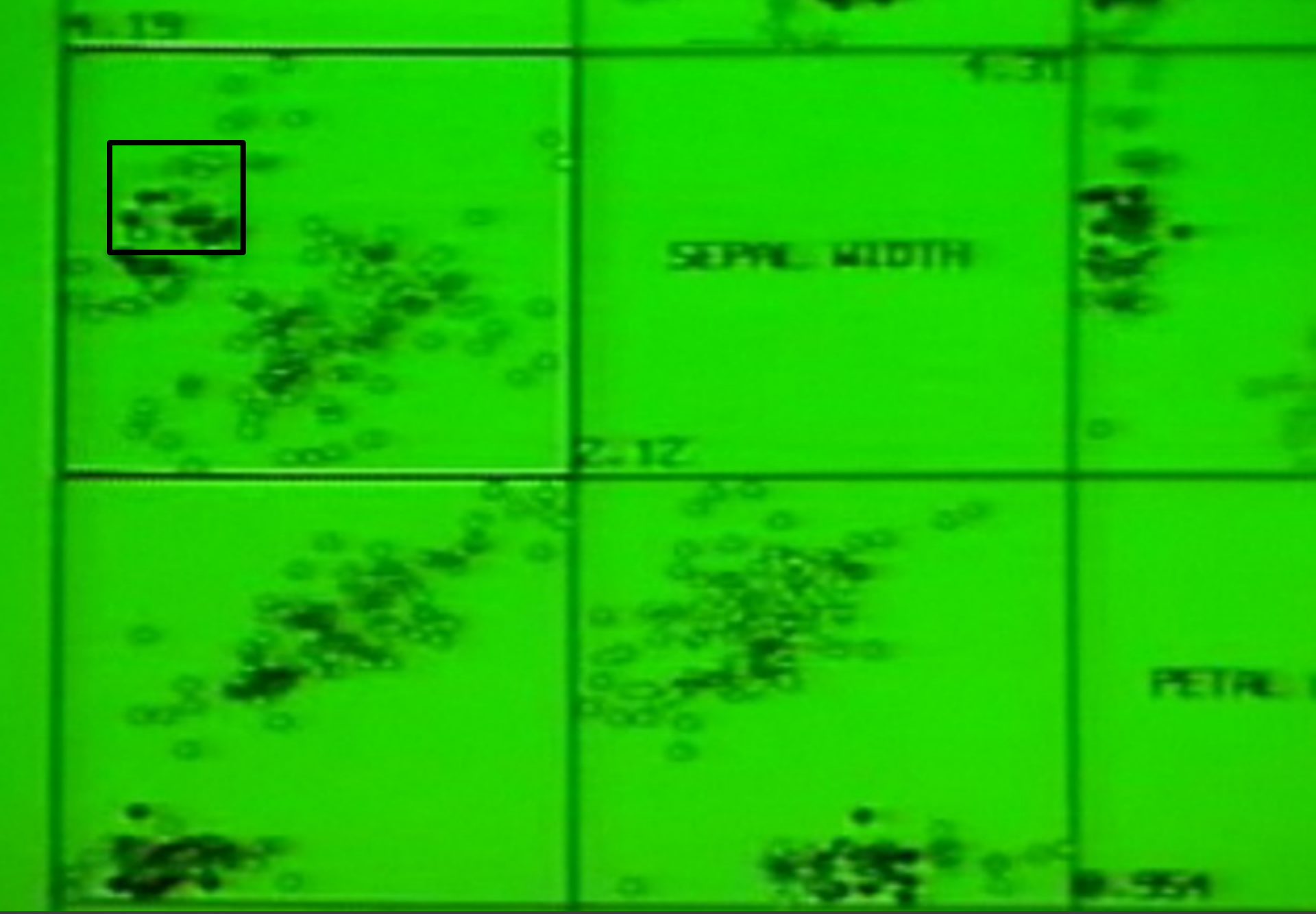
Direct attention to a data subset within a graph [Wills 95]



Brushing and Linking

Select (“brush”) a subset of data
See selected data in other views

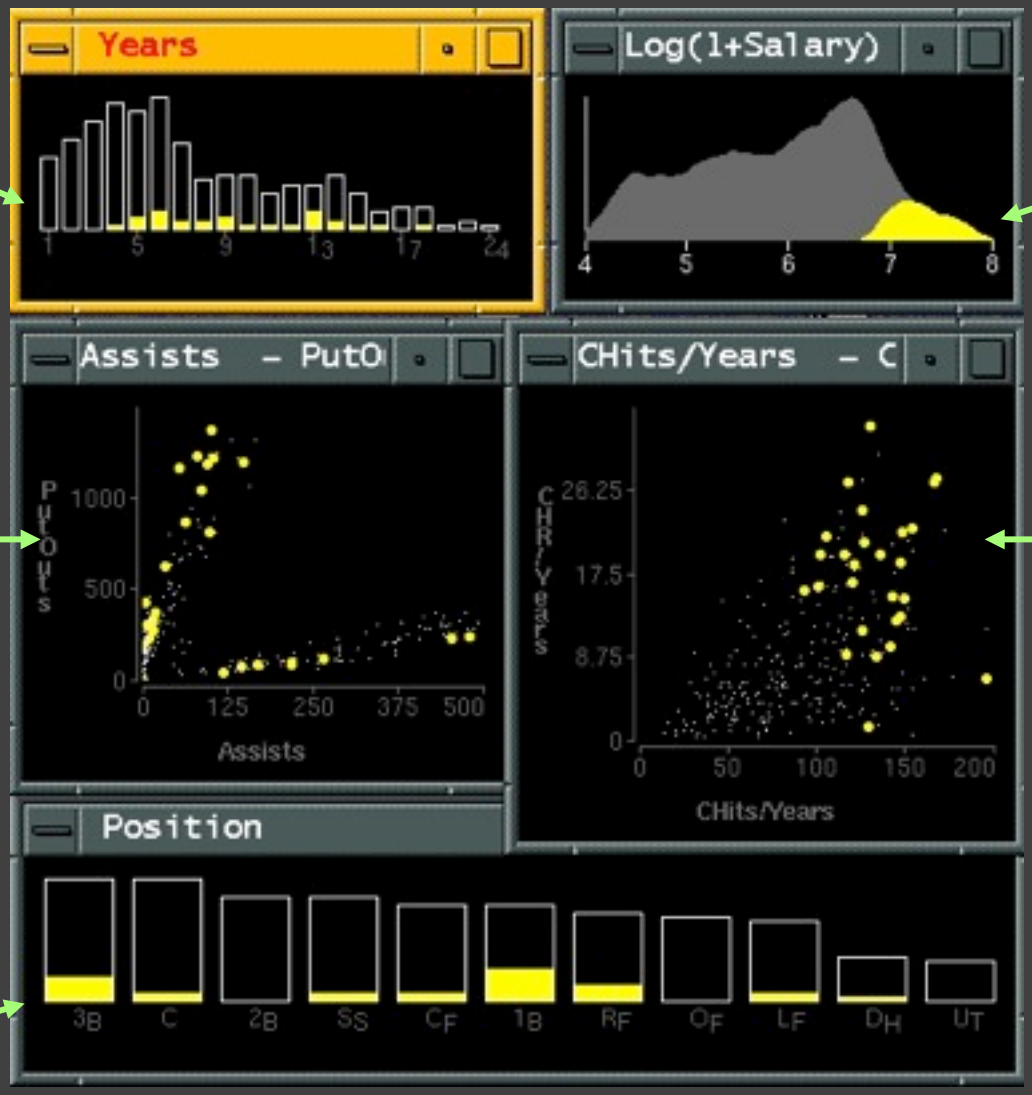
The components must be *linked*
by *tuple* (matching data points), or
by *query* (matching range or values)



Brushing Scatterplots, Becker & Cleveland 1982

Baseball Statistics [from Wills 95]

how long in majors



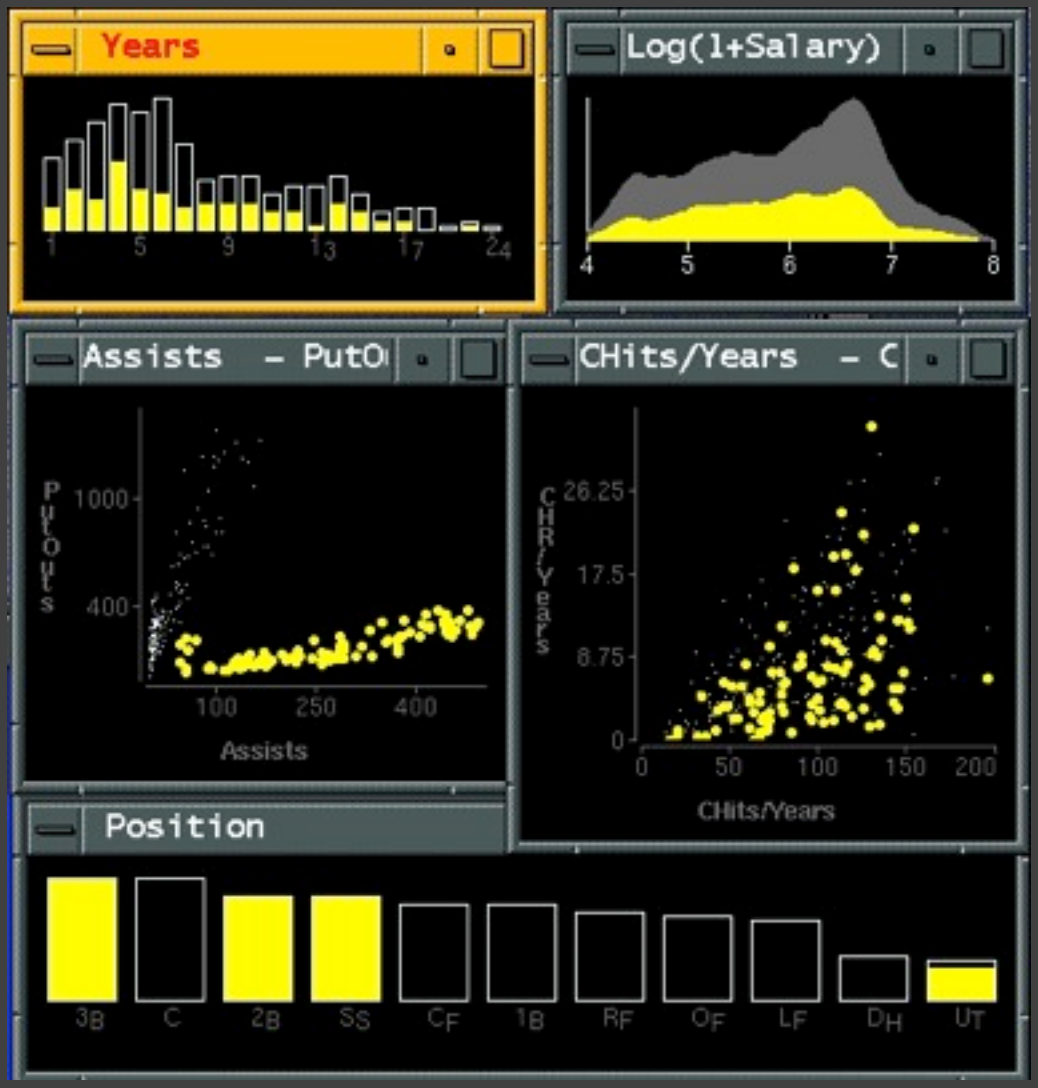
select high salaries

avg assists vs avg putouts (fielding ability)

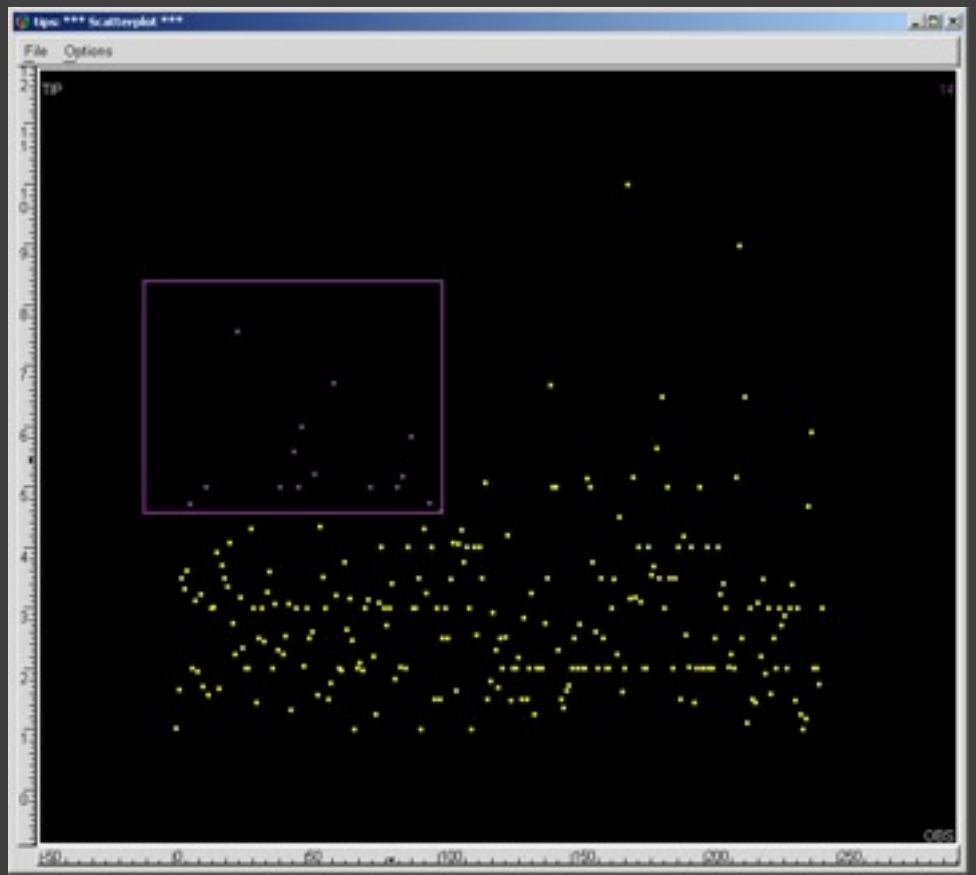
avg career HRs vs avg career hits (batting ability)

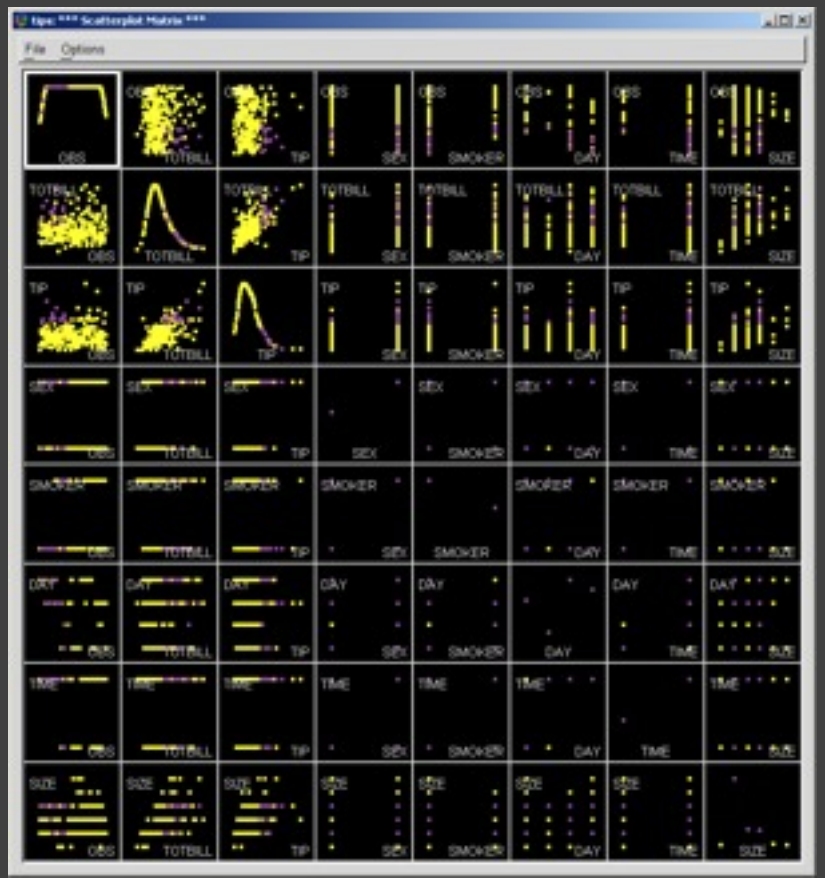
distribution of positions played

Linking Assists to Positions



GGobi: Brushing



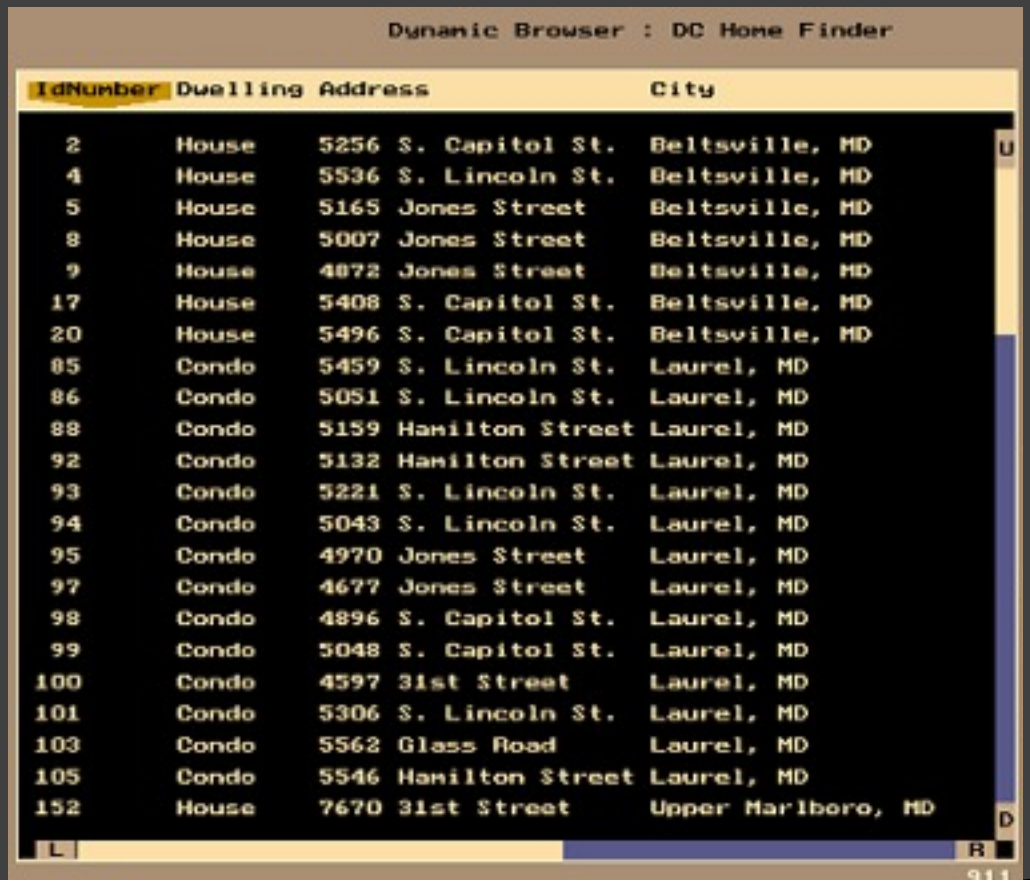


http://www.ggobi.org/

Dynamic Queries

Query and Results

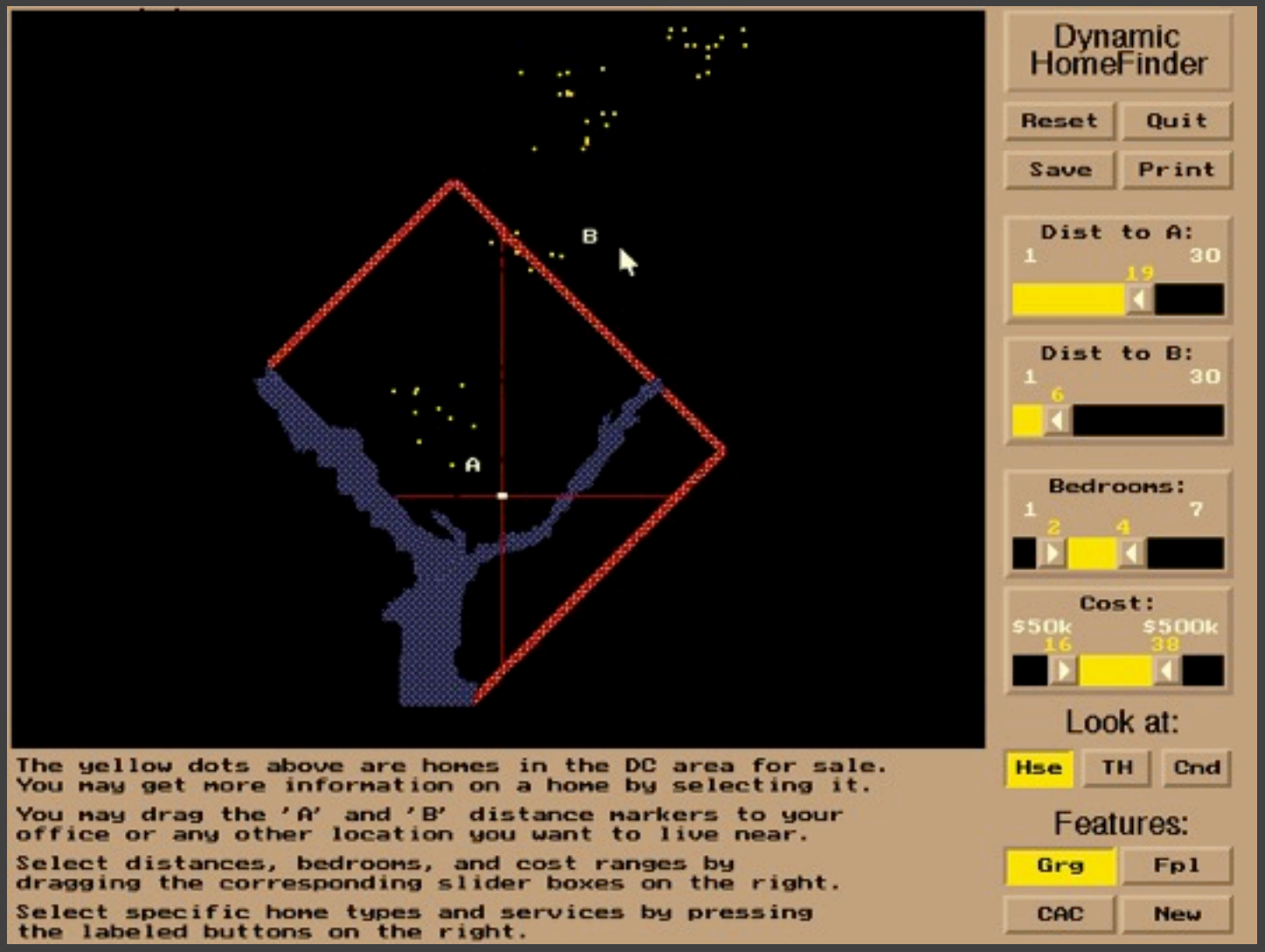
SELECT house FROM seattle_homes
WHERE price < 1,000,000 AND bedrooms > 2
ORDER BY price



Issues

1. For programmers
2. Rigid syntax
3. Only shows exact matches
4. Too few or too many hits
5. No hint on how to reformulate the query
6. Slow question-answer loop
7. Results returned as table

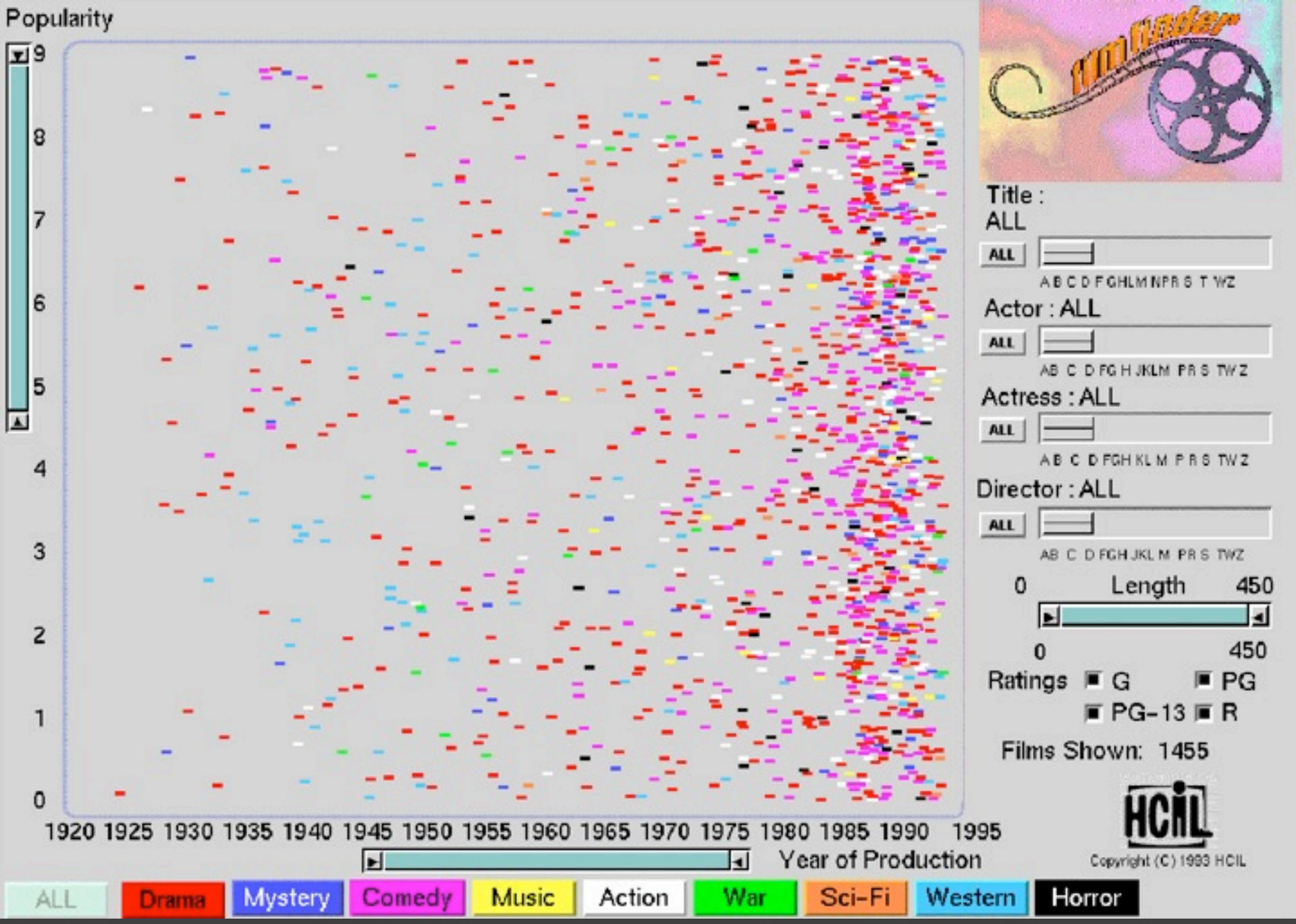
HomeFinder



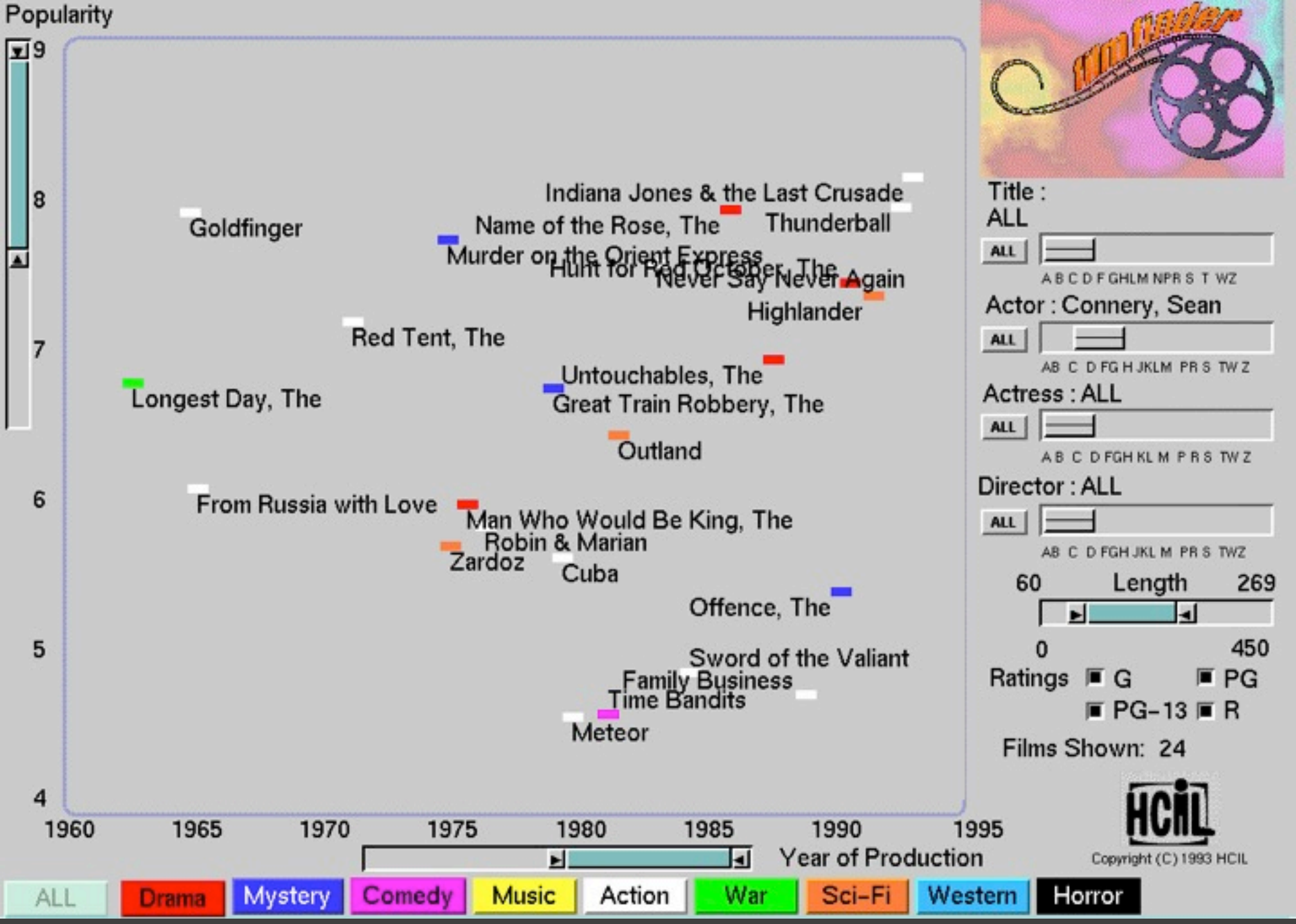
[Williamson and Shneiderman 92]

Direct Manipulation

1. Visual representation of objects and actions
2. Rapid, incremental and reversible actions
3. Selection by pointing (not typing)
4. Immediate and continuous display of results



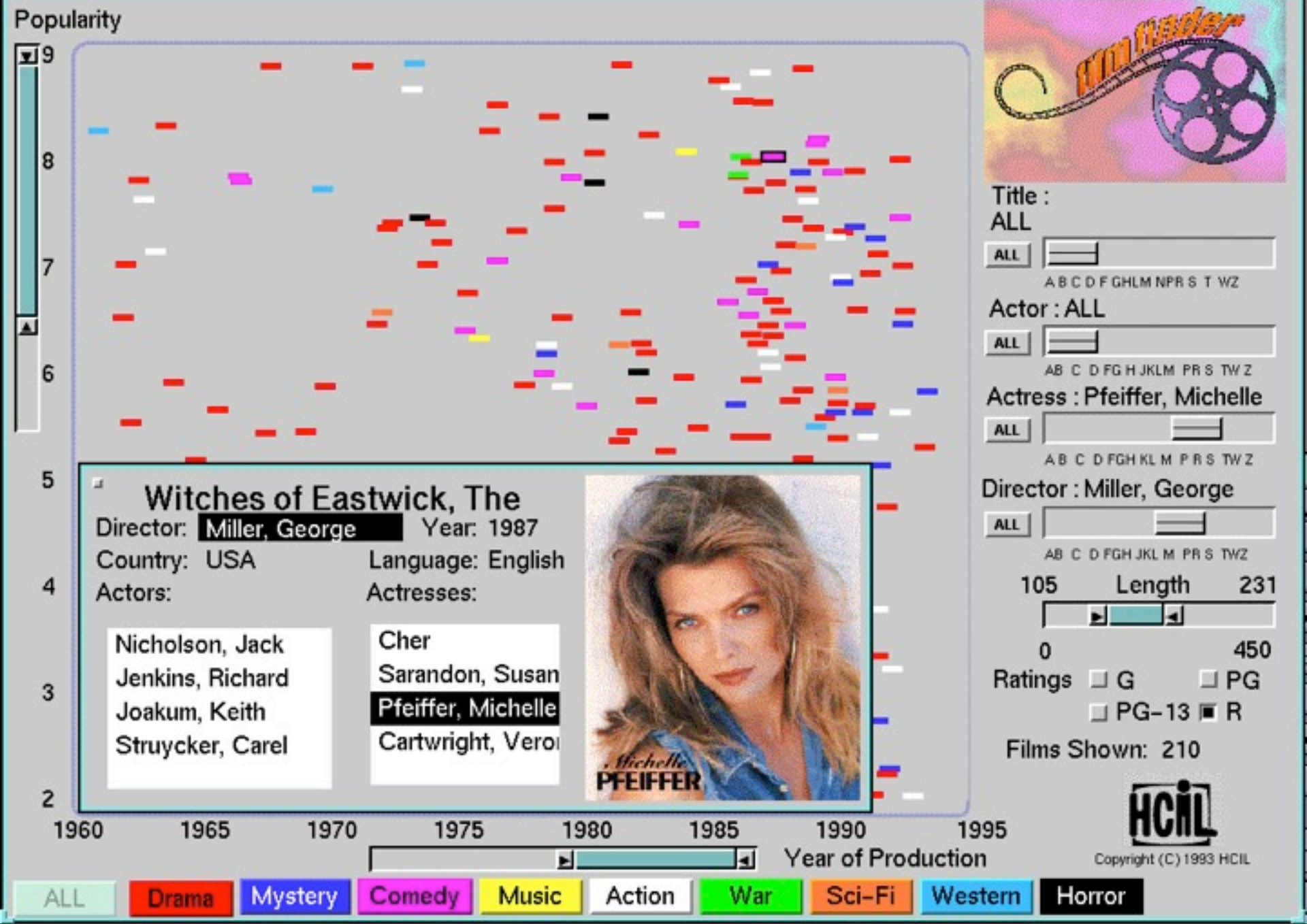
[Ahlberg and Shneiderman 94]



[Ahlberg and Shneiderman 94]

Alphaslider

[Ahlberg and Shneiderman 94]



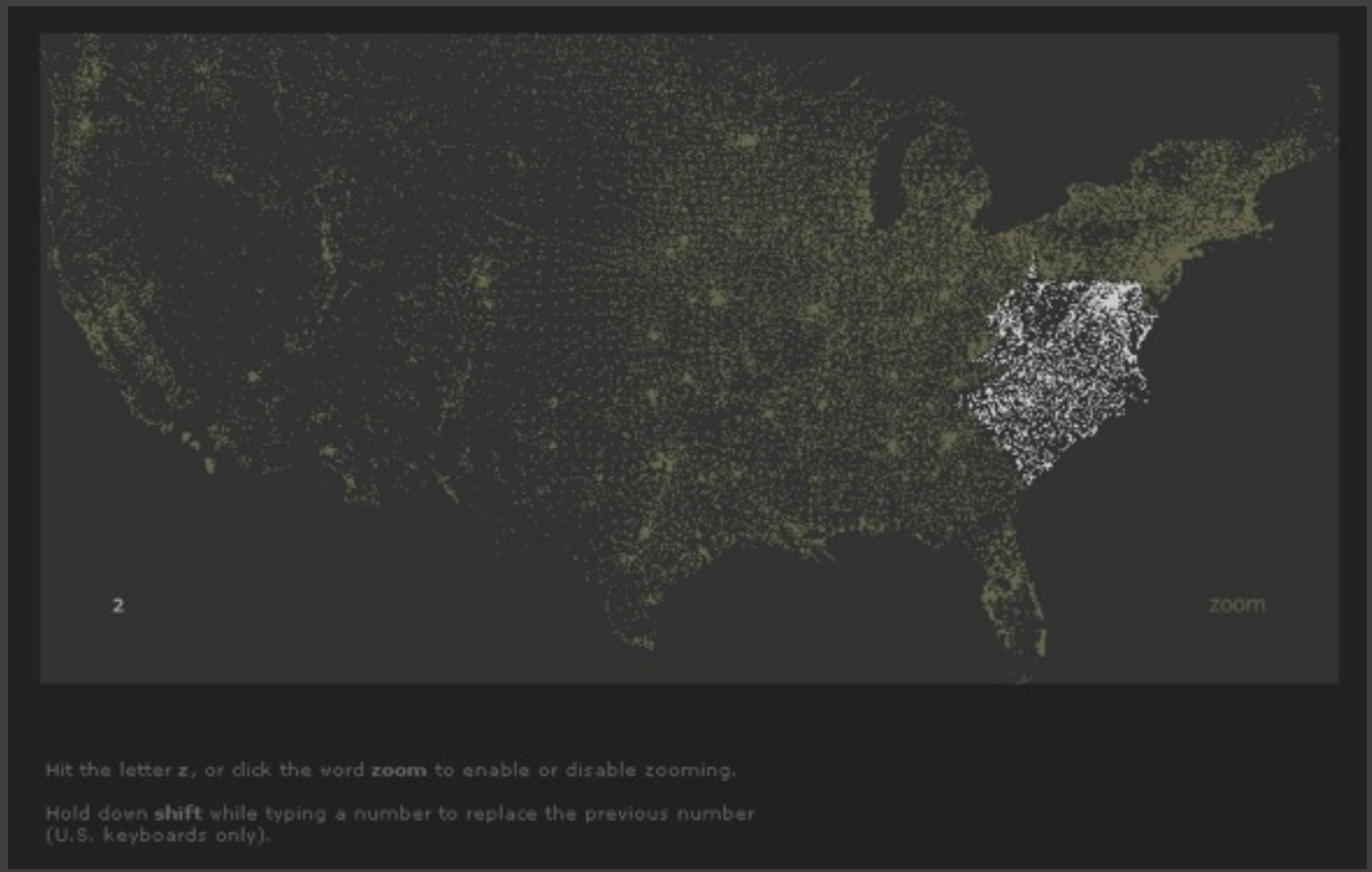
[Ahlberg and Shneiderman 94]

Attribute Explorer [Spence and Tweedie 98]

- Video Clip

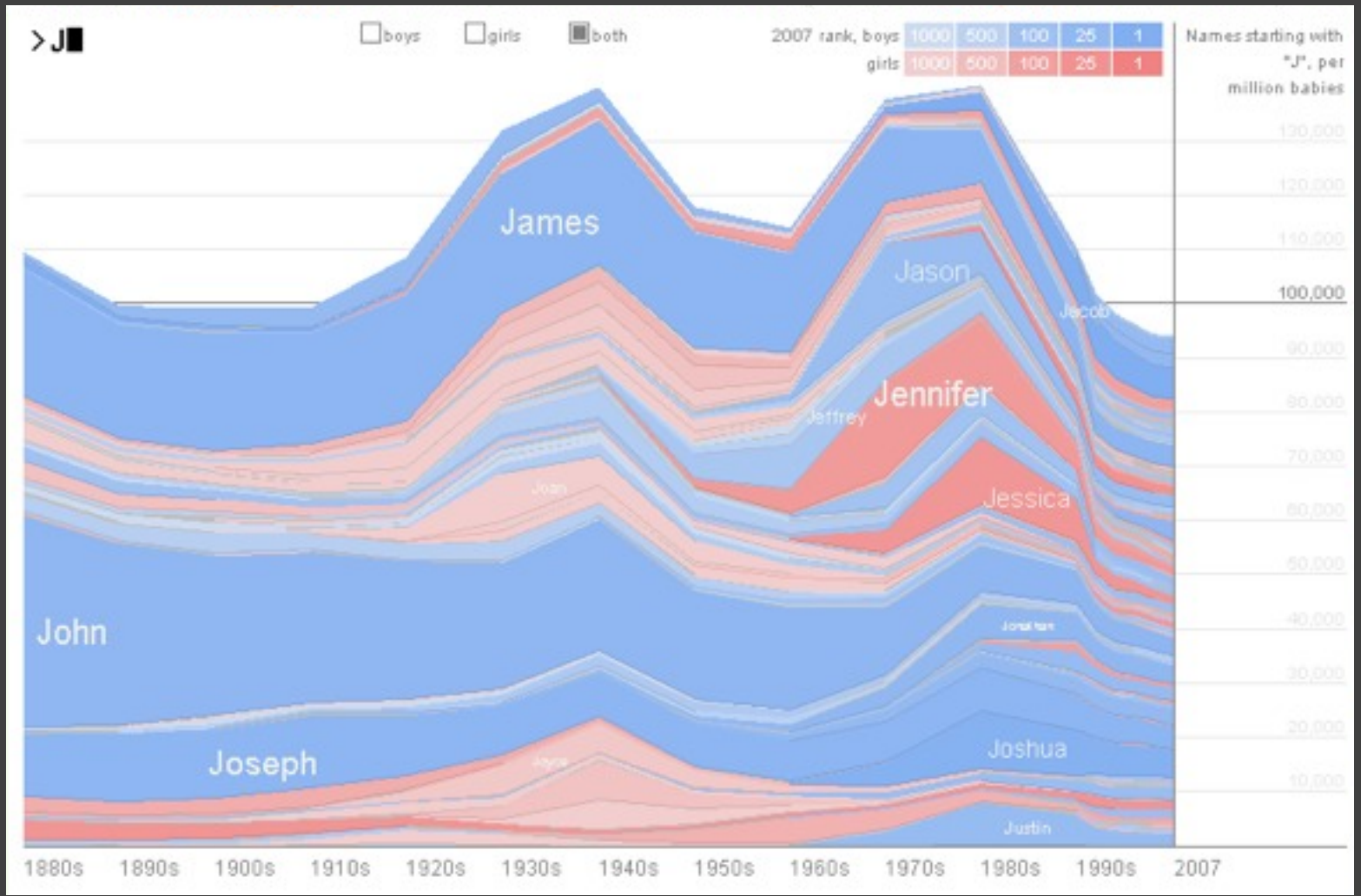
- The Attribute Explorer

Zipdecode [Fry 04]



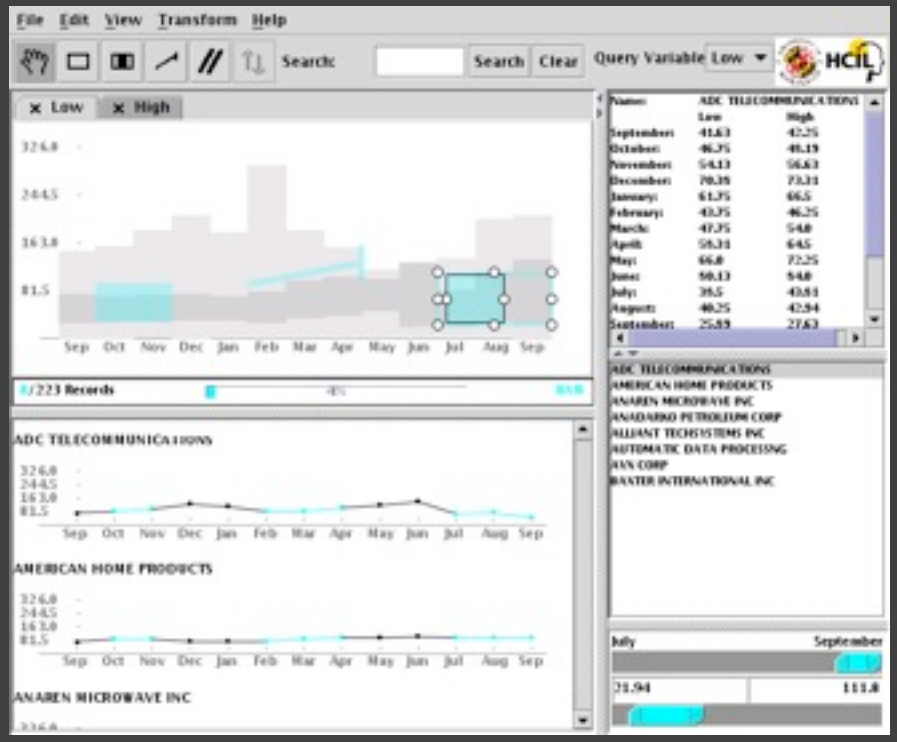
http://benfry.com/zipdecode/

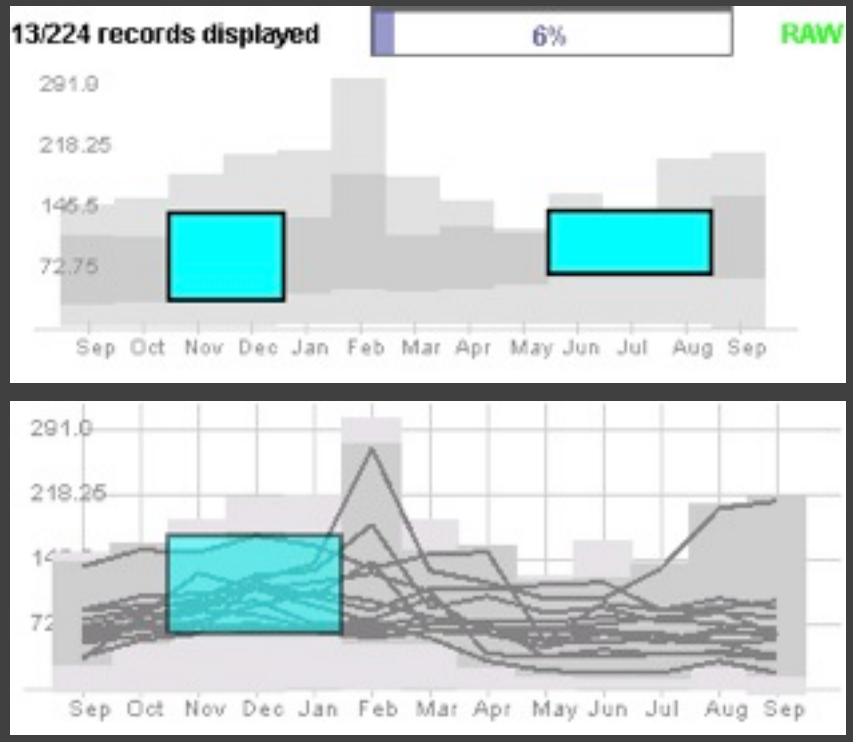
NameVoyager



http://www.babynamewizard.com/voyager

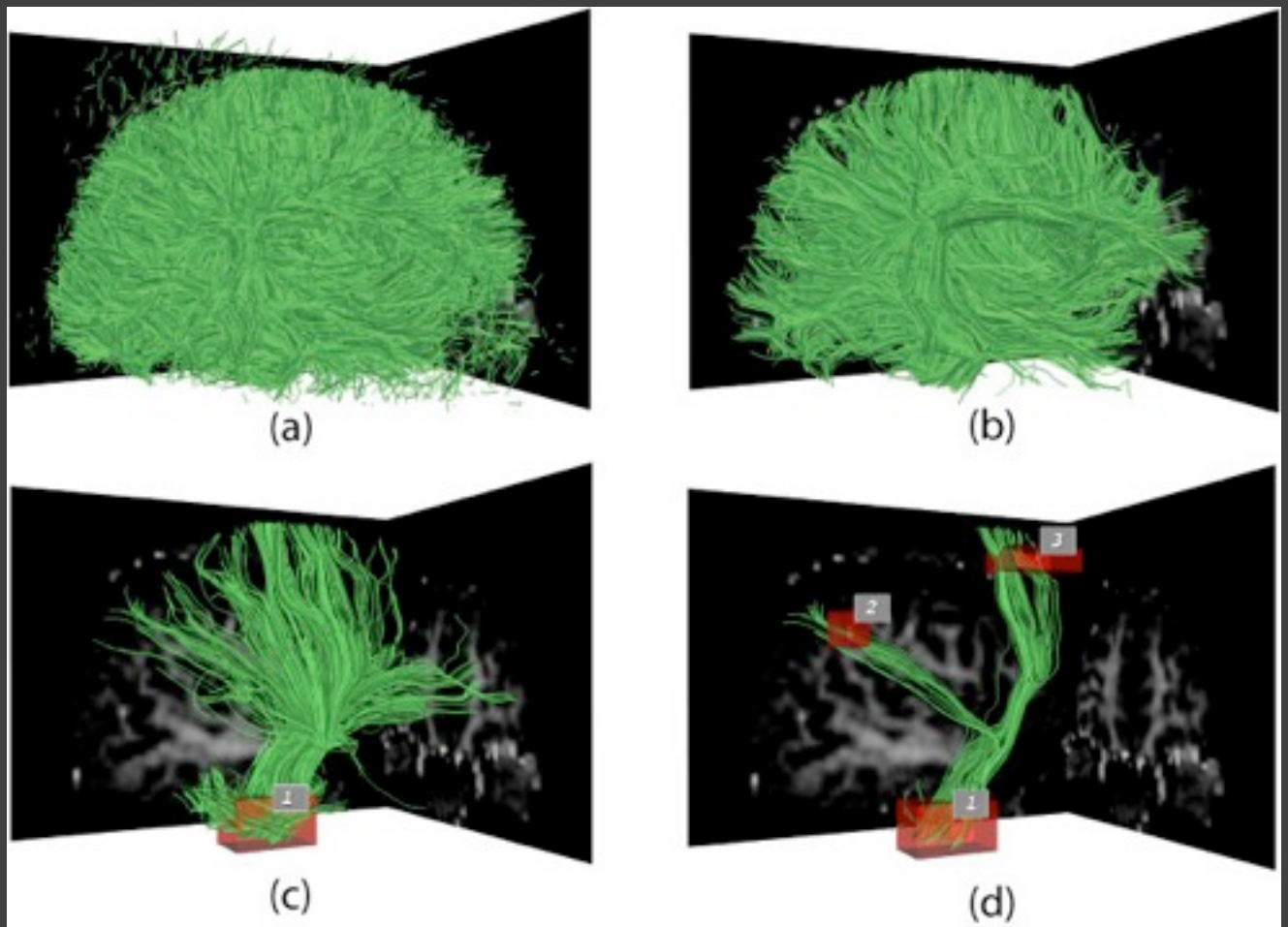
TimeSearcher [Hochheiser & Shneiderman 02]



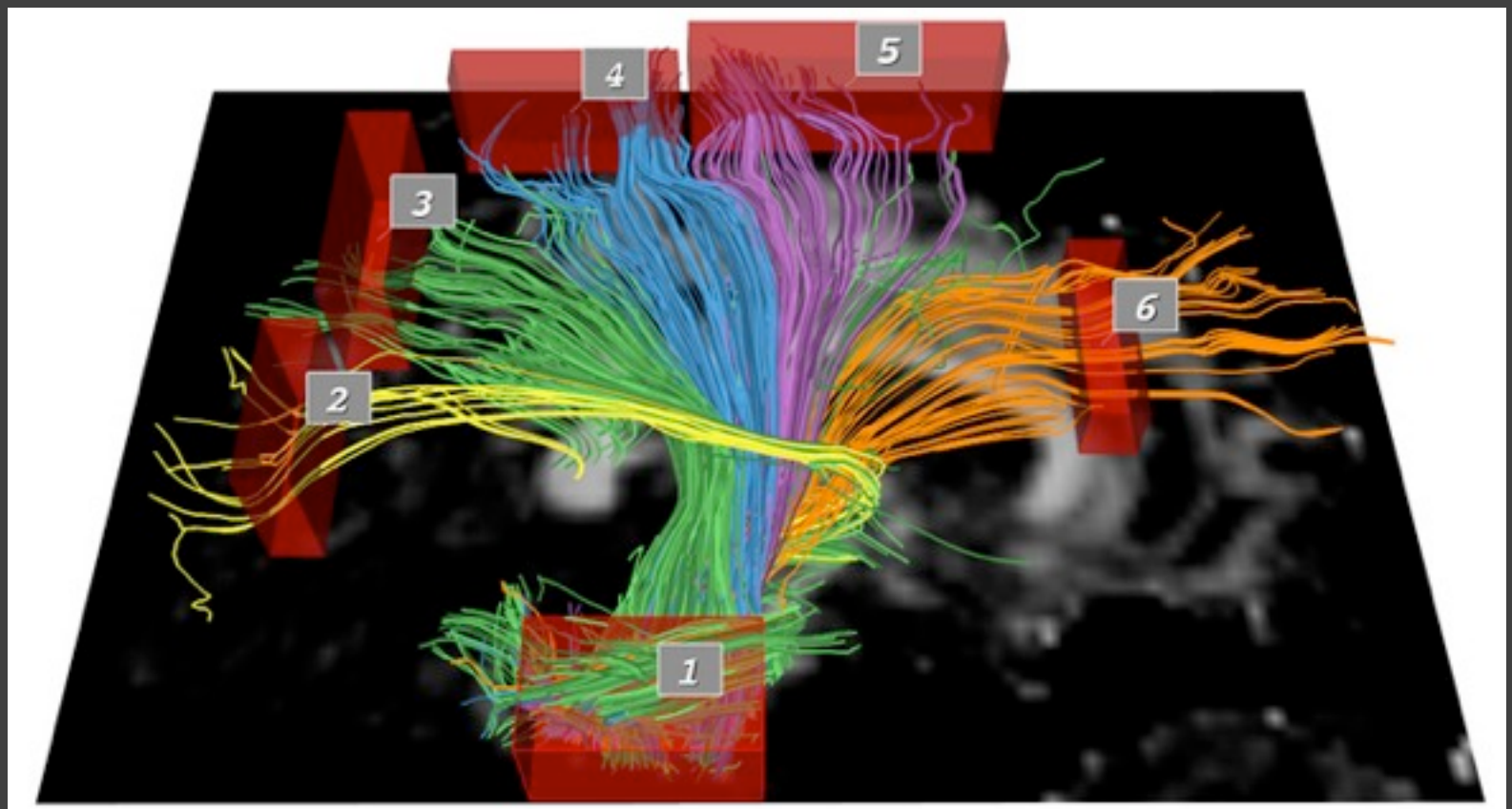


Based on Wattenberg's [2001] idea for sketch-based queries of time-series data.

3D dynamic queries [Akers et al. 04]



3D dynamic queries [Akers et al. 04]



Pros and Cons

Pros

Controls useful for both novices and experts

Quick way to explore data

Cons

Simple queries

Lots of controls

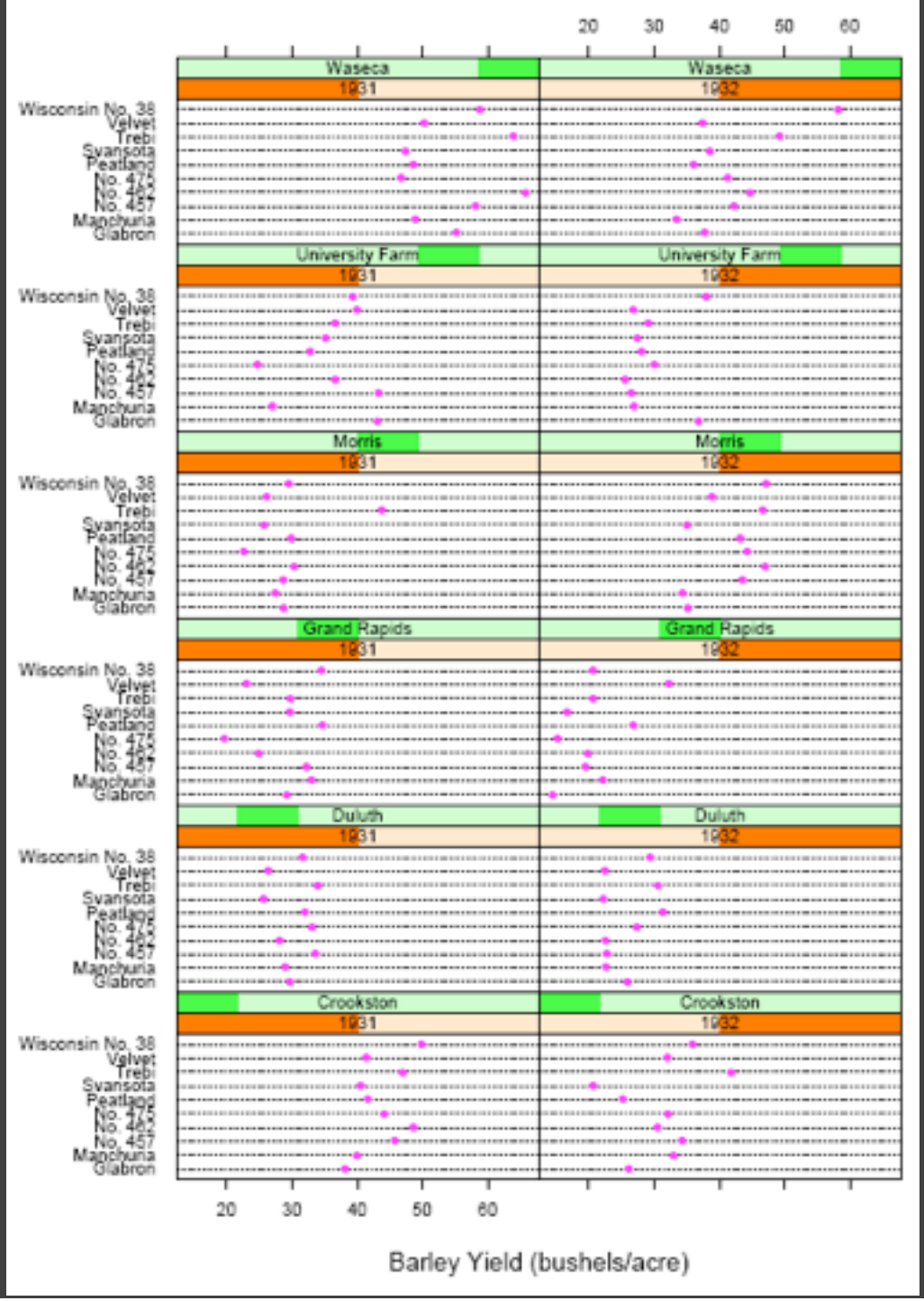
Amount of data shown limited by screen space

Who would use these kinds of tools?

Sorting

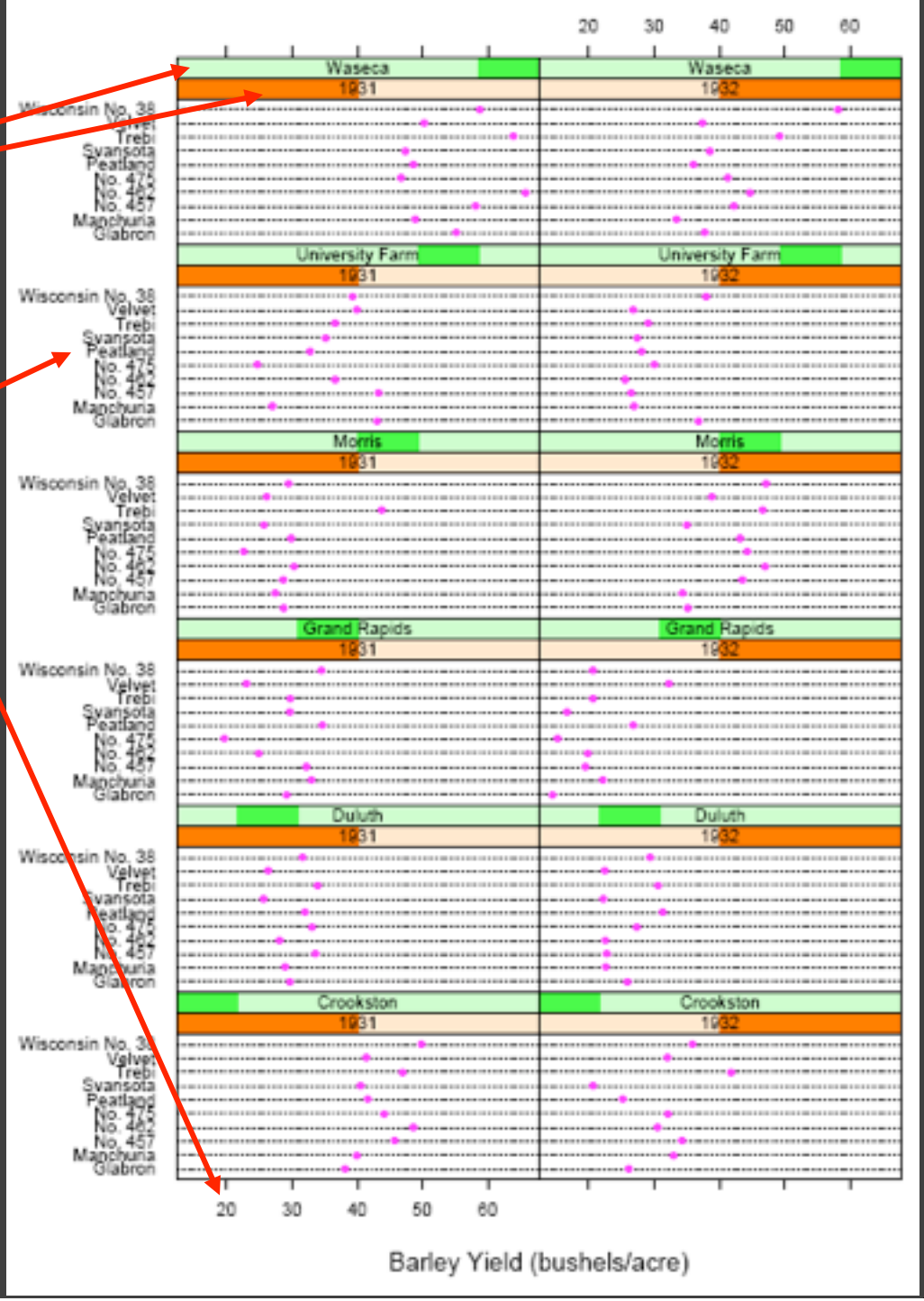
Trellis Display

[Becker, Cleveland, and Shyu 96]



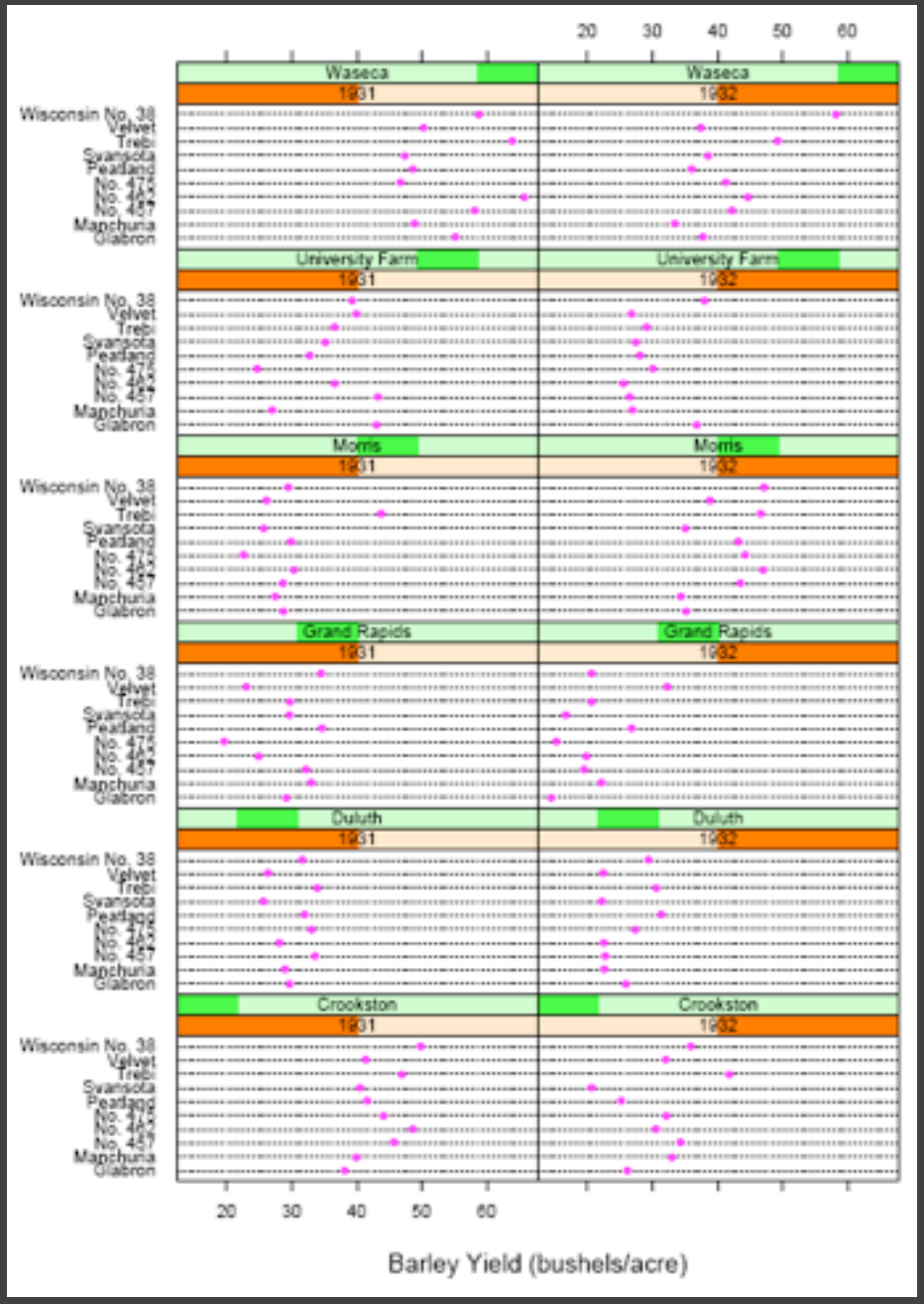
Condition variables
location, year

Panel variables
type, yield

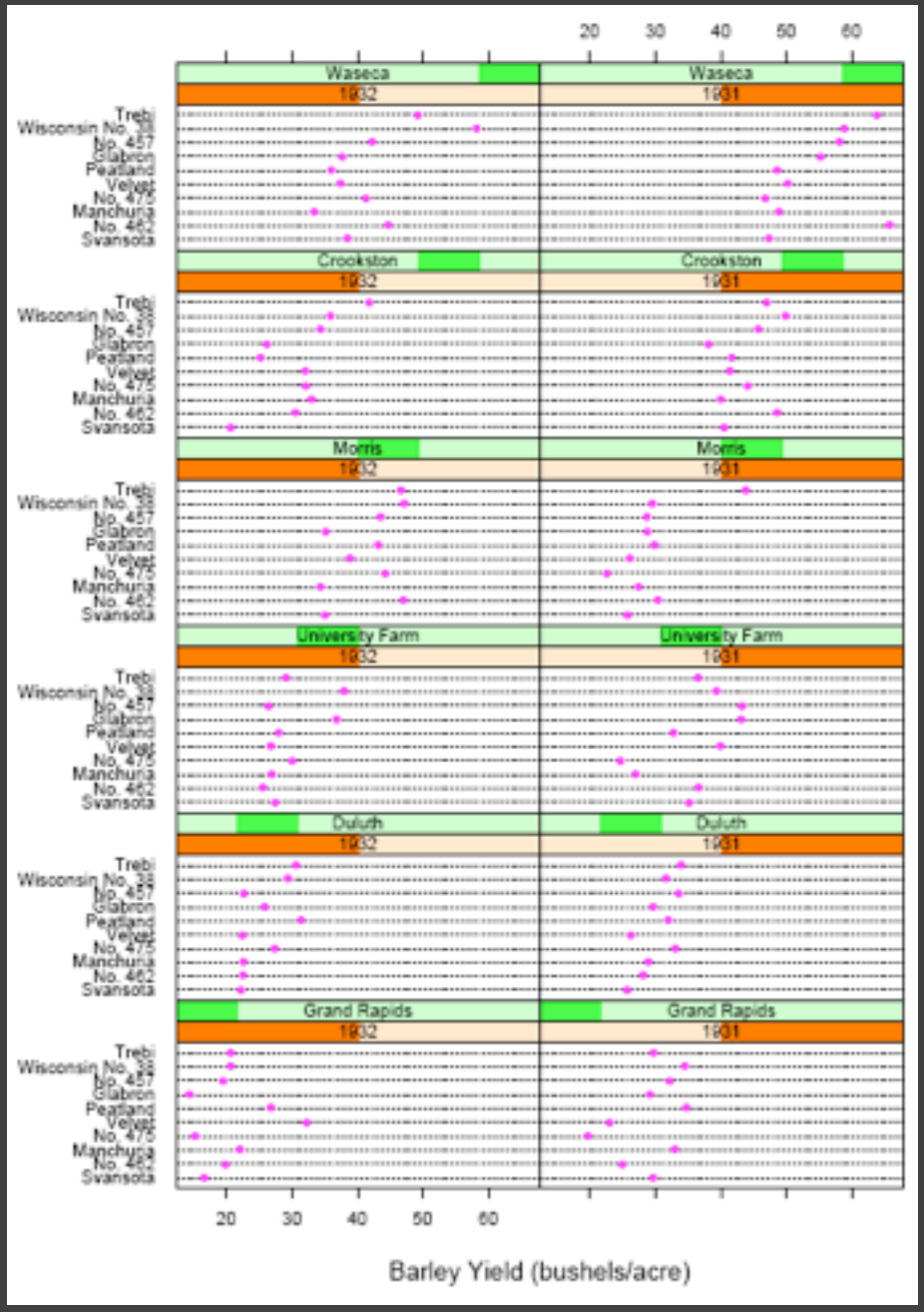


Trellis Display

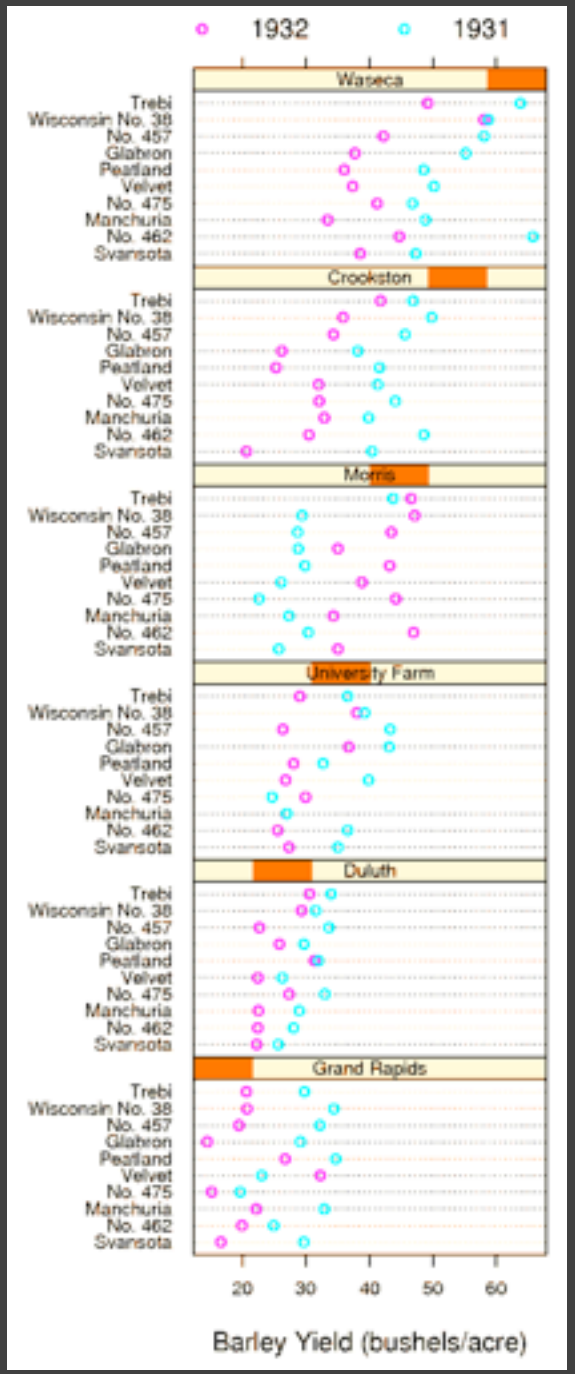
[Becker, Cleveland, and Shyu 96]

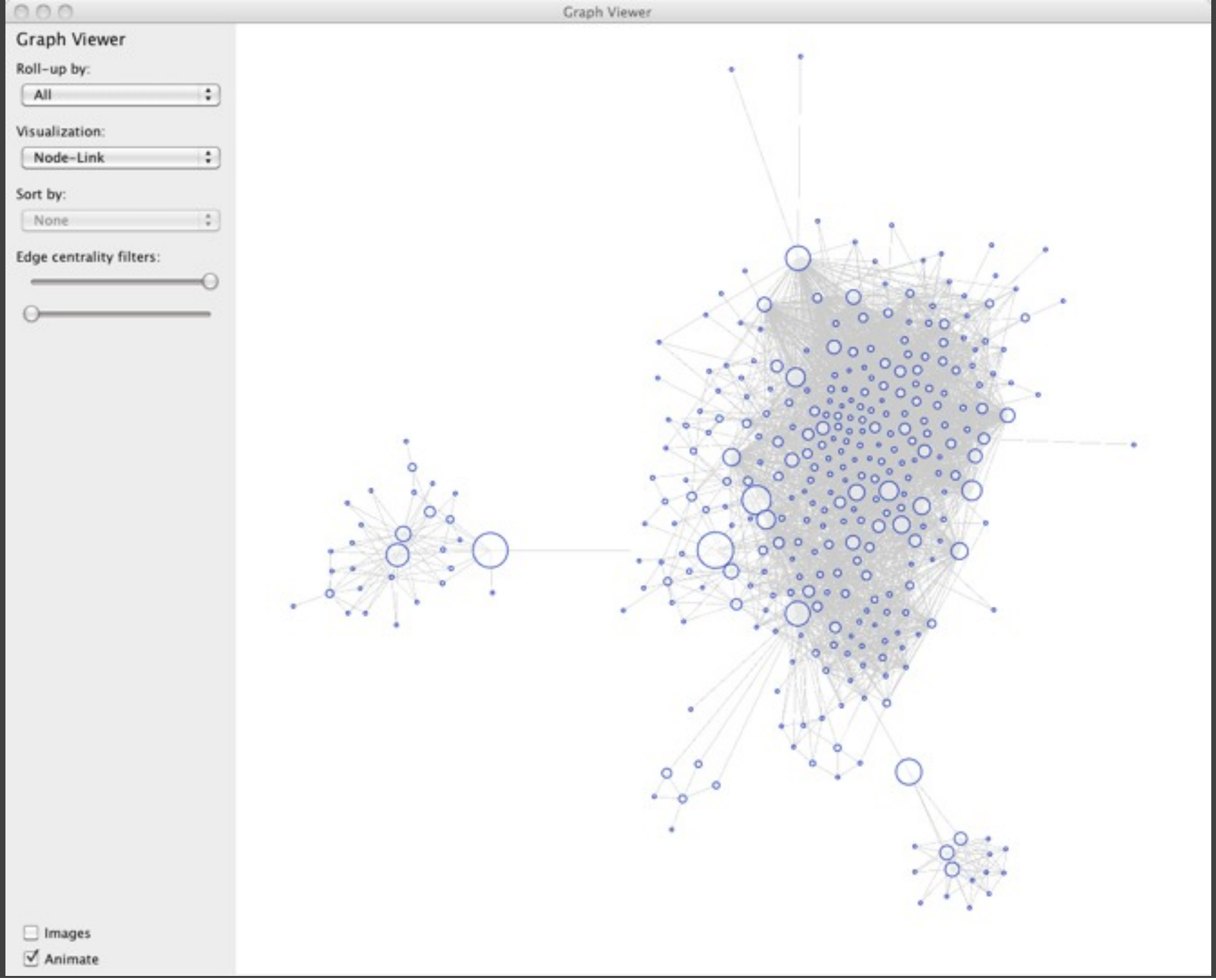


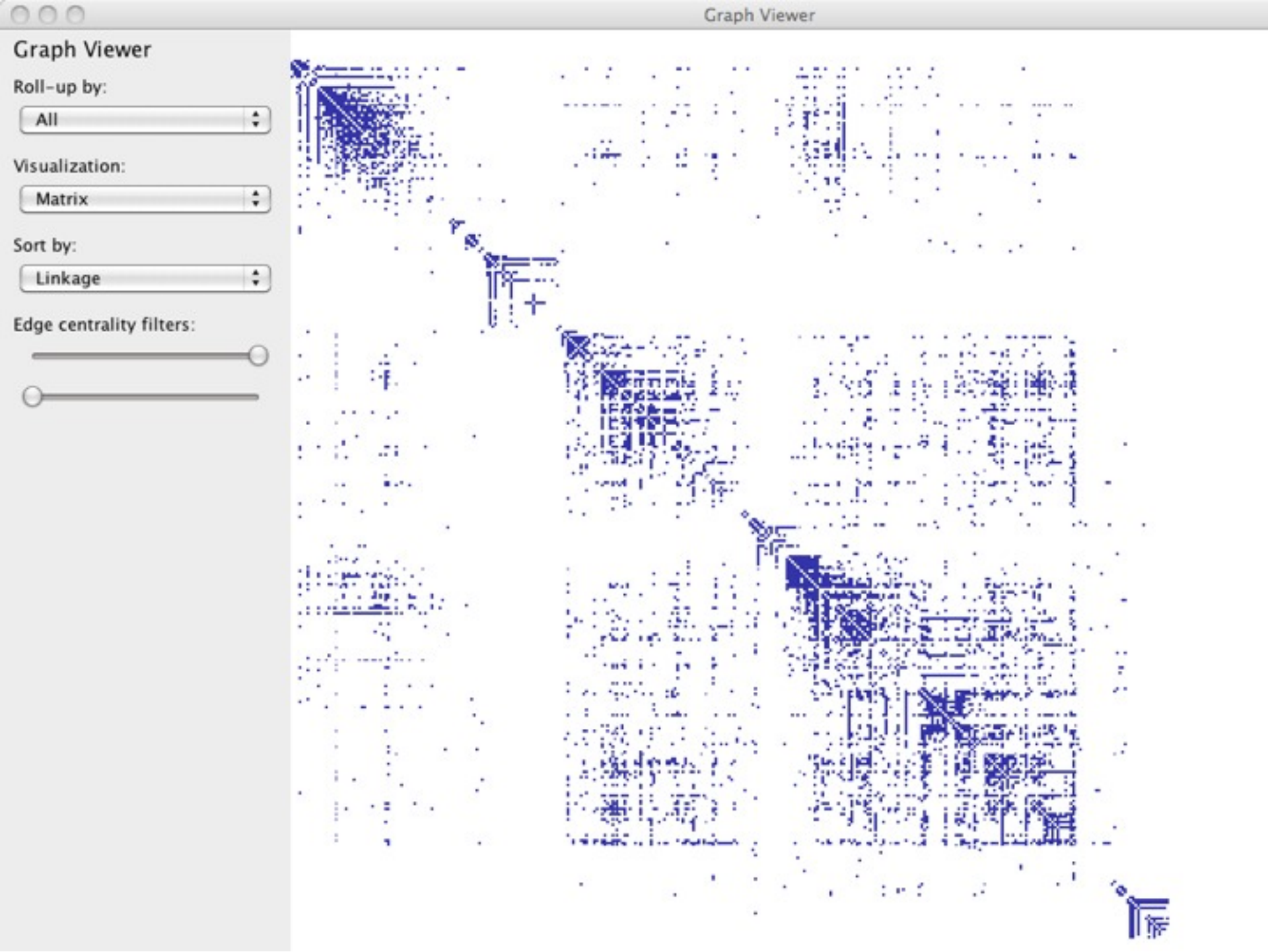
Alphabetical ordering



Main-effects ordering


1932
1931
Waseca
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
Crookston
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
Morris
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
University Farm
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
Duluth
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
Grand Rapids
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
20
30
40
50
60
Barley Yield (bushels/acre)


Graph Viewer
Graph Viewer
Roll-up by:
All
Visualization:
Node-Link
Sort by:
None
Edge centrality filters:
Images
Animate


Graph Viewer
Graph Viewer
Roll-up by:
All
Visualization:
Matrix
Sort by:
Linkage
Edge centrality filters:

Graph Viewer

Graph Viewer

Roll-up by:

All

Visualization:

Matrix

Sort by:

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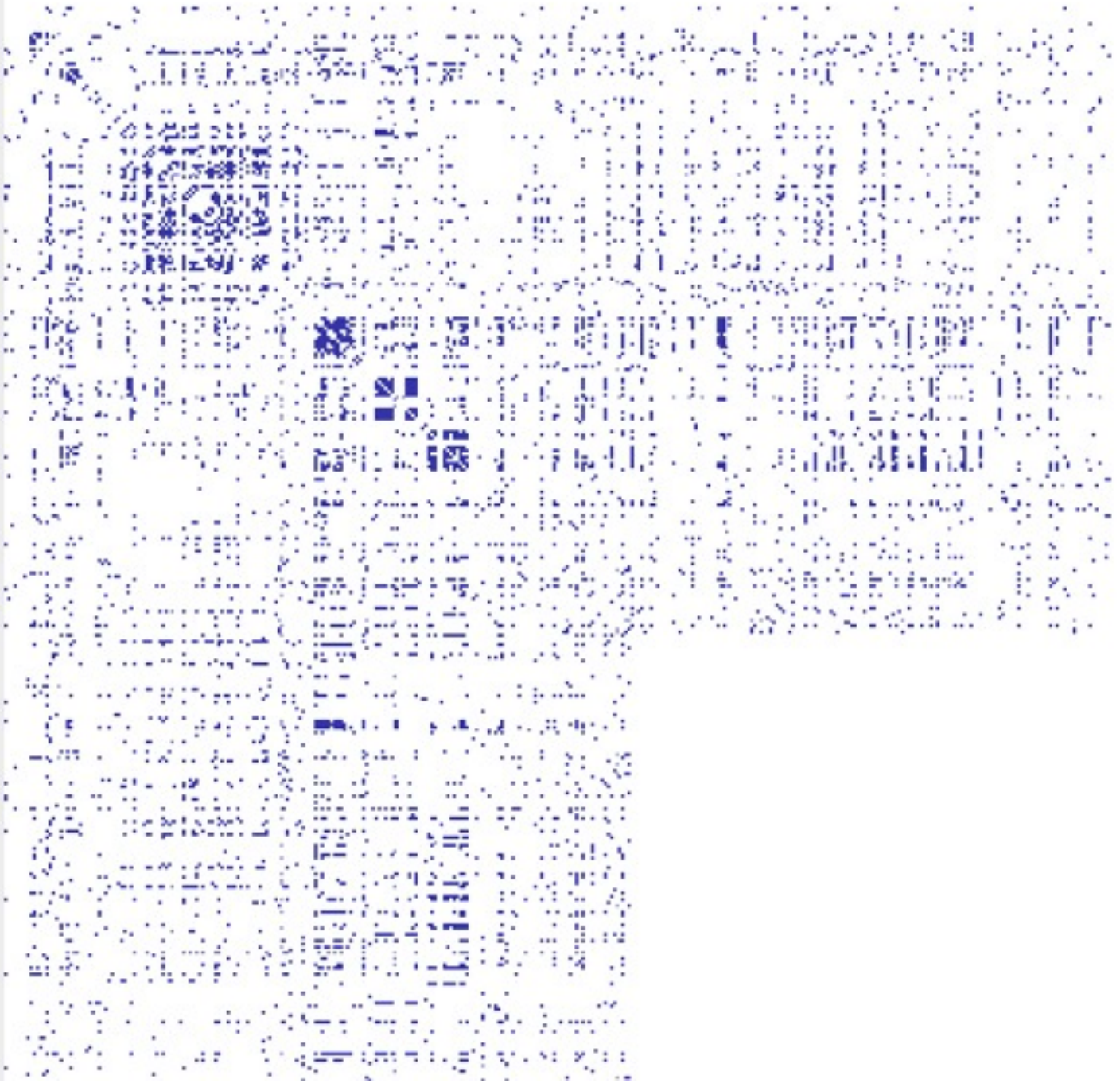
Edge centrality filters:



Administrivia

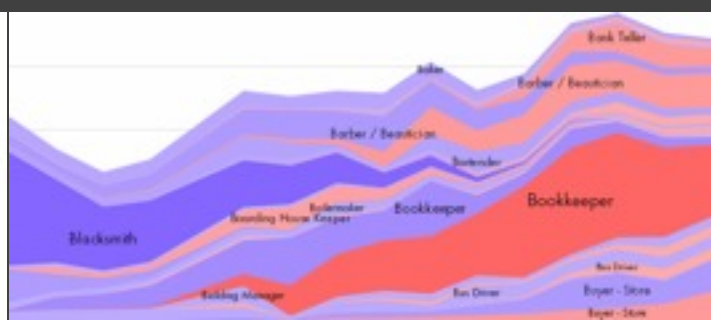
A3: Interactive Visualization

Create an interactive visualization application. Choose a data domain and select an appropriate visualization technique.

1. Choose a data set and storyboard your interface
2. Implement the interface using tools of your choice
3. Submit your application and produce a final write-up

You should work in groups of 2.

Due by *5pm* on **Monday, February 10**

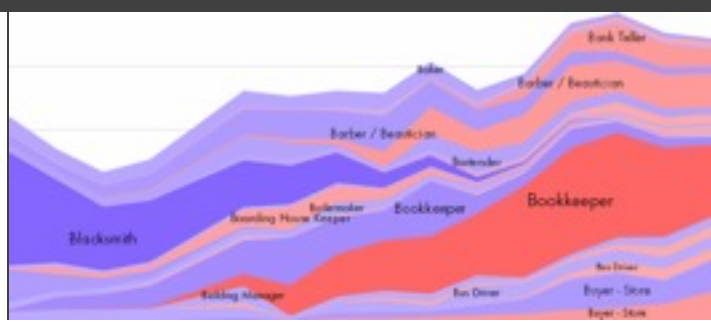


Assignment 3: Project Partners

For A3, you should work in **groups of 2**.

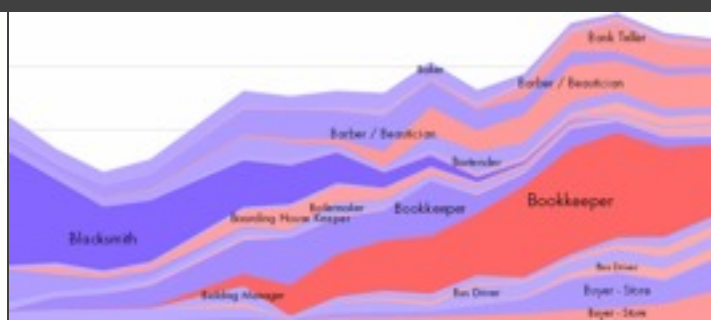
If you do not have a partner, you should

1) Use the facilities on Piazza
2) Stay after class to meet potential partners



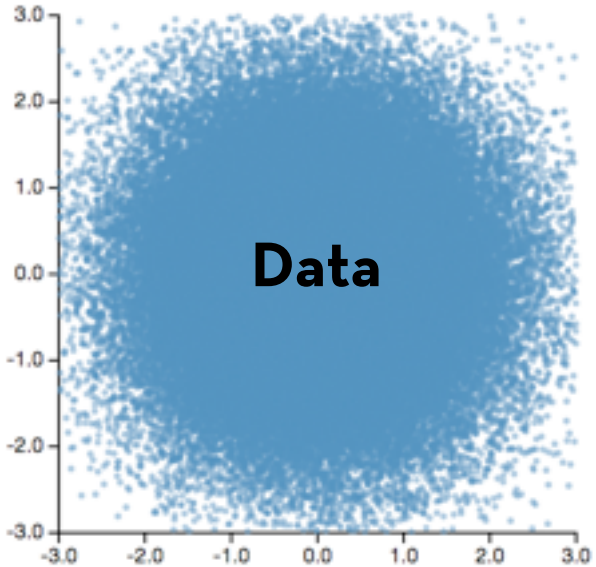
Assignment 3 Tips

1) **Start now**. It will take longer than you think.
2) **Keep it simple**. (Eschew the kitchen sink.) Choose the minimal set of interactions that enables users to explore and generate interesting insights. Keep the design clean.
3) **Promote engagement**. How do your chosen interactions reveal interesting observations?



imMens

How can we visualize and interact with **billion+ record** databases in real-time?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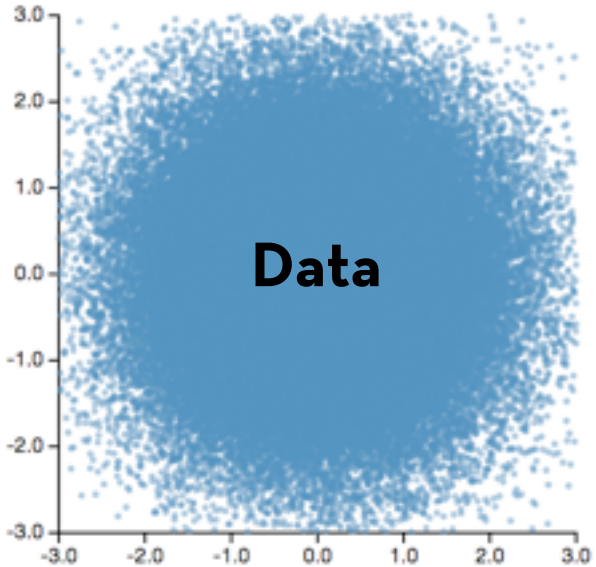
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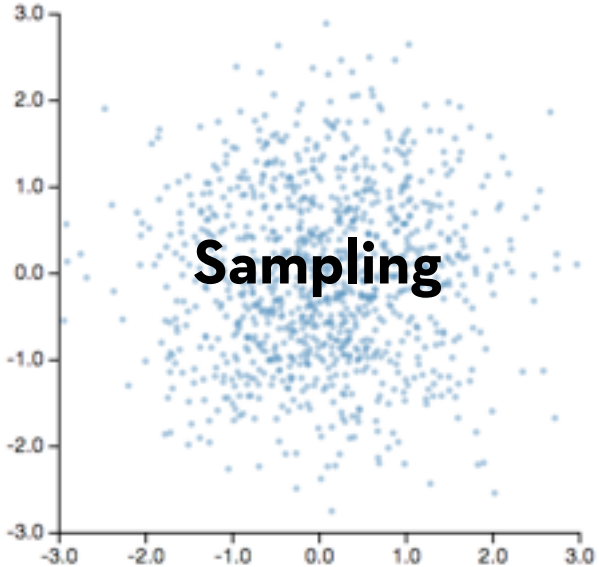
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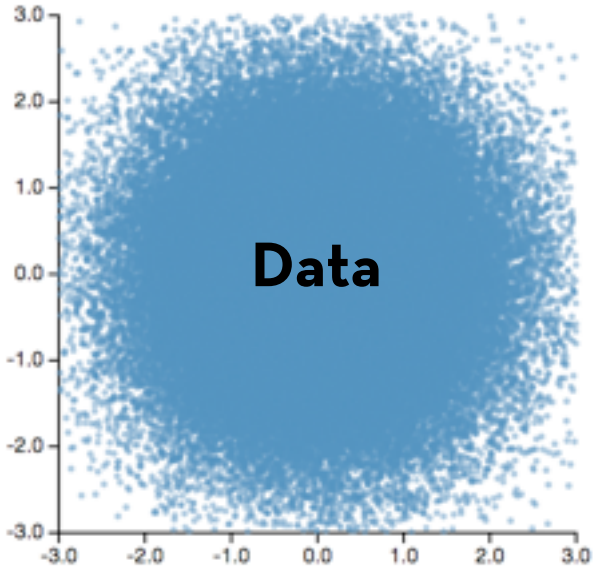
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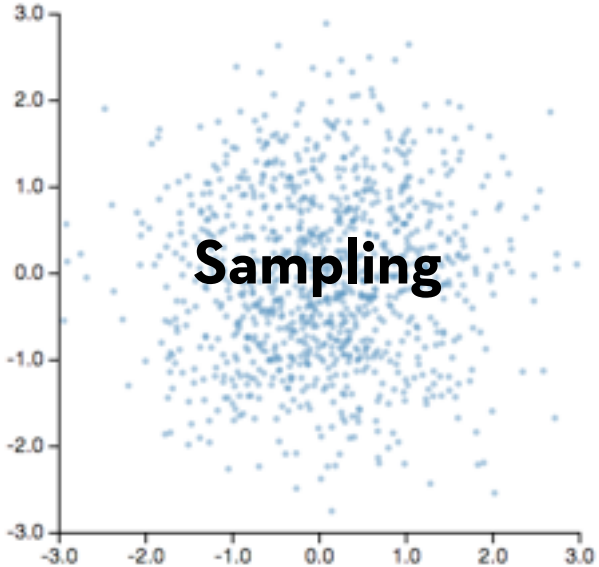
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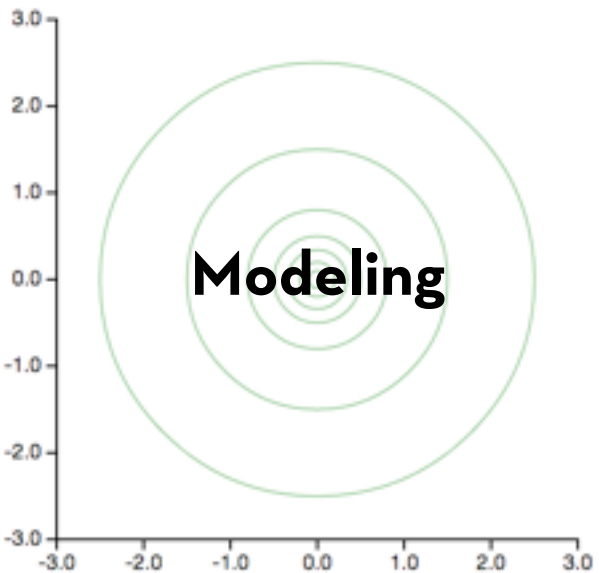
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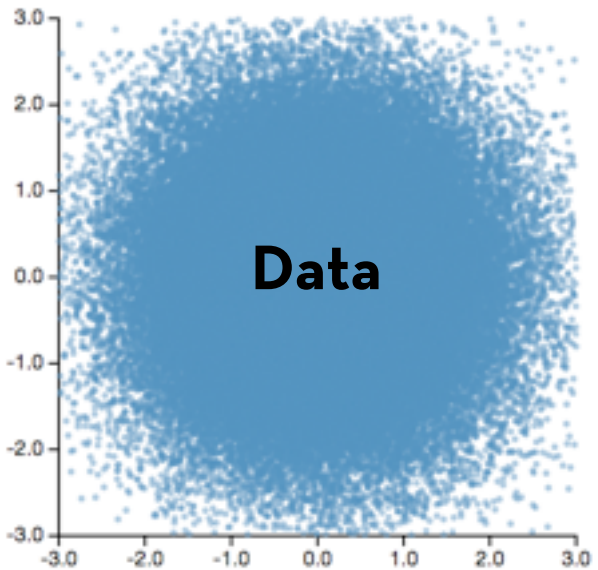
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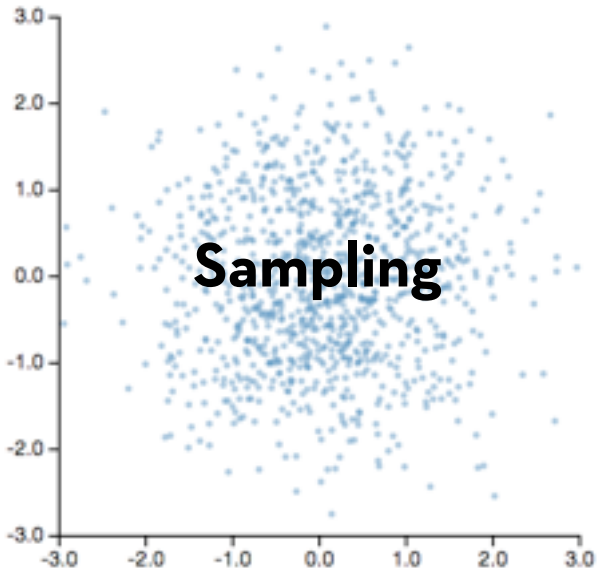
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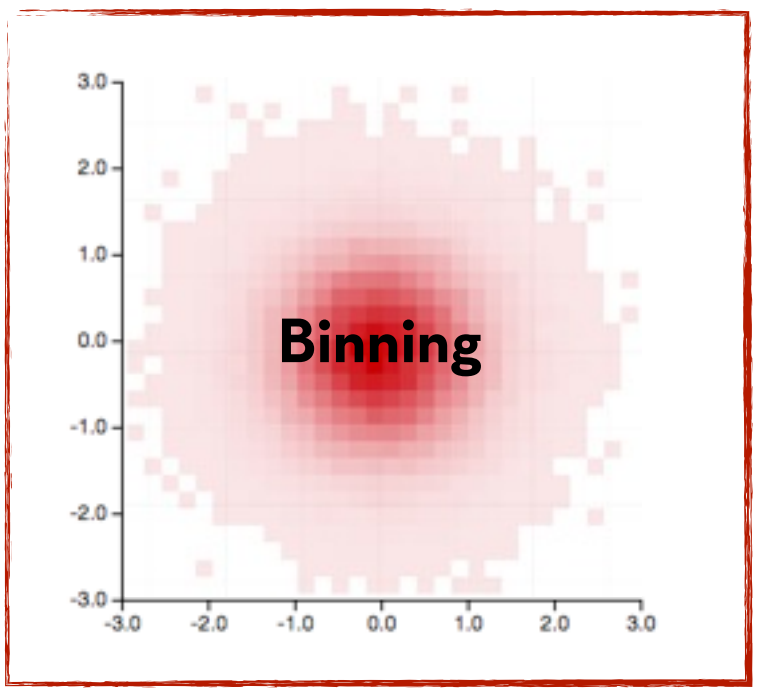
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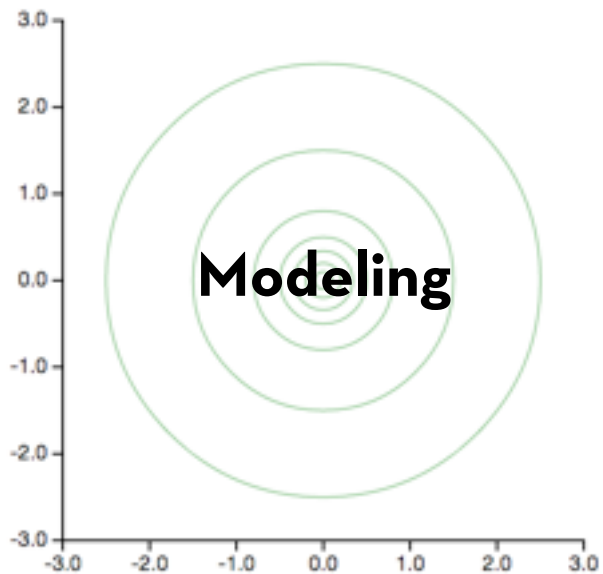
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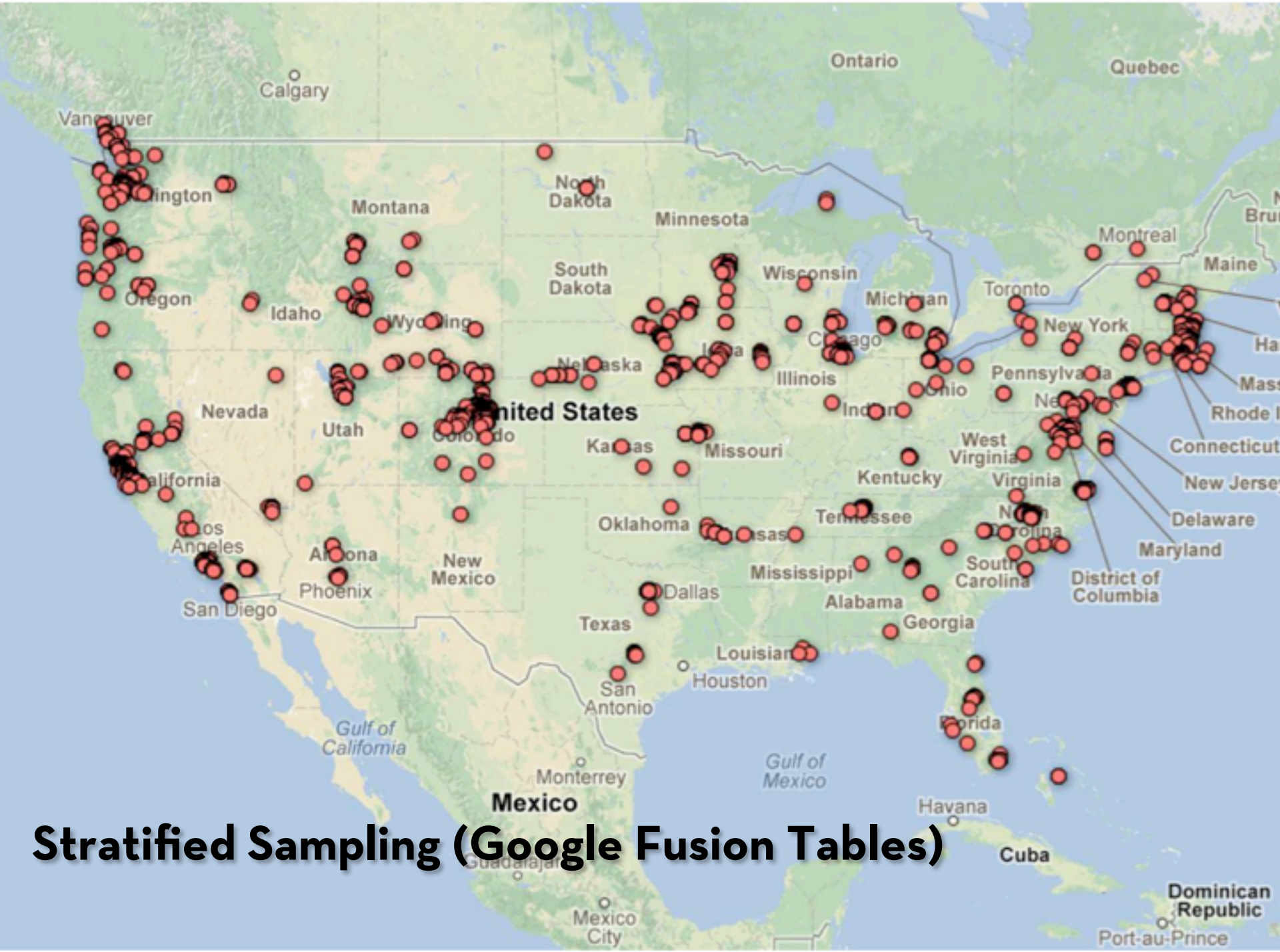
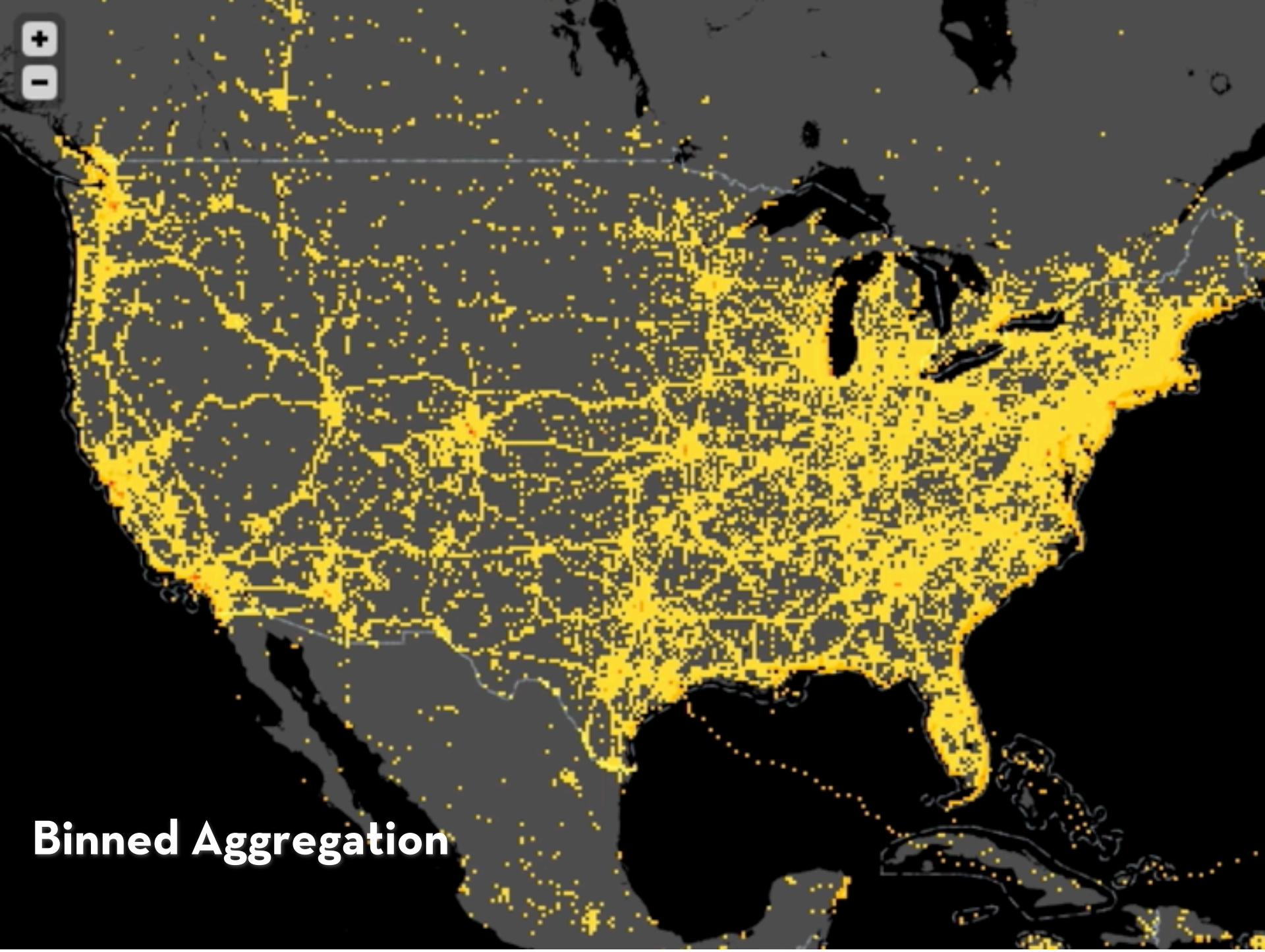
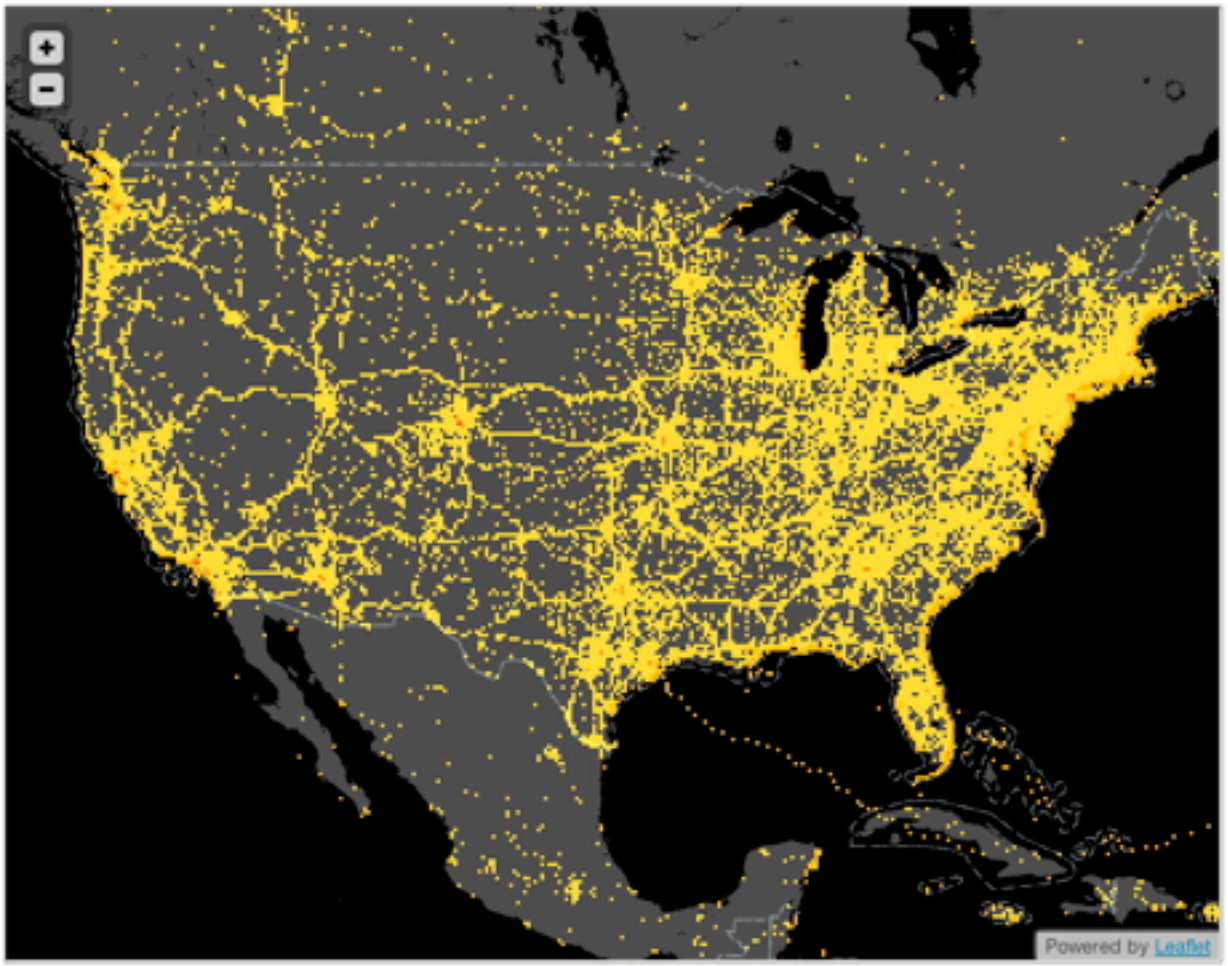
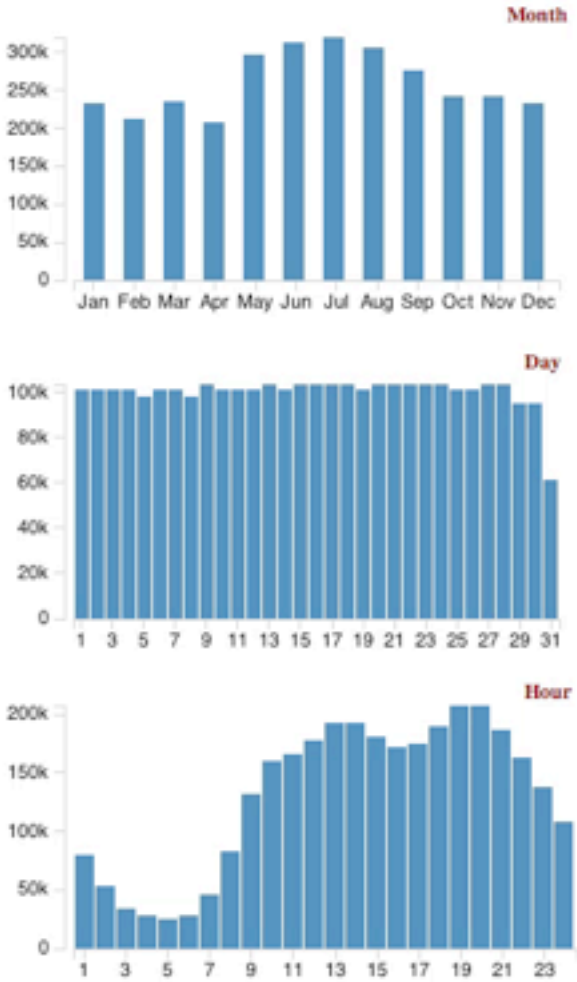


Stratified Sampling (Google Fusion Tables)


Binned Aggregation





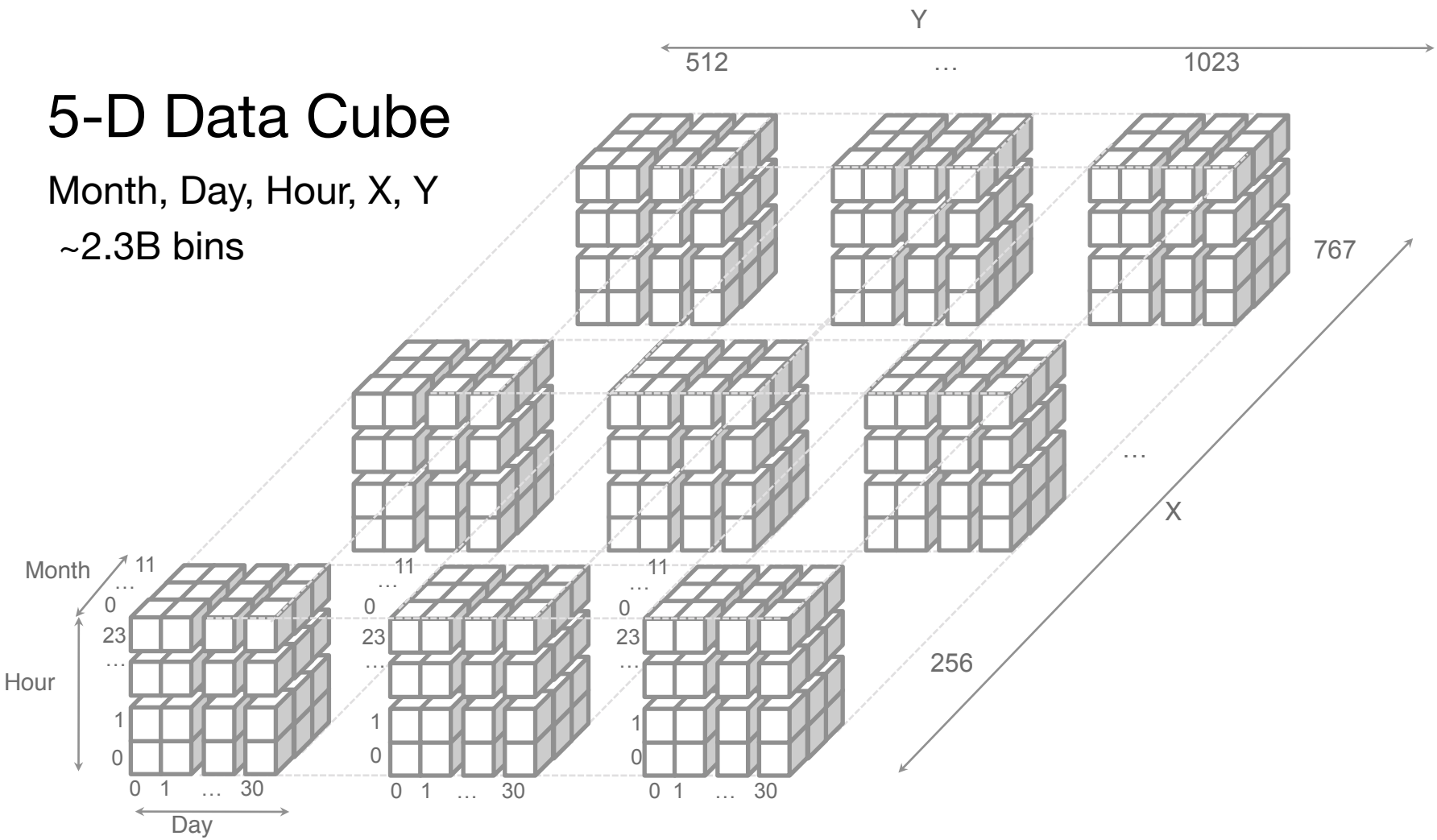
imMens: Real-Time Visual Querying of Big Data

with Zhicheng (Leo) Liu & Biye Jiang

5-D Data Cube

Month, Day, Hour, X, Y

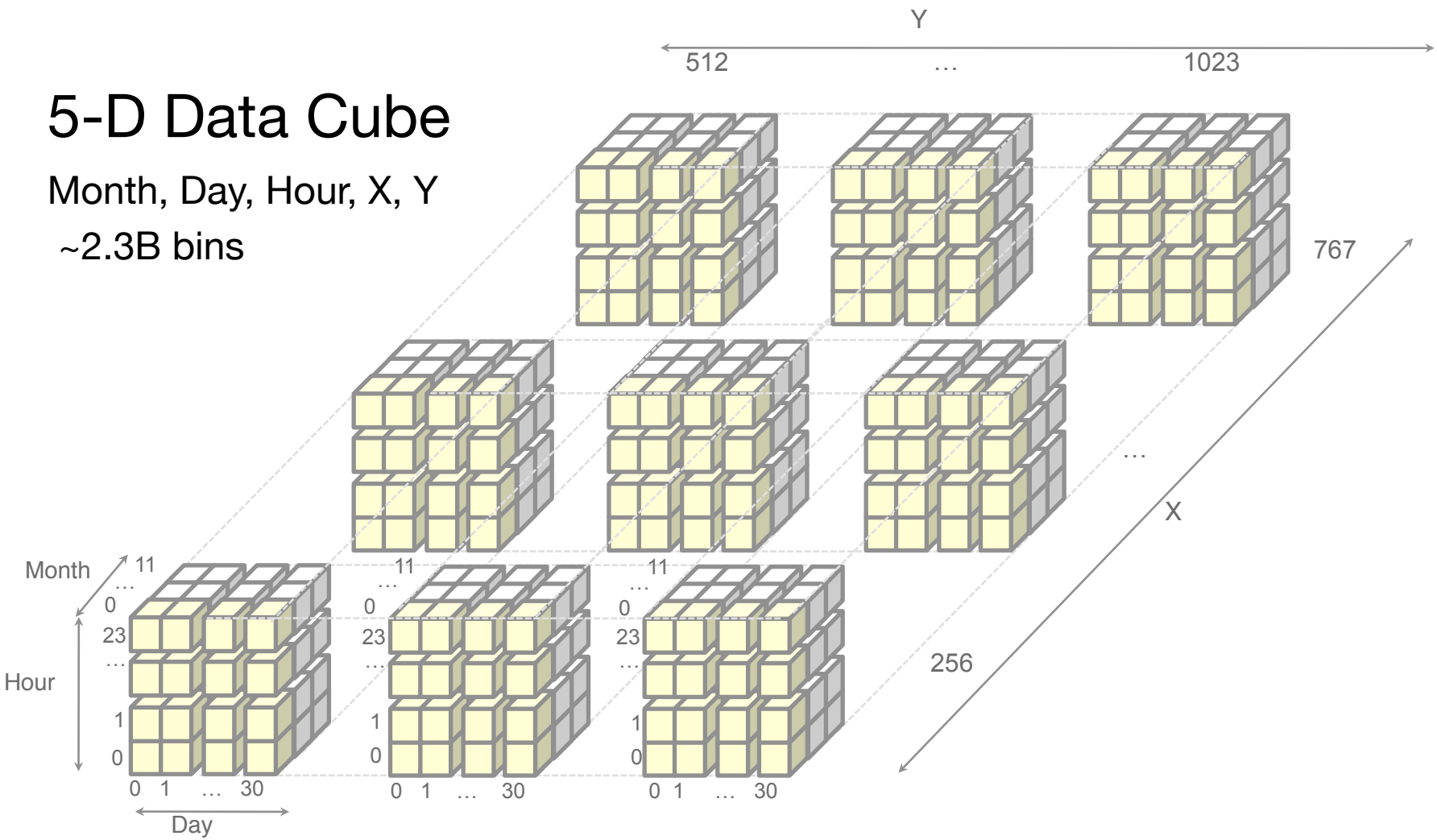
~2.3B bins

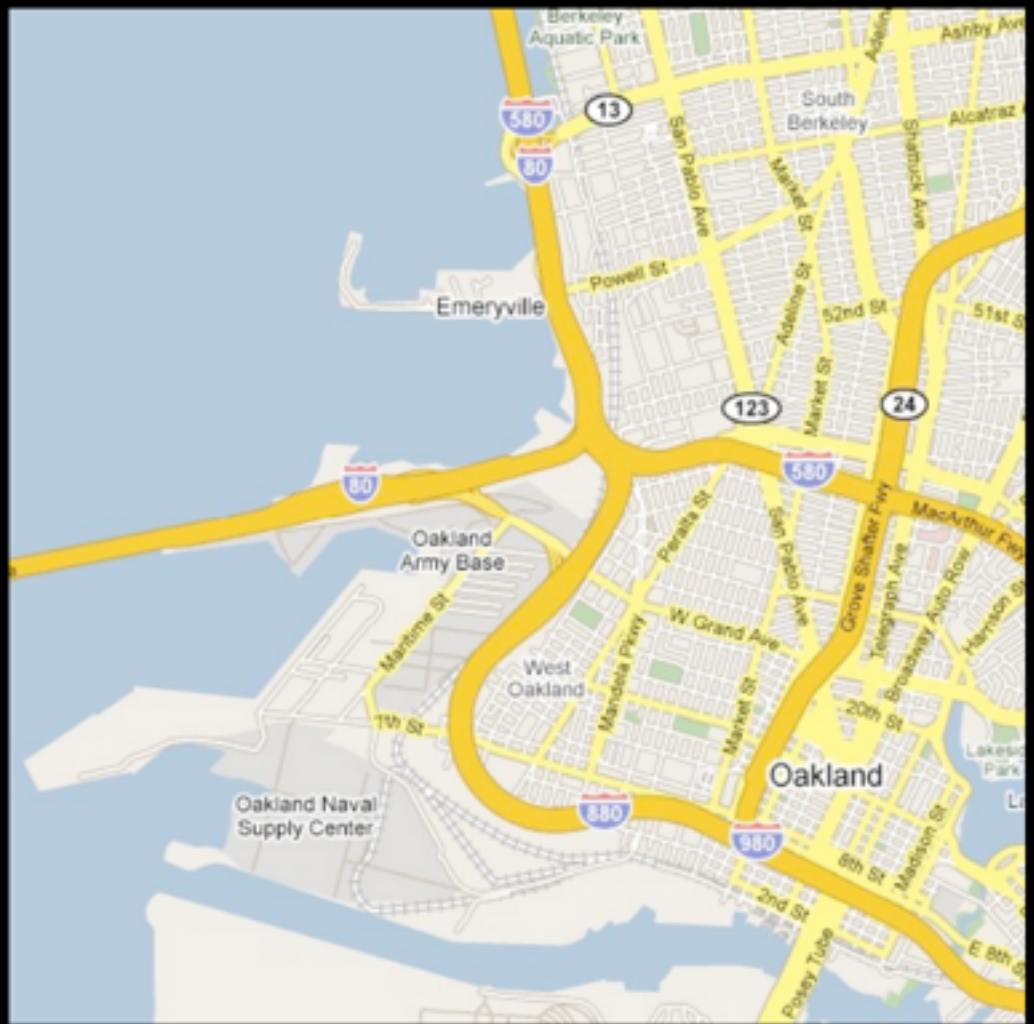


5-D Data Cube

Month, Day, Hour, X, Y

~2.3B bins

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South Berkeley
Alcatraz
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51st St
123
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Market St
580
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MacArthur Fwy
Oakland Army Base
Peralta St
San Pablo Ave
Grove Shafter Fwy
Telegraph Ave
Broadway Auto Row
Harrison St
Maritime St
W Grand Ave
West Oakland
Mandela Pkwy
20th St
7th St
Market St
Oakland
Oakland Naval Supply Center
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6th St
Madison St
2nd St
E 8th St
Posey Tube


Emeryv
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Berkeley
Aquatic Park
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Oakland
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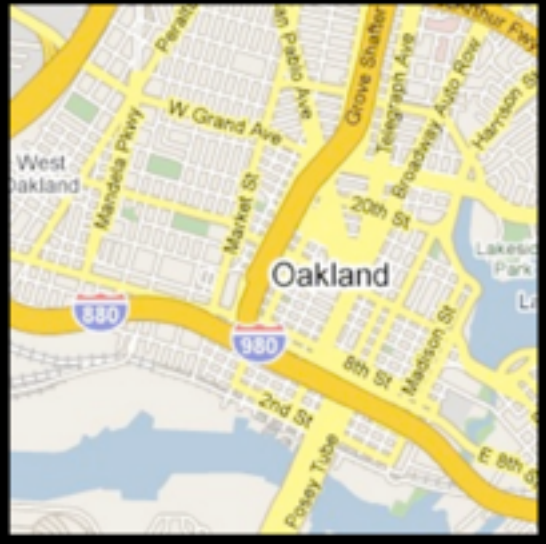
Supply Center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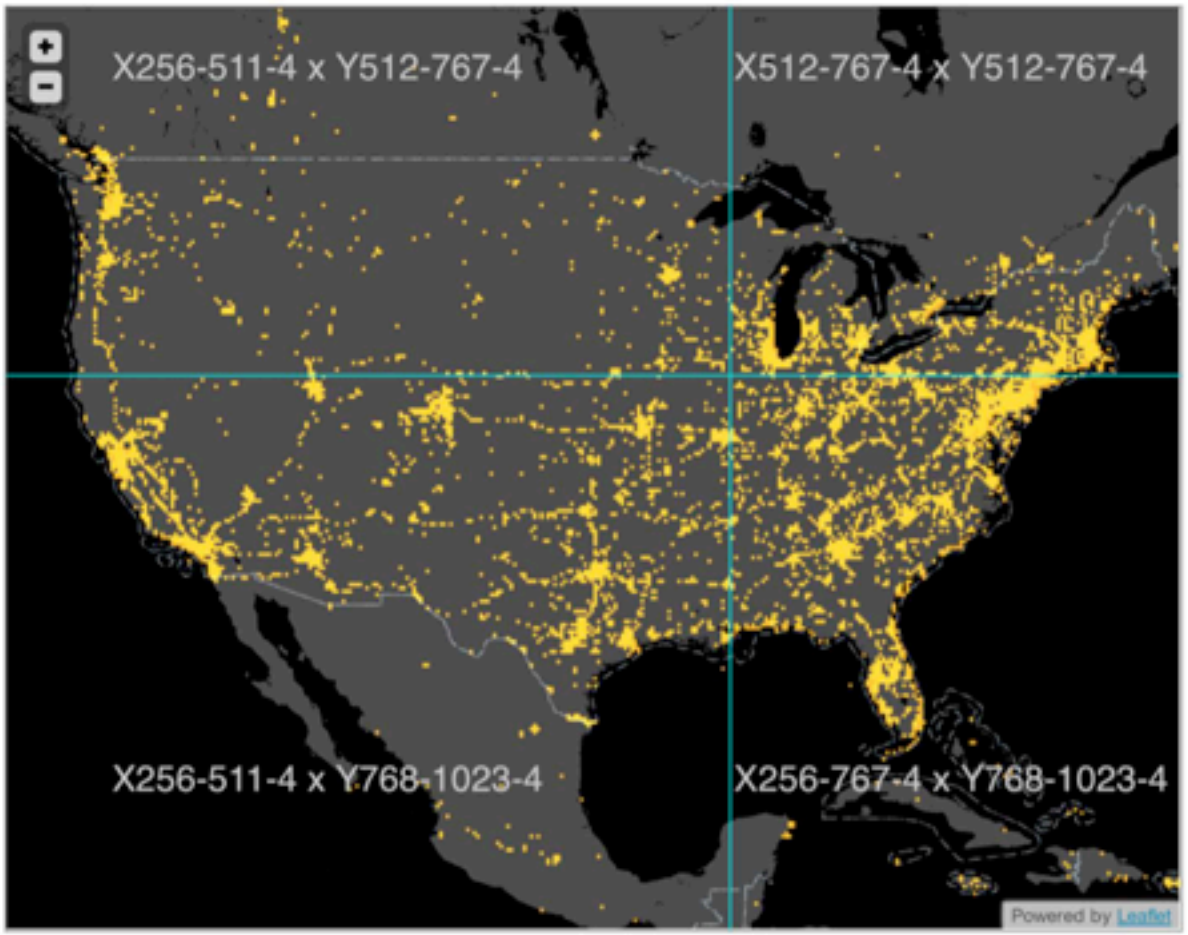
8th St
Madison St
2nd St
E 8th St
Posey Tube

Multivariate Data Tiles

1. Send data, not pixels
2. Embed multi-dim data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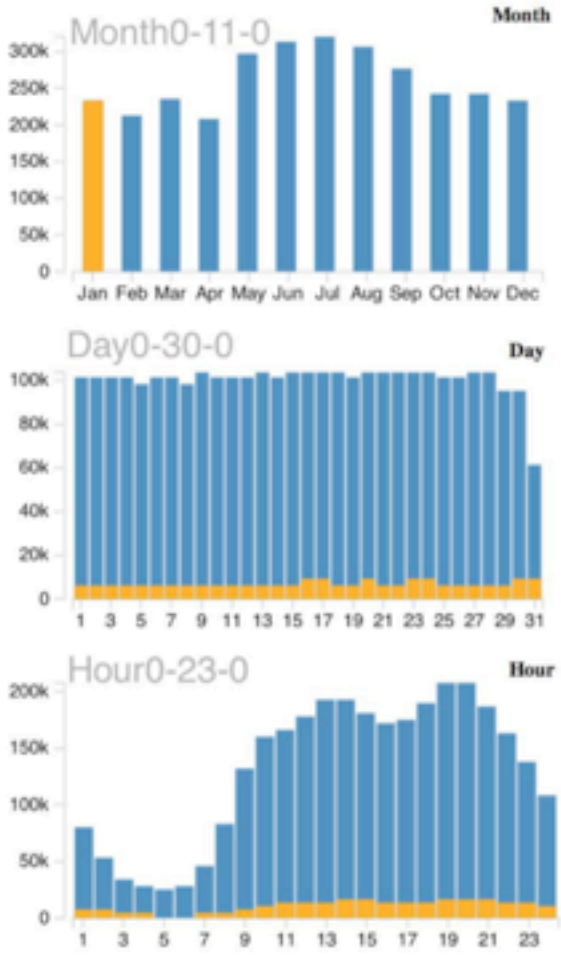
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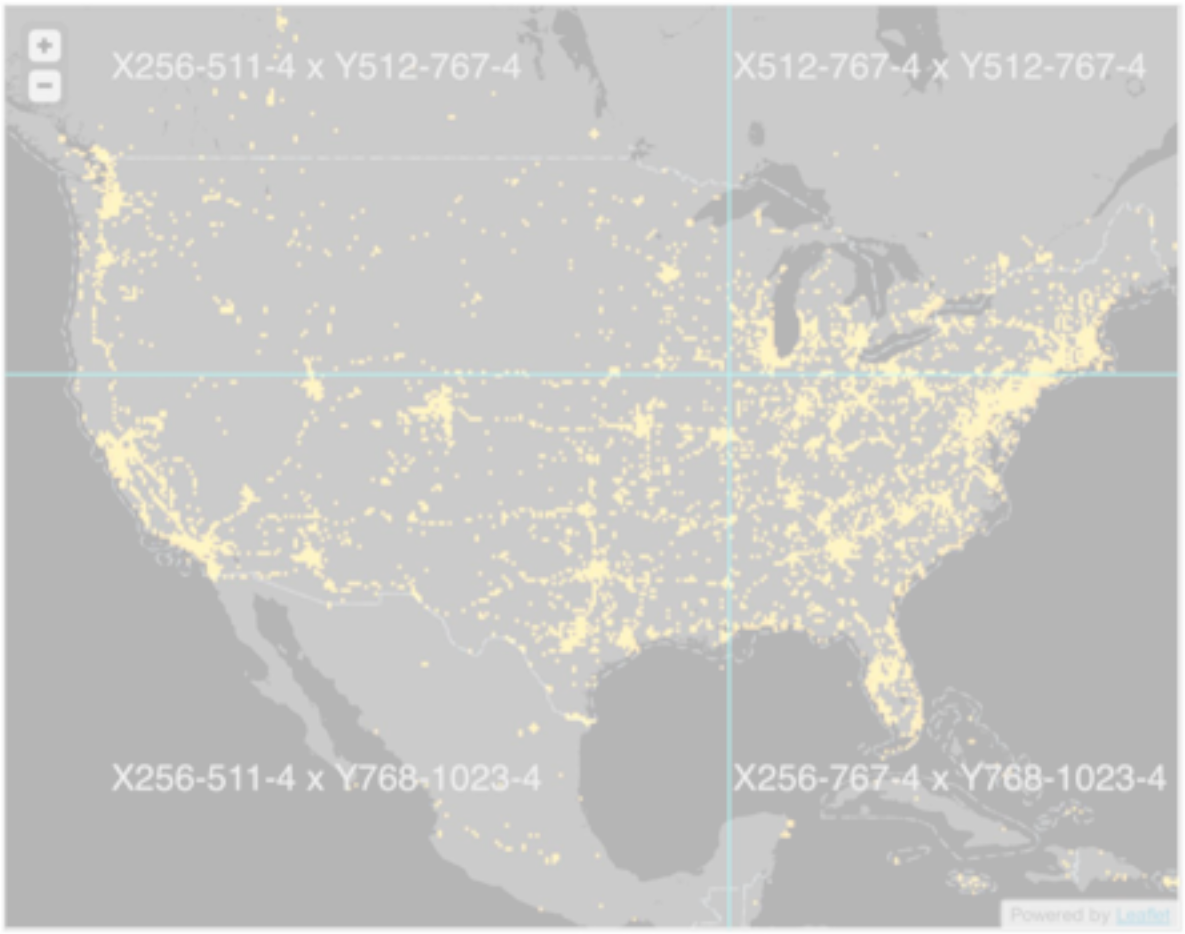
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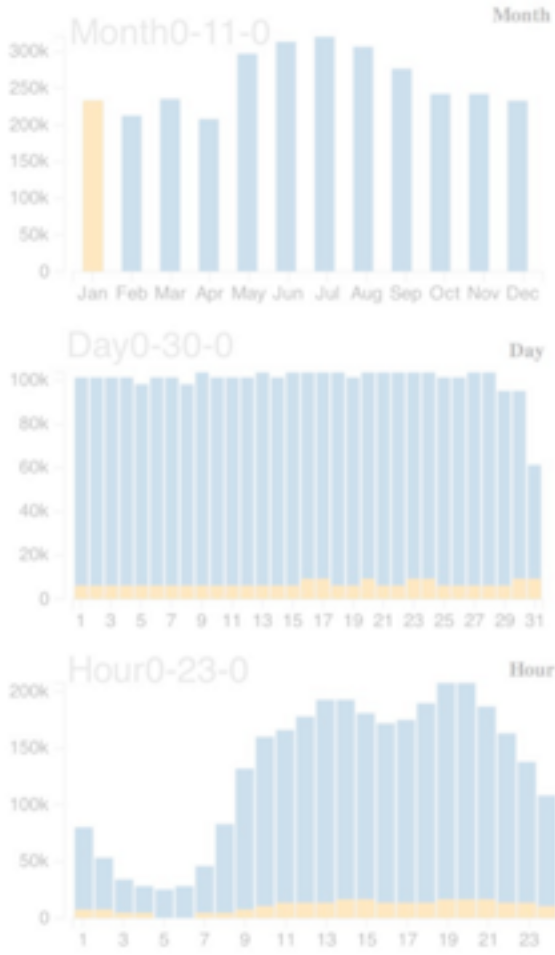
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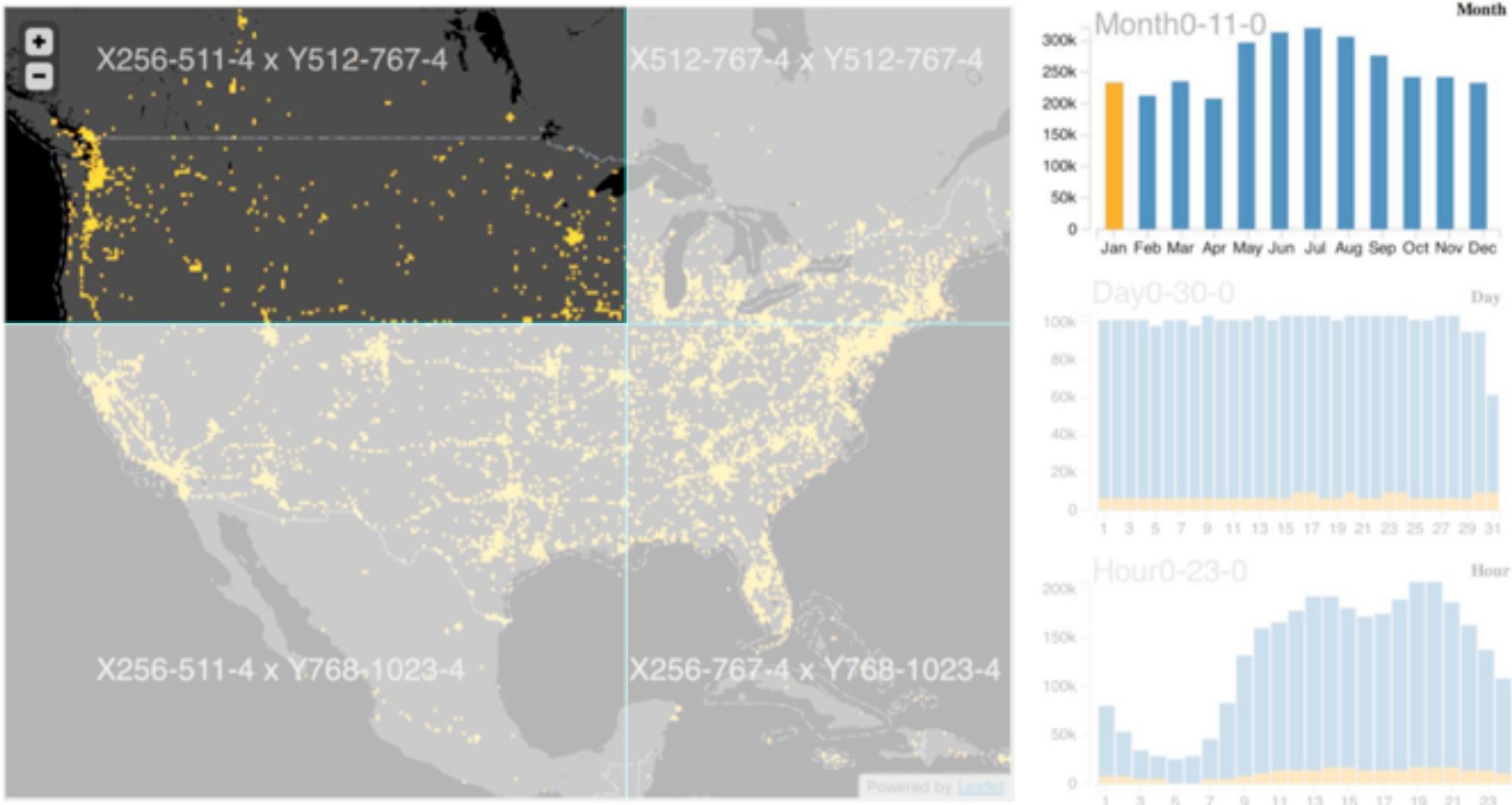
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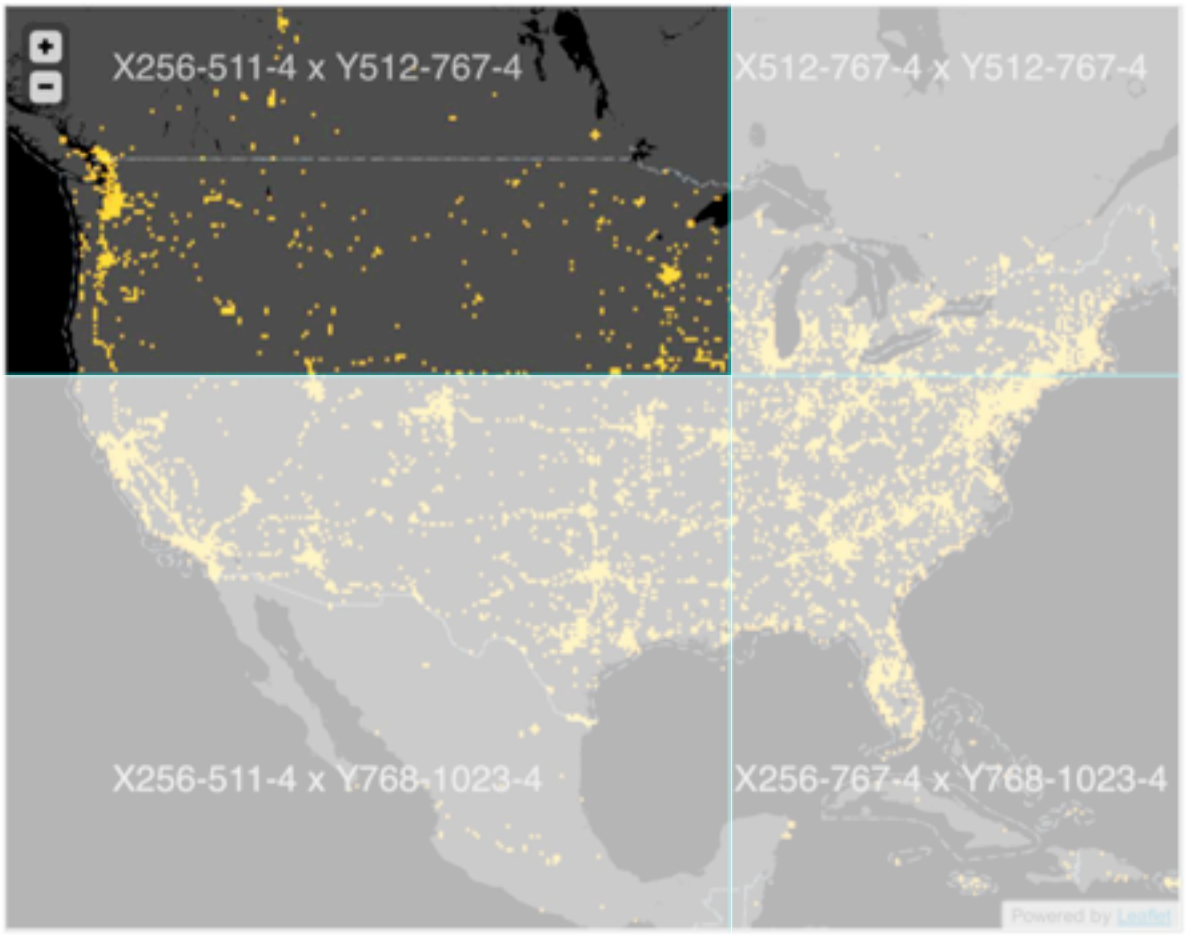
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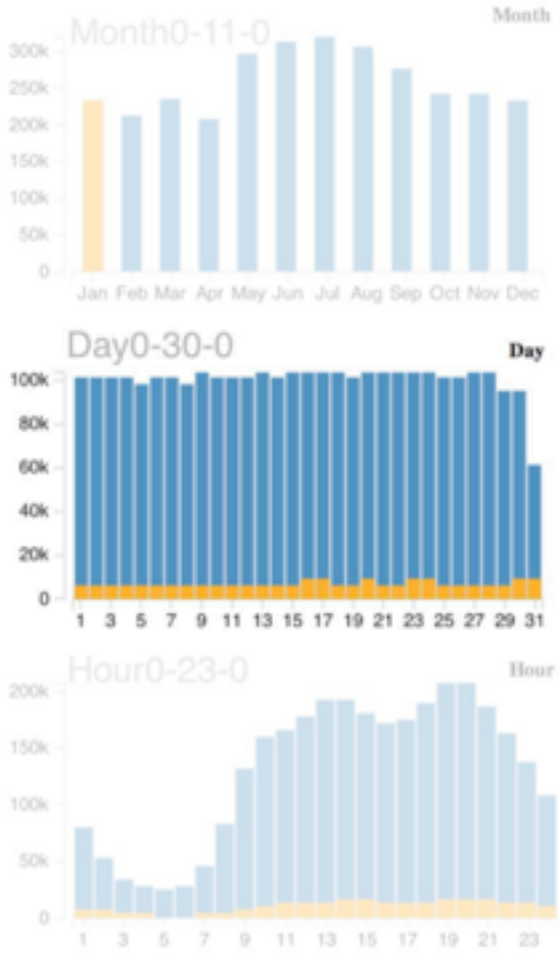
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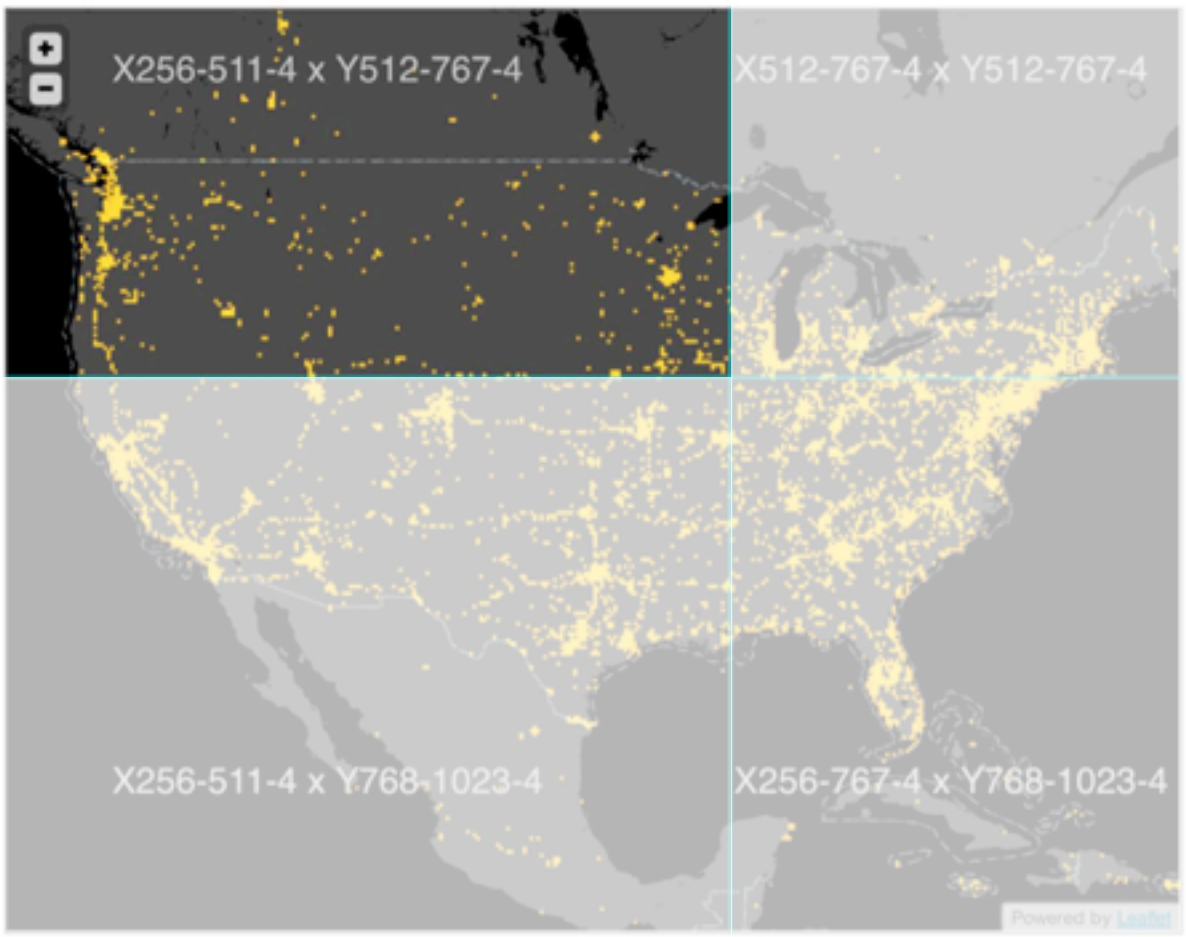
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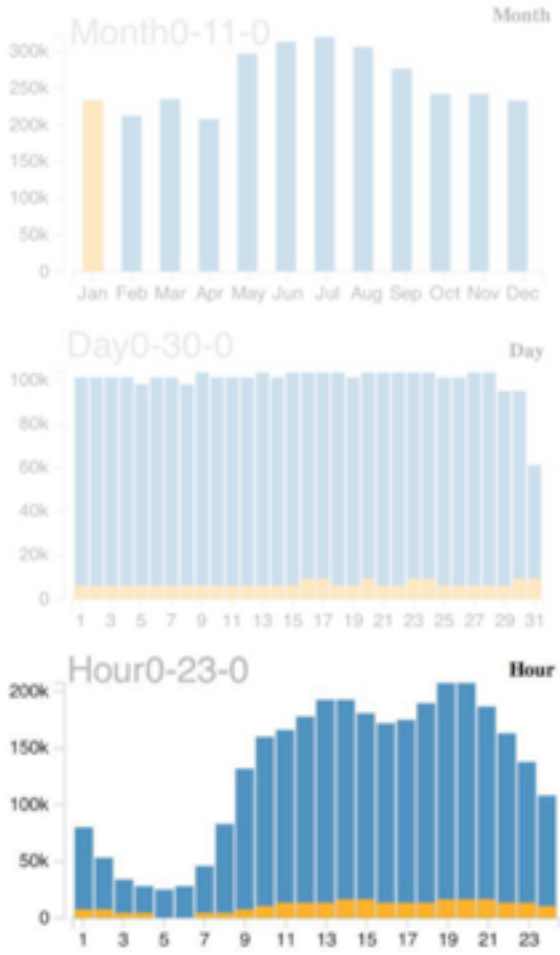
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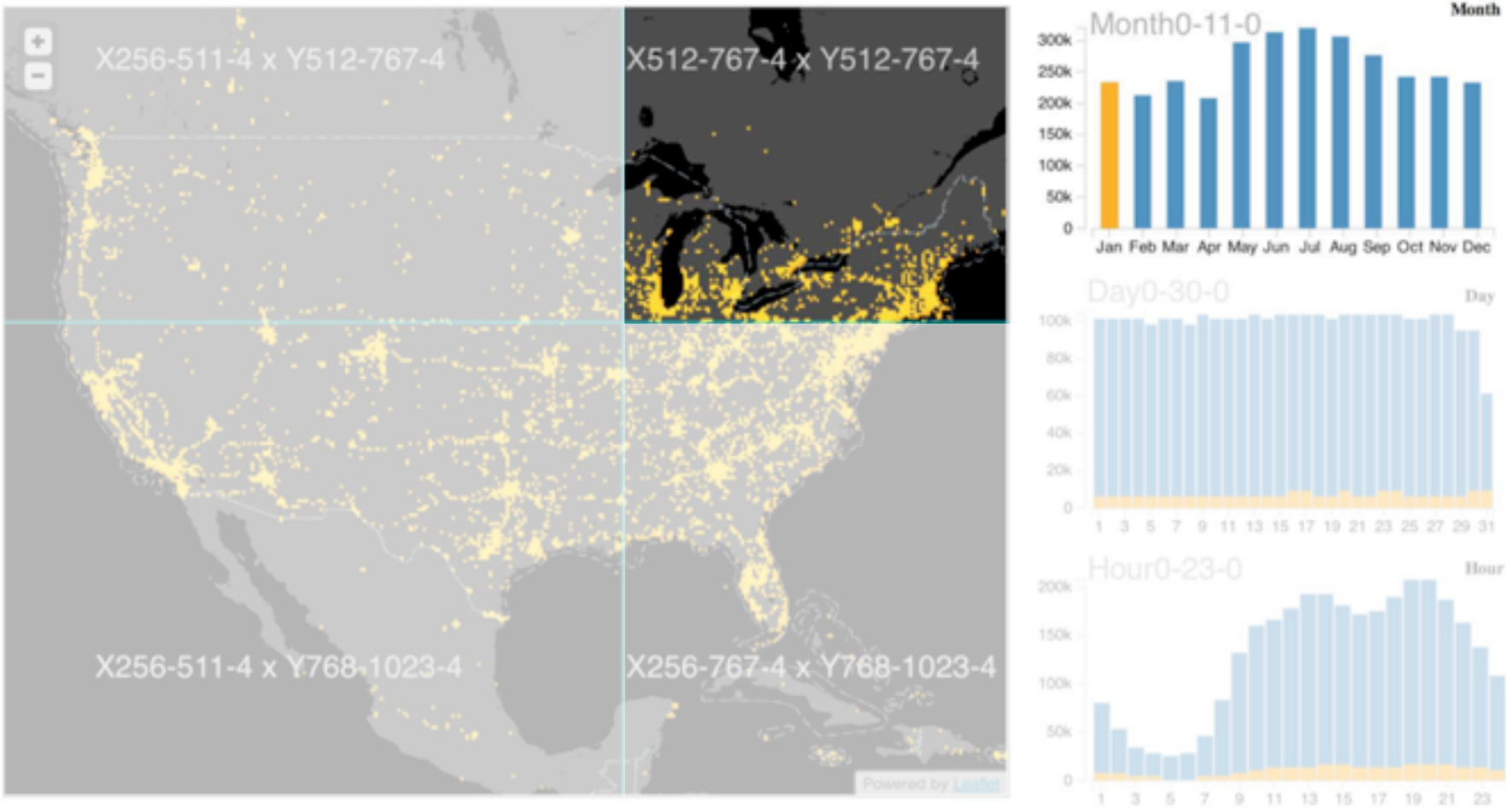
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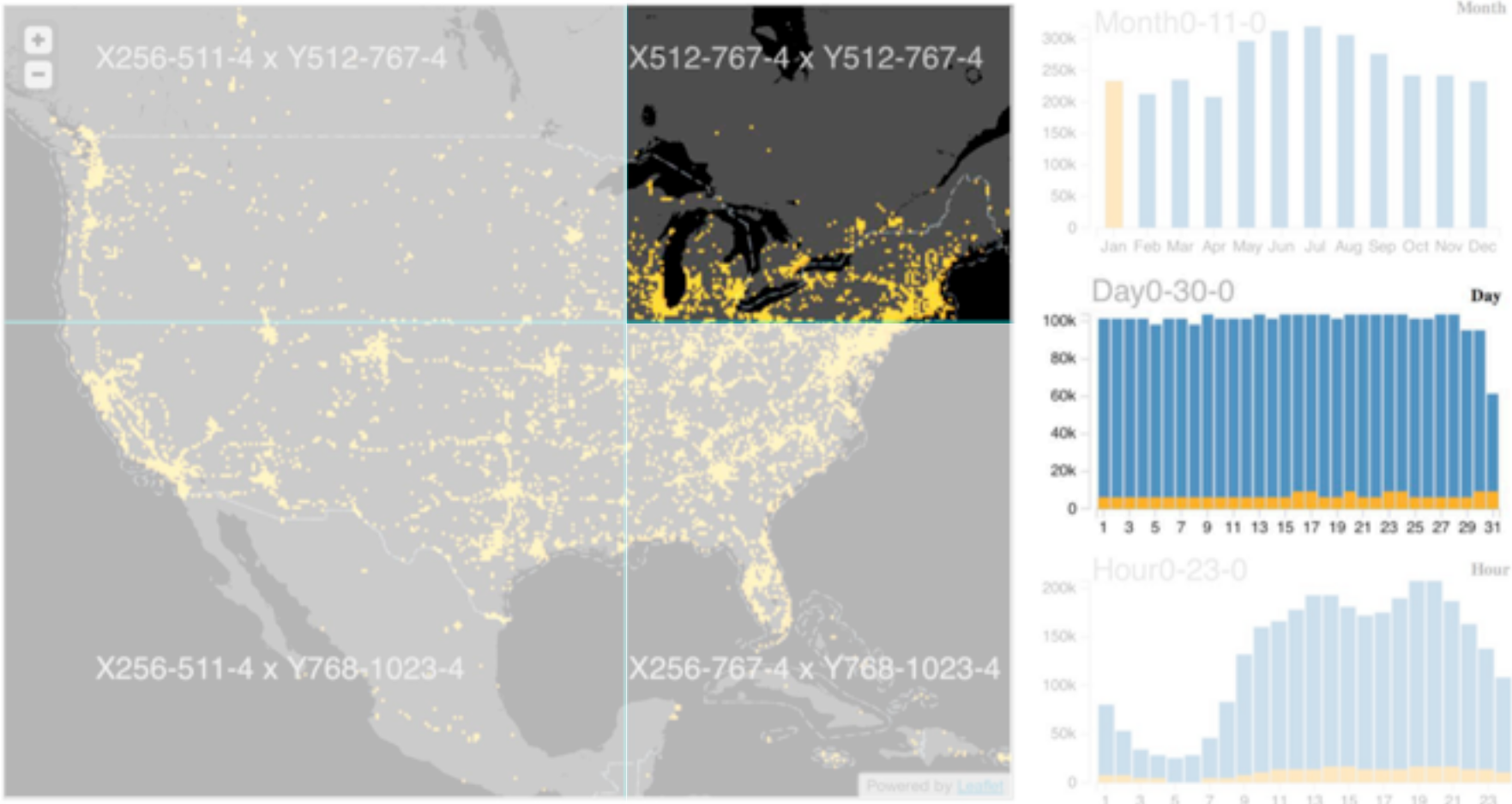
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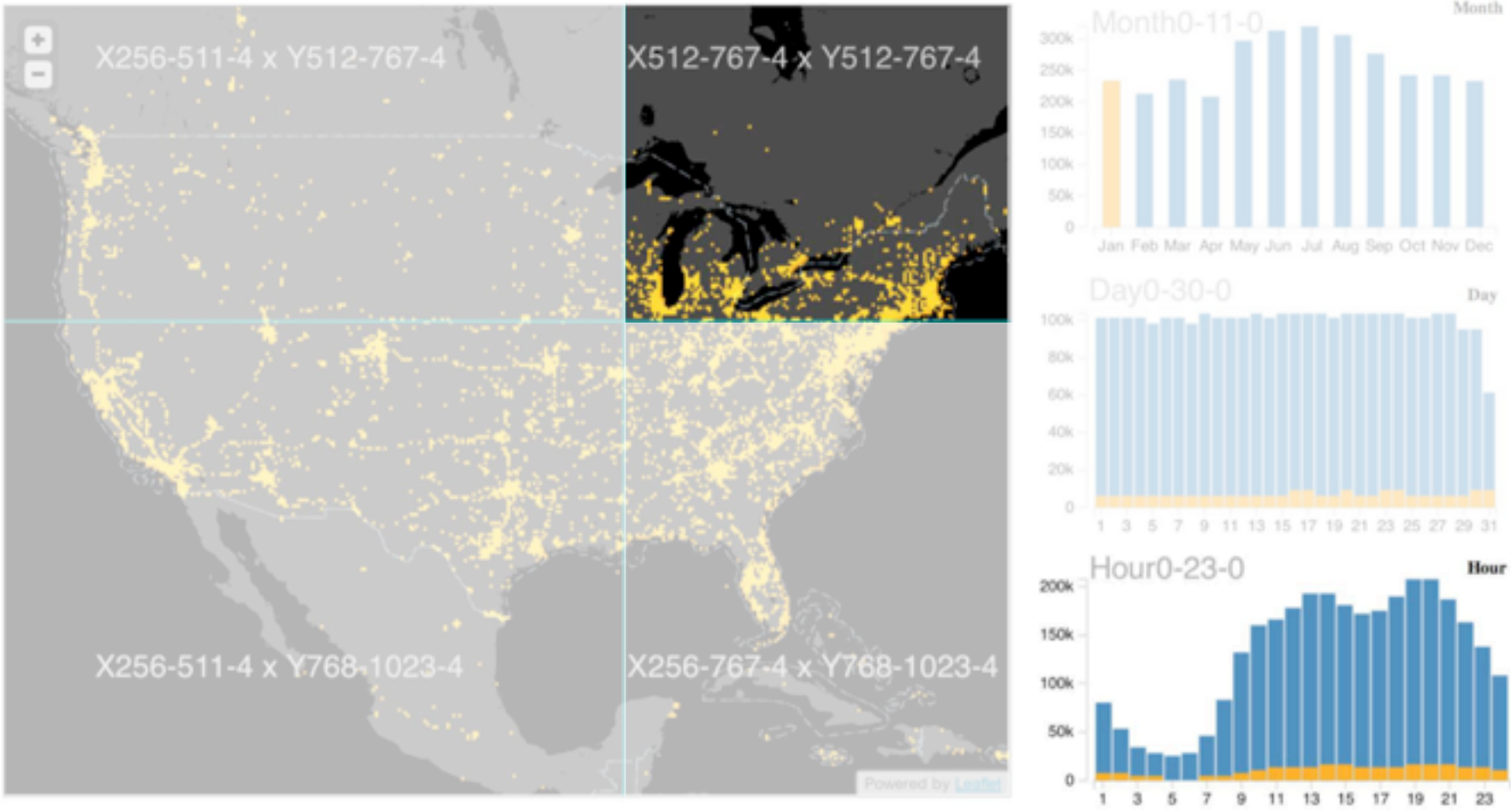
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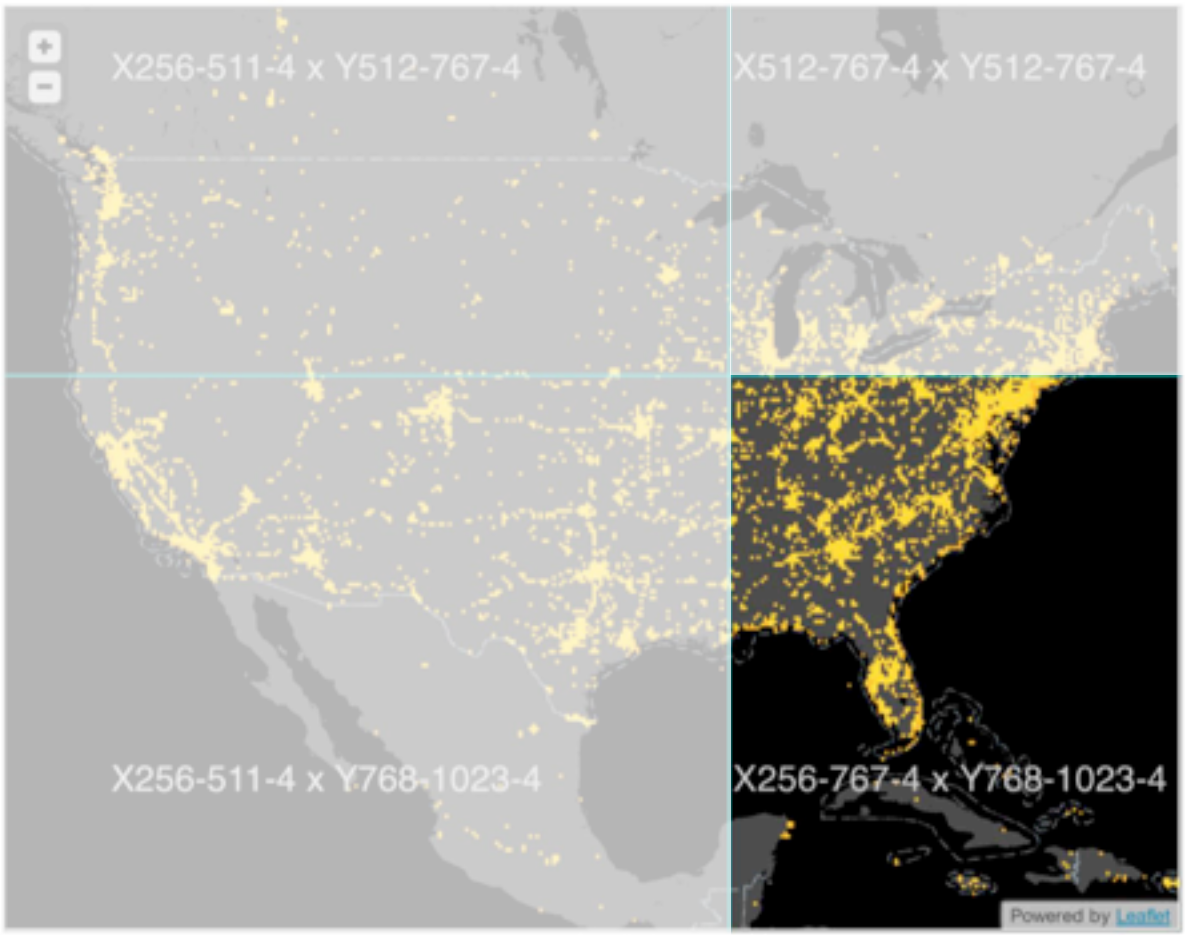
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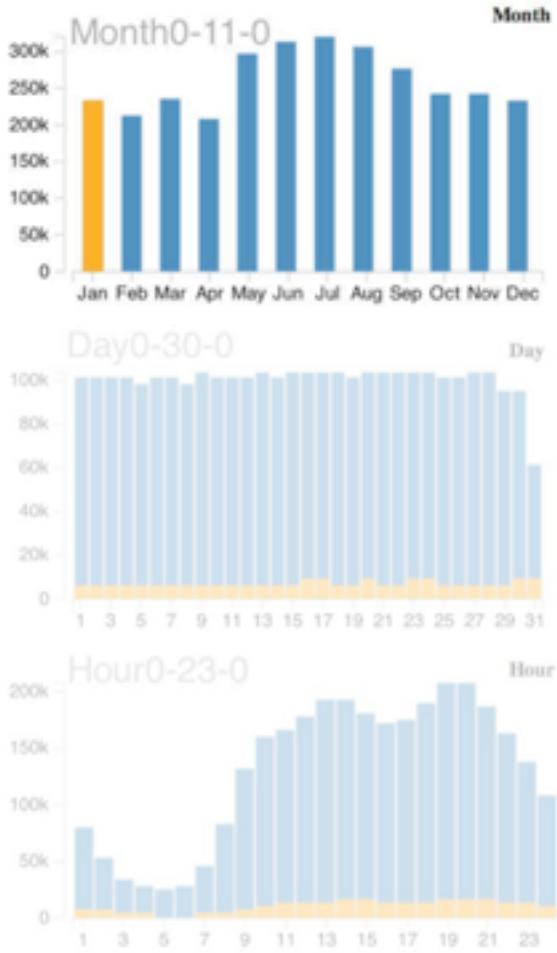
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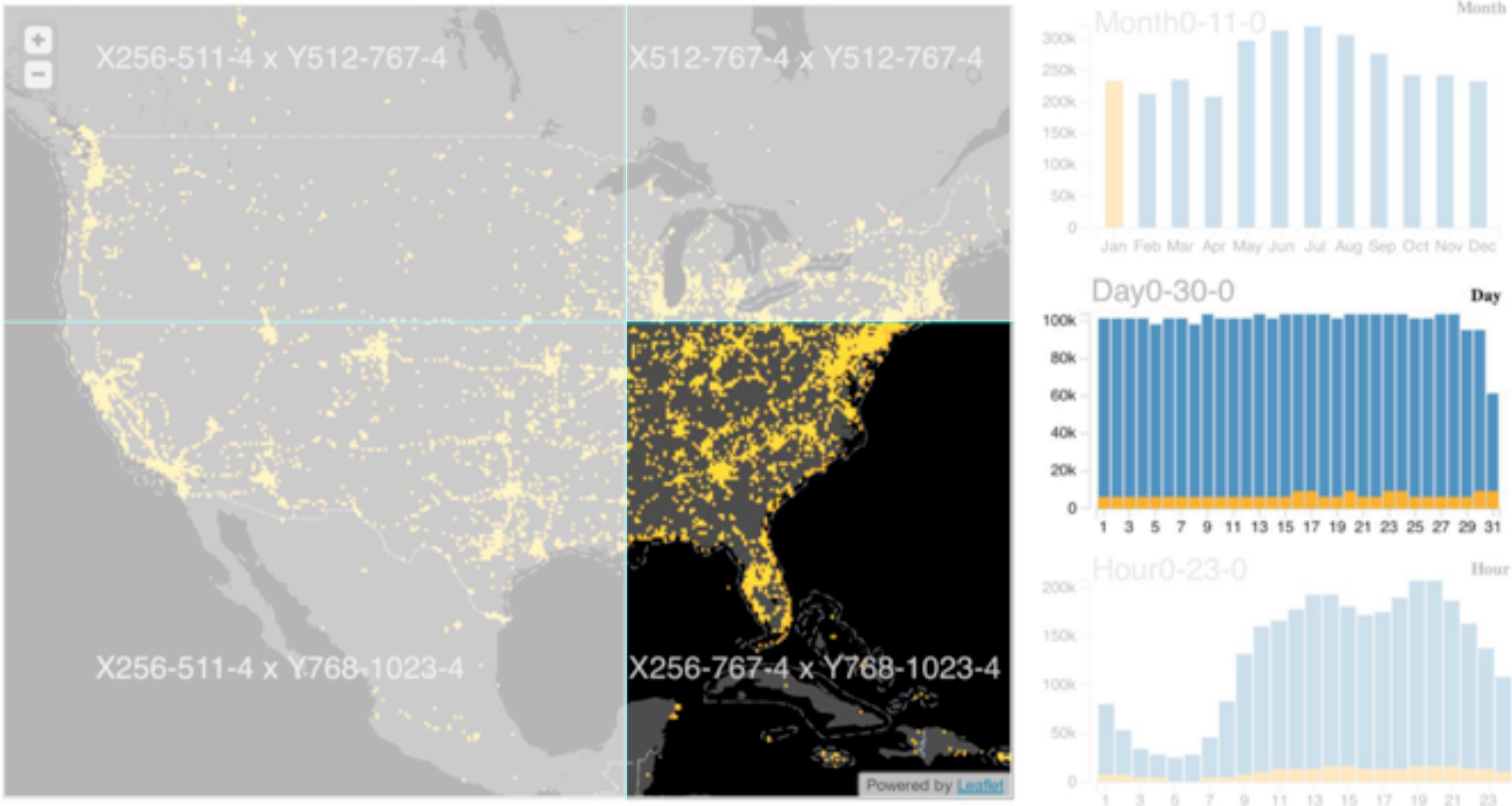
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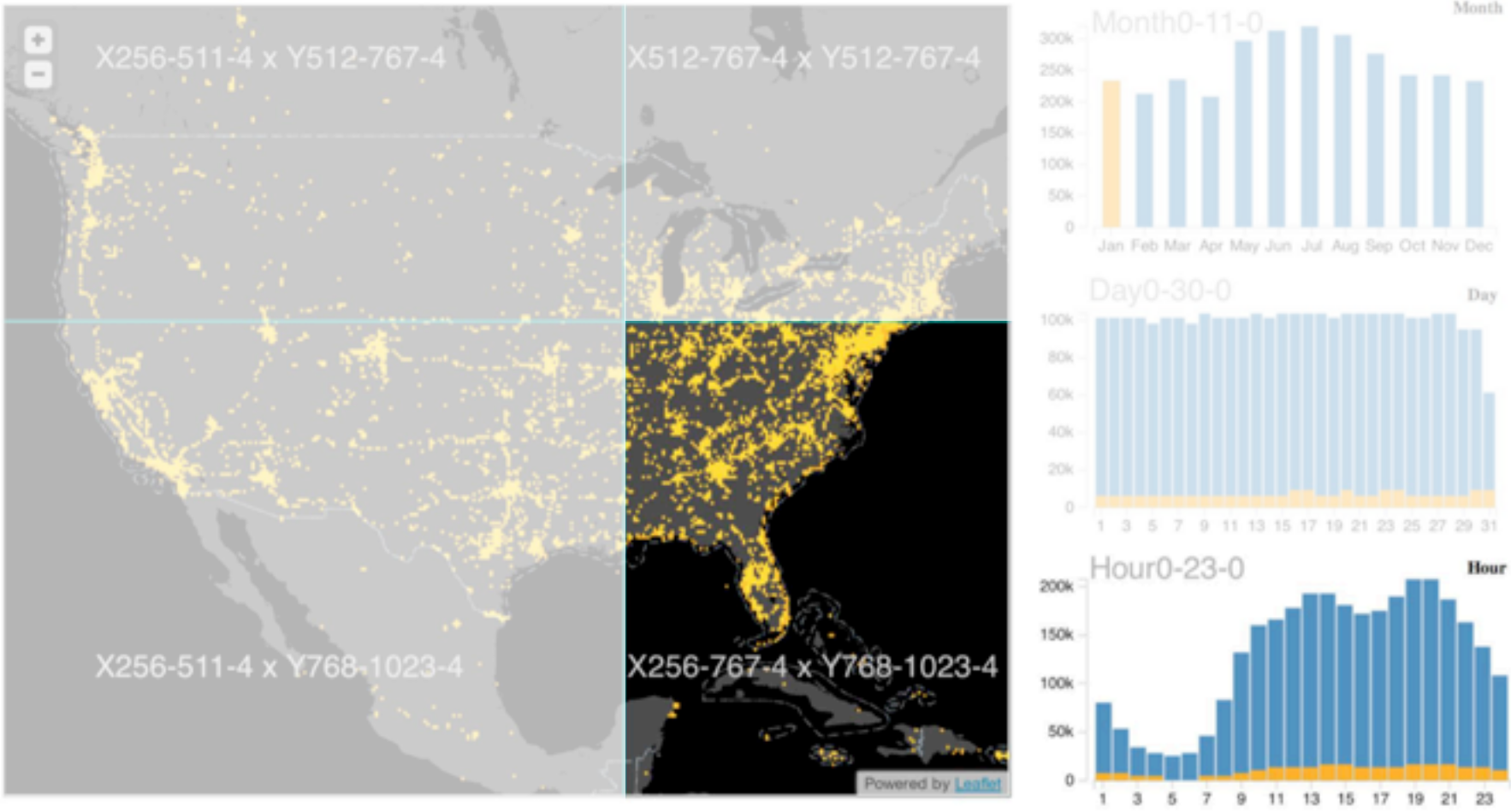
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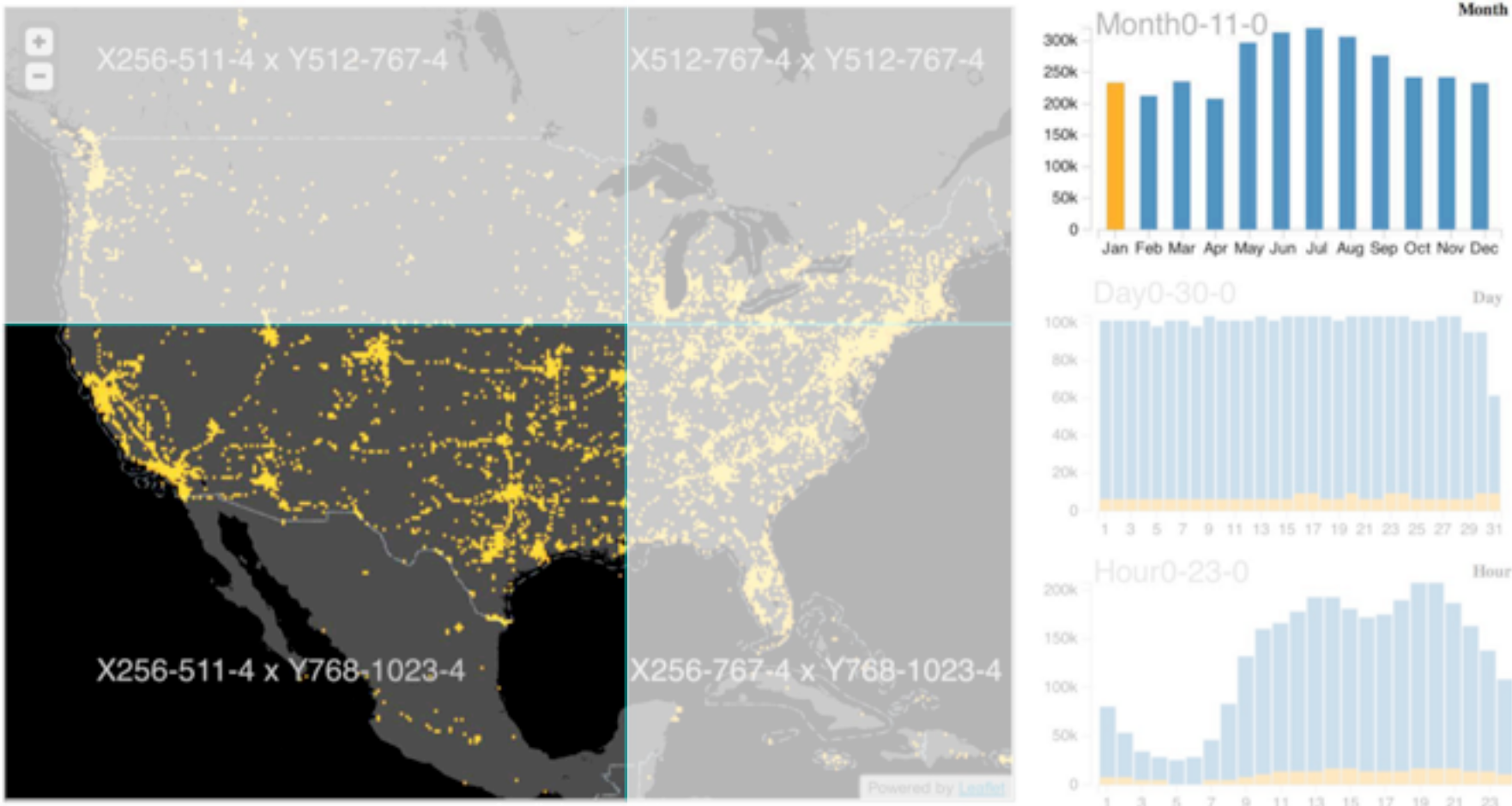
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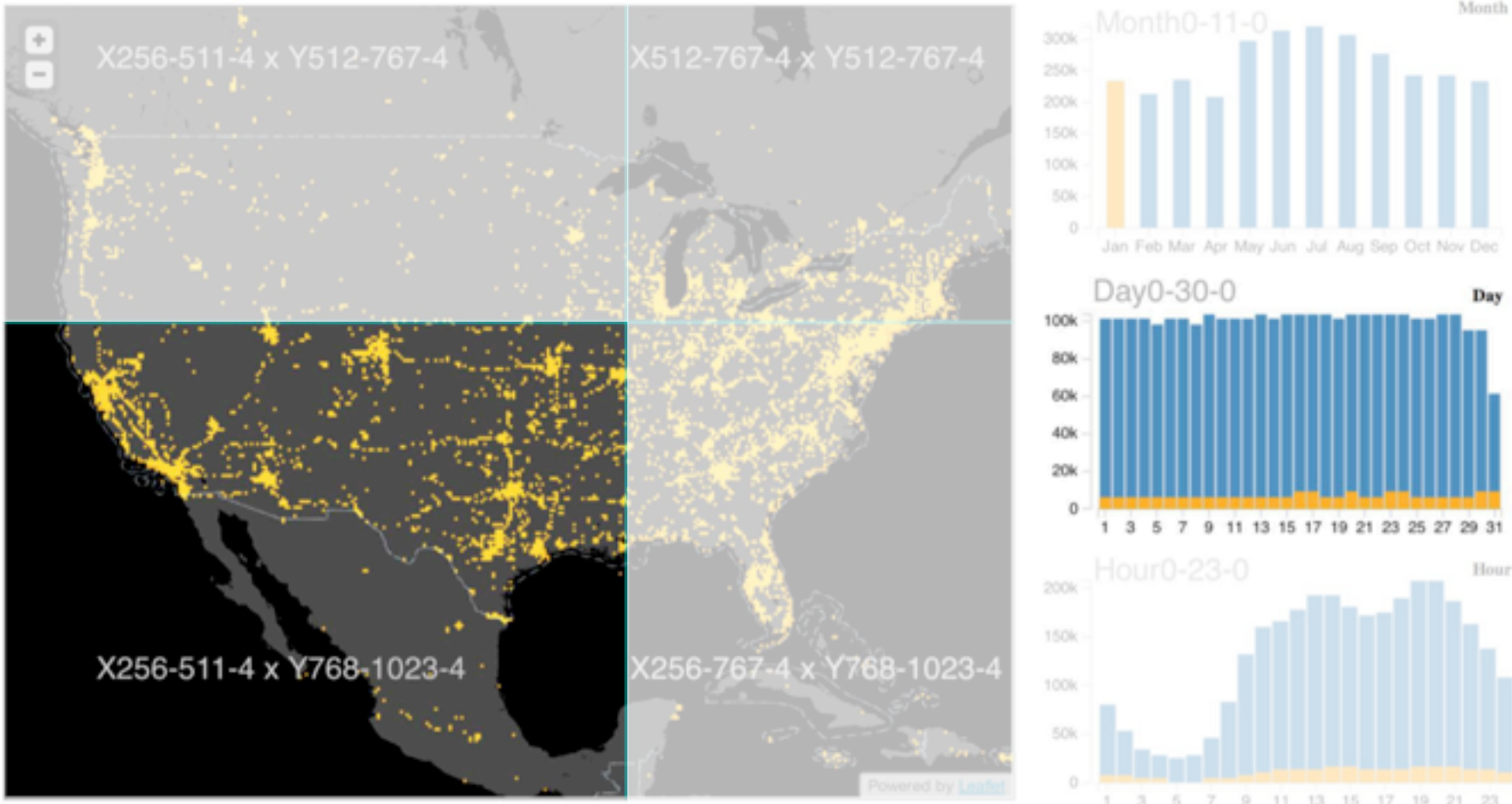
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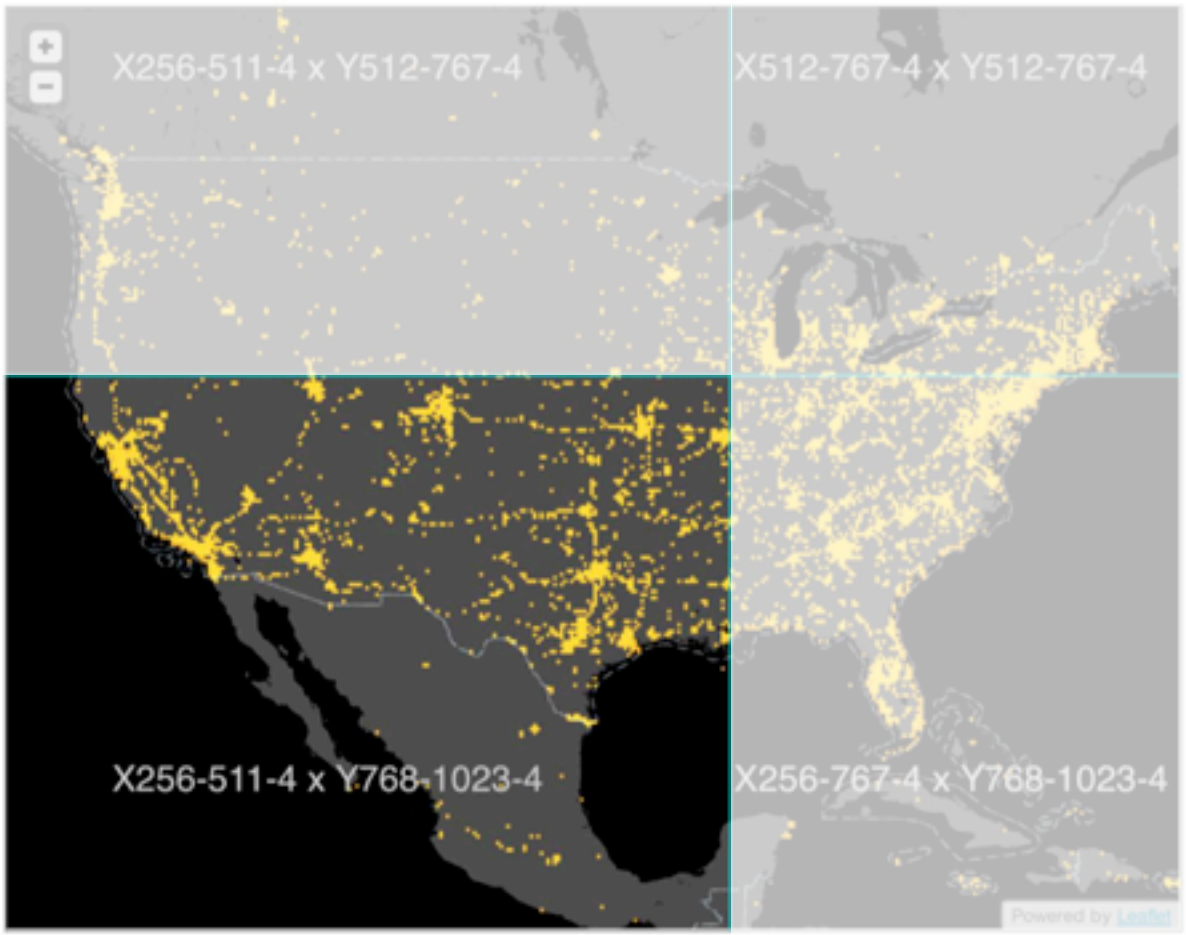
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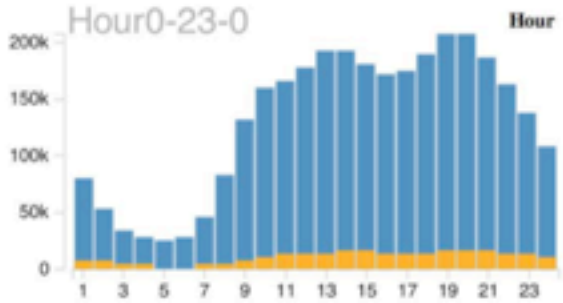
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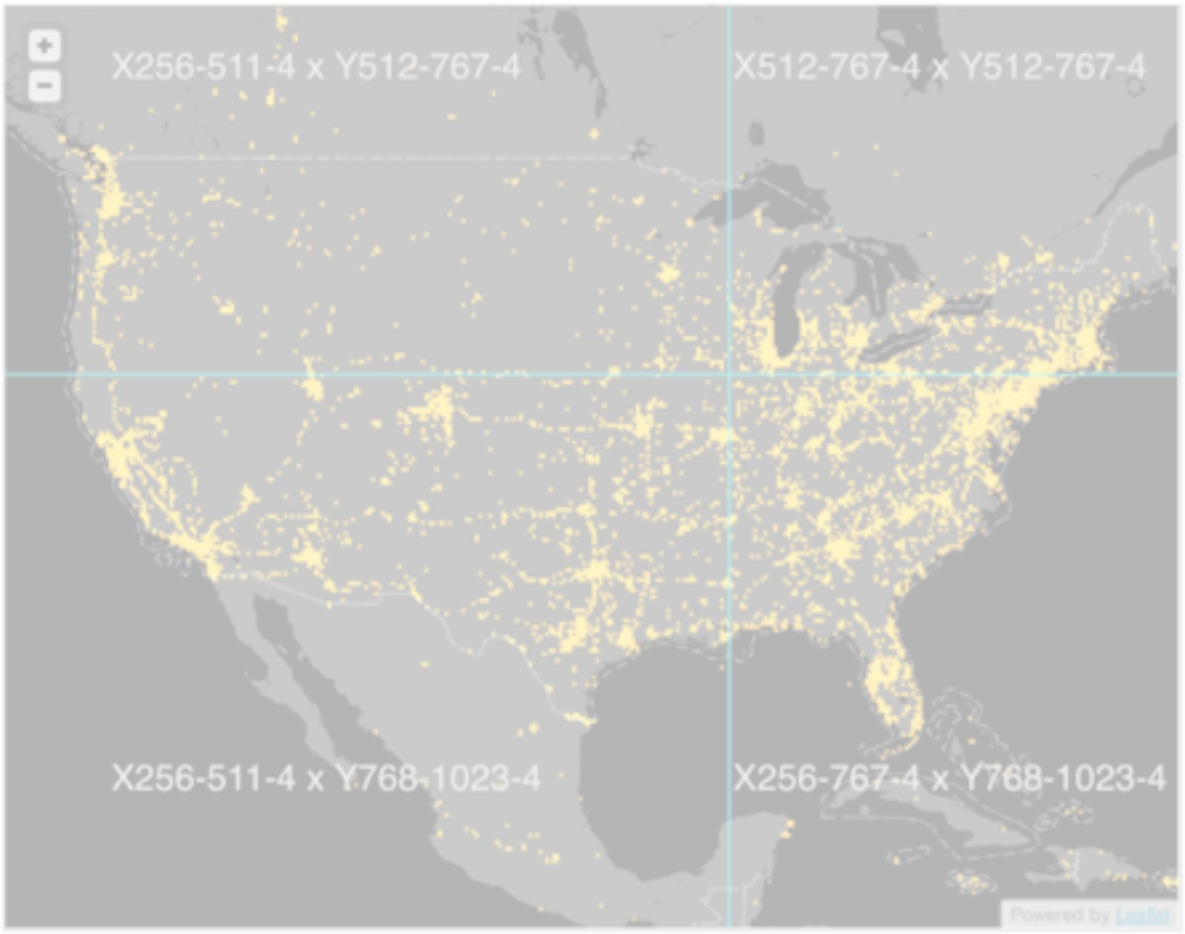
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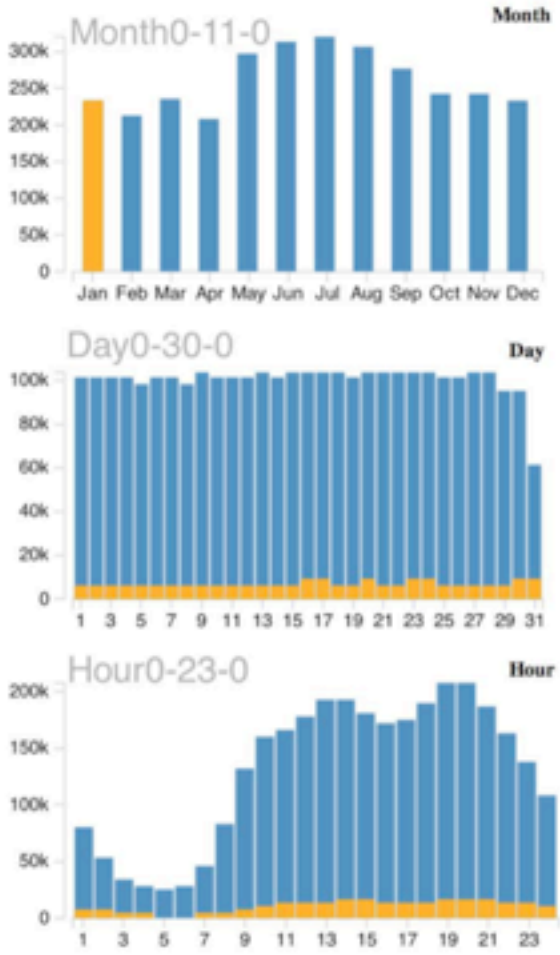
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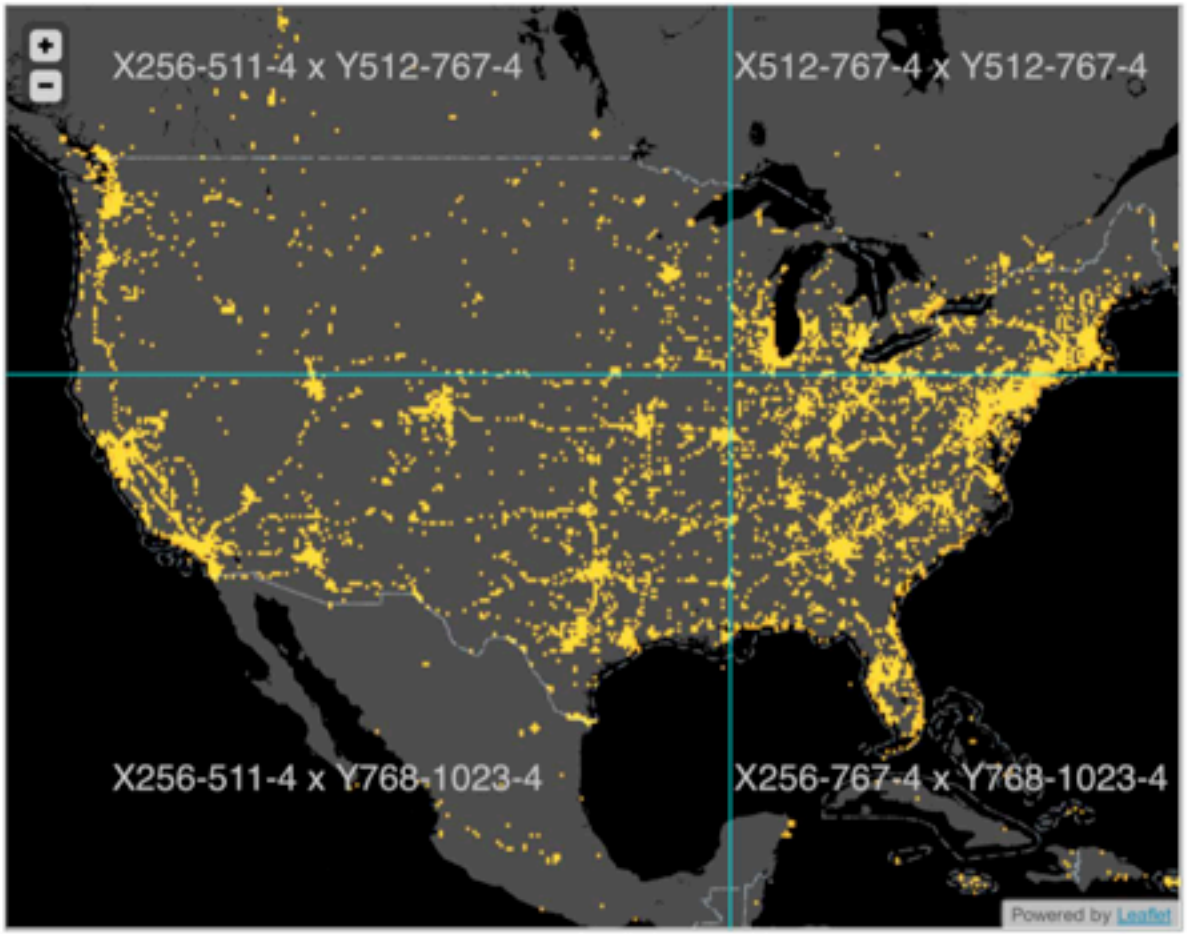
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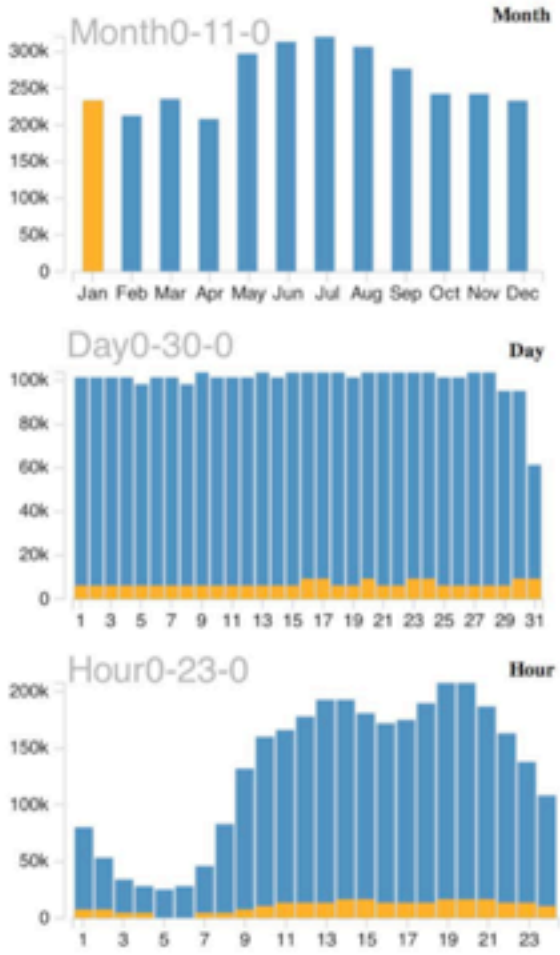
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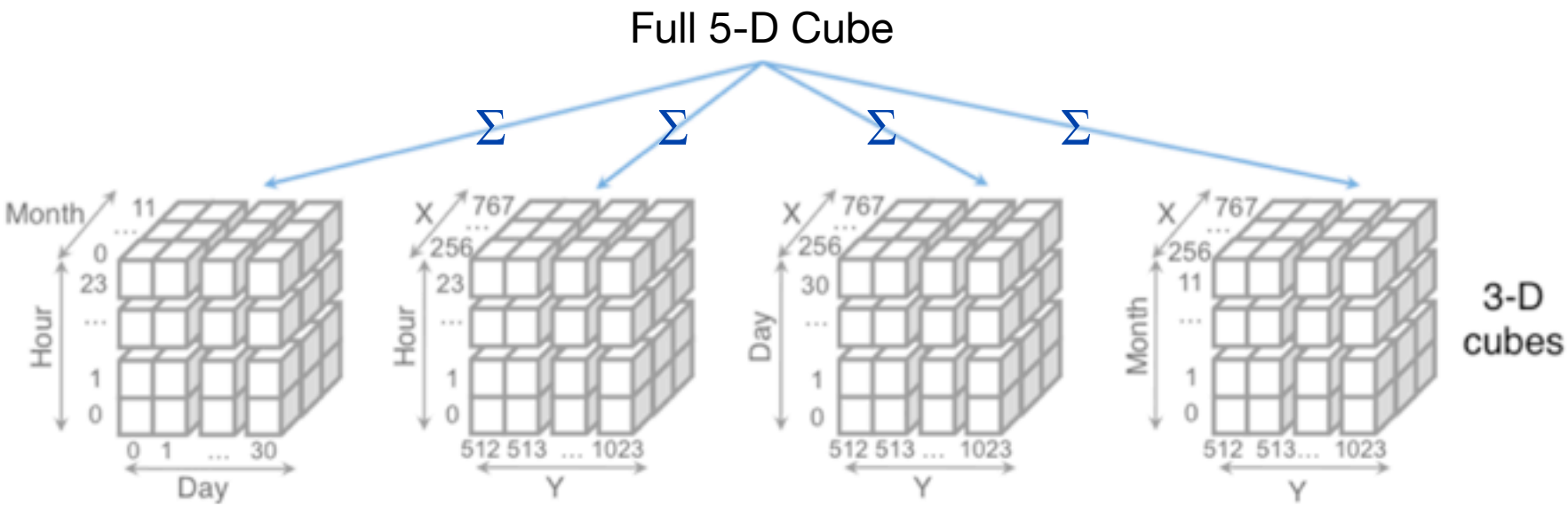
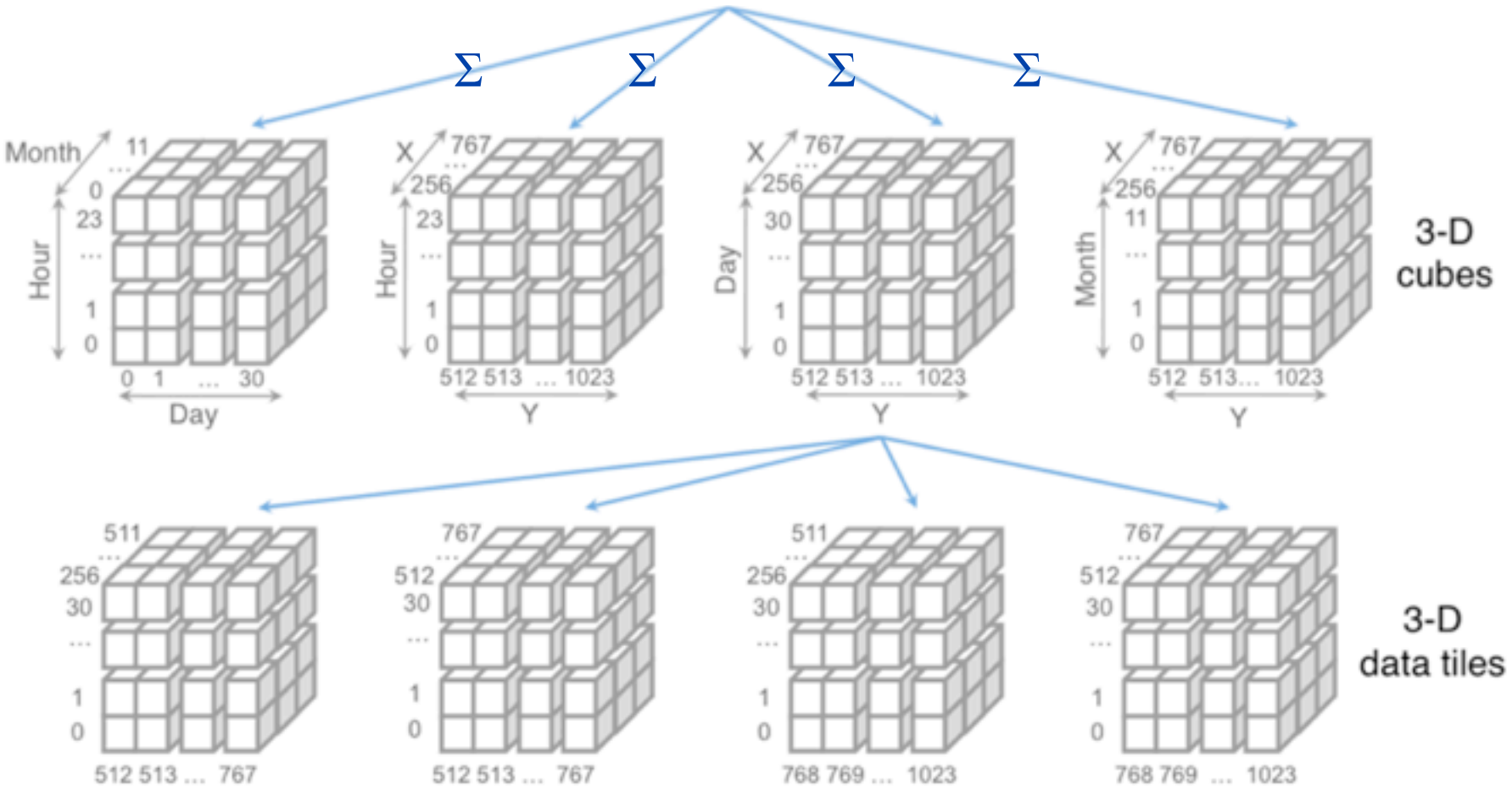
1 3 5 7 9 11 13 15 17 19 21 23

Full 5-D Cube



For any pair of 1D or 2D binned plots, the maximum number of dimensions needed to support brushing & linking is **four**.


Full 5-D Cube
Σ
Σ
Σ
Σ
Month
Hour
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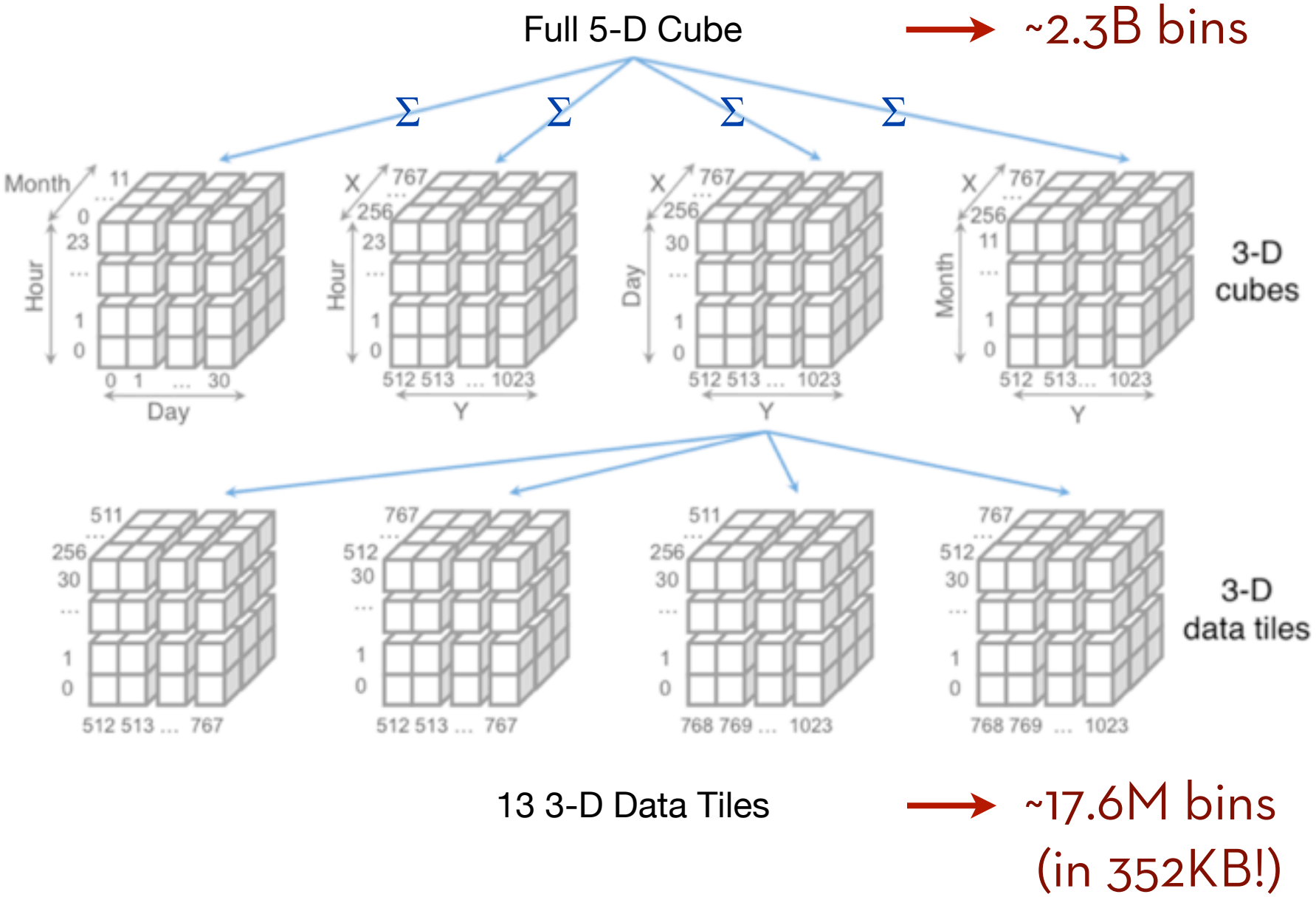
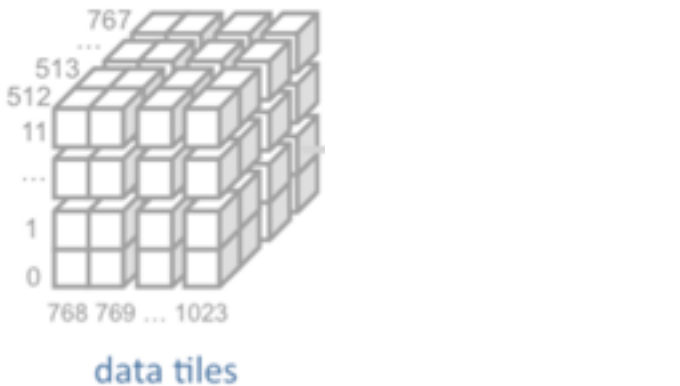
Hour
Y
X
Day
Y
X
Month
Y
3-D cubes
3-D data tiles
13 3-D Data Tiles


Full 5-D Cube
~2.3B bins
Σ
Σ
Σ
Σ
Month
Hour
Day
X
Hour
Y
X
Day
Y
X
Month
Y
3-D cubes
3-D data tiles
13 3-D Data Tiles
~17.6M bins
(in 352KB!)

Multivariate Data Tiles

1. Send data, not pixels
2. Embed multi-dim data
3. Parallelize queries (GPU)

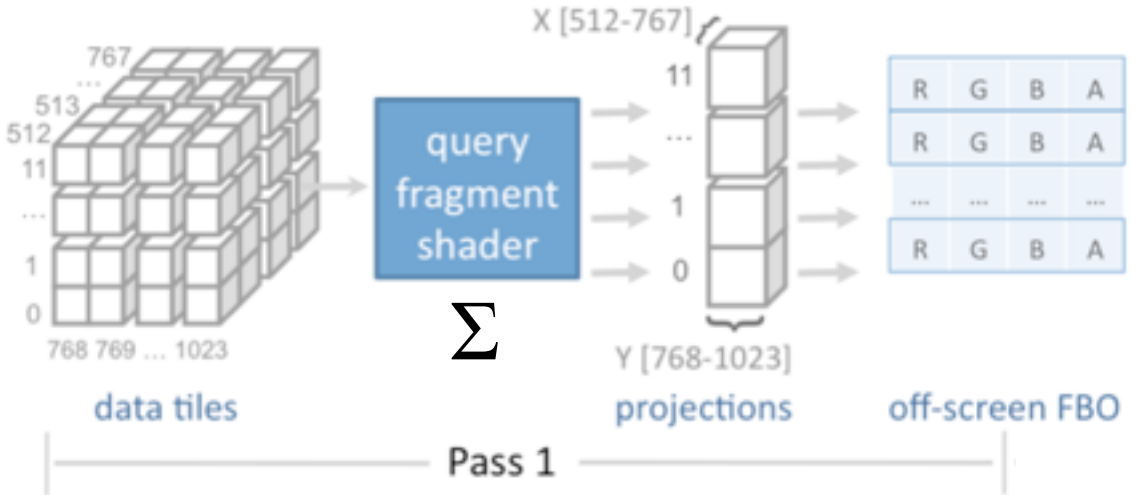
Query & Render on GPU via WebGL



Pack data tiles as PNG image files,

bind to WebGL as image textures.

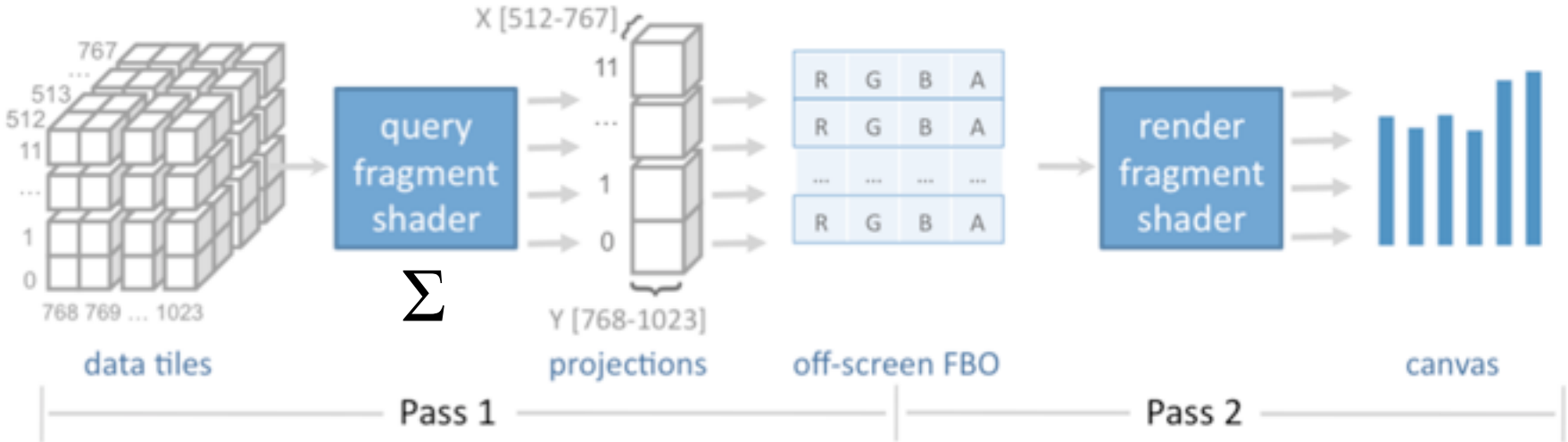
Query & Render on GPU via WebGL



Compute aggregation for each output bin.

Executes in parallel on GPU.

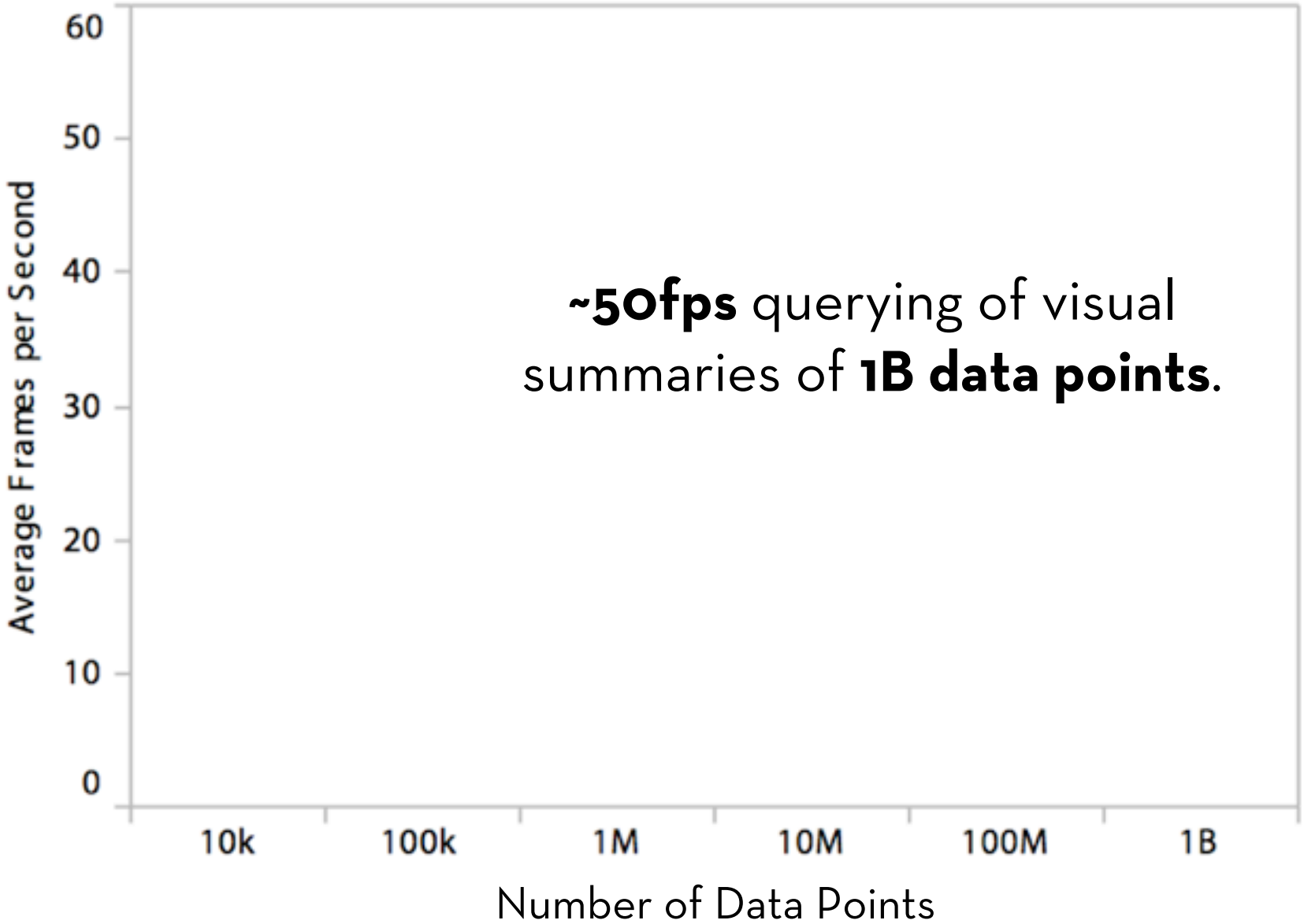
Query & Render on GPU via WebGL



Accumulate results in offscreen buffer.

Render resulting plots in second pass.

5 dimensions x 50 bins/dim x 25 plots

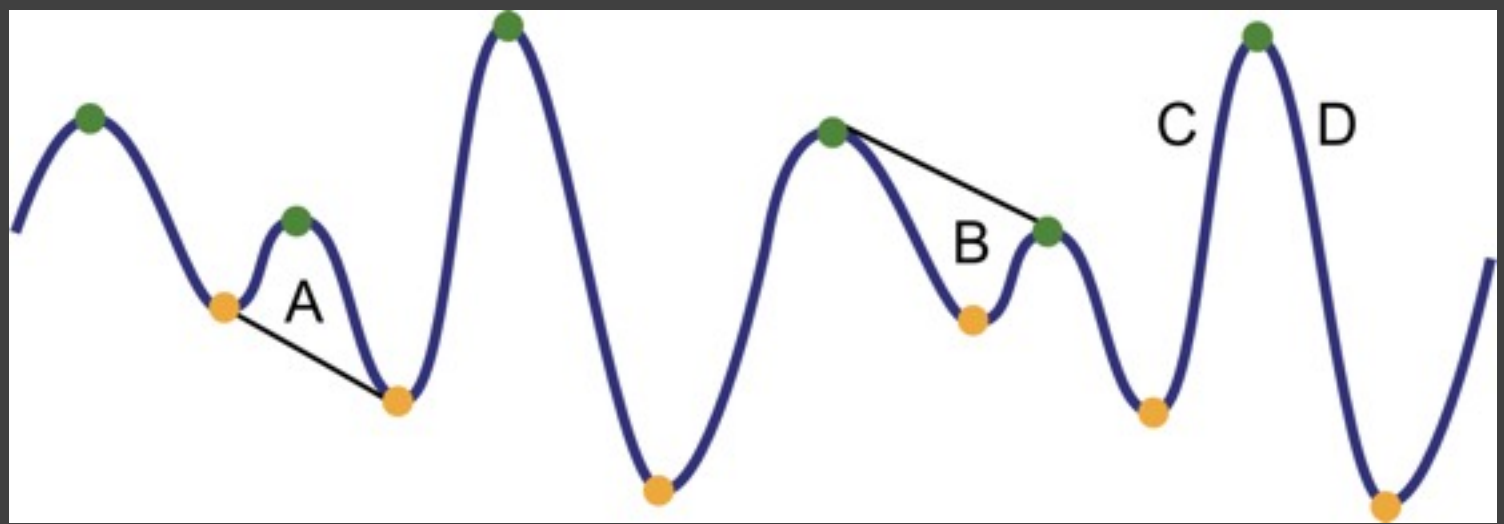


~50fps querying of visual summaries of **1B data points**.

Parting Thoughts

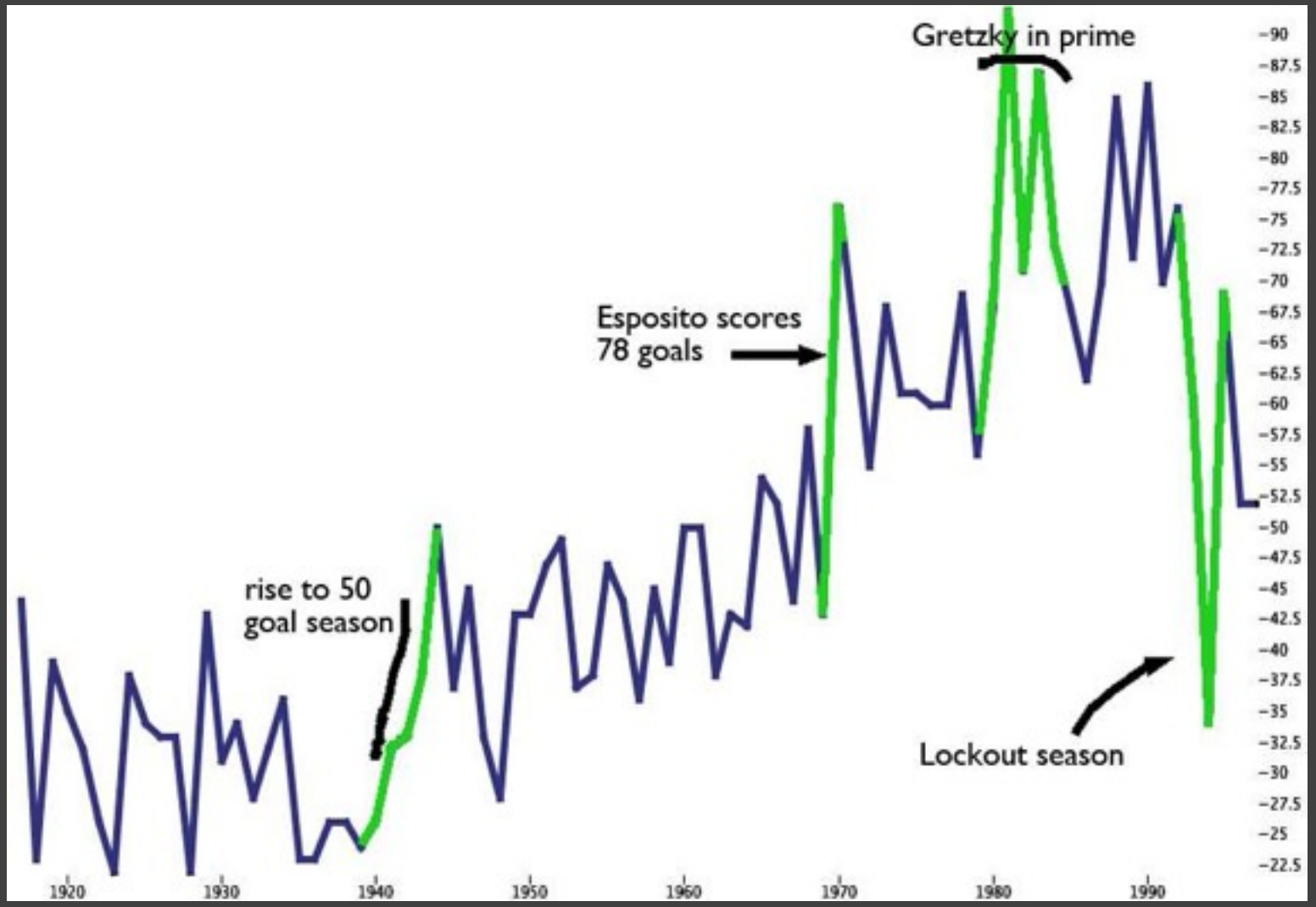
Consider how the structure and/or semantics of the data might be leveraged to aid analysis.

One idea: look beyond data features to incorporate perceptual features of the display.



Peaks, valleys, & slopes

Perceptual Annotation [Kong & Agrawala 09]



NHL Goals per Year

Summary

Most visualizations are interactive
Even passive media elicit interactions

Good visualizations are task dependent
Pick the right interaction technique
Consider the semantics of the data domain

Fundamental interaction techniques
Selection / Annotation, Sorting, Navigation, Brushing & Linking, Dynamic Queries