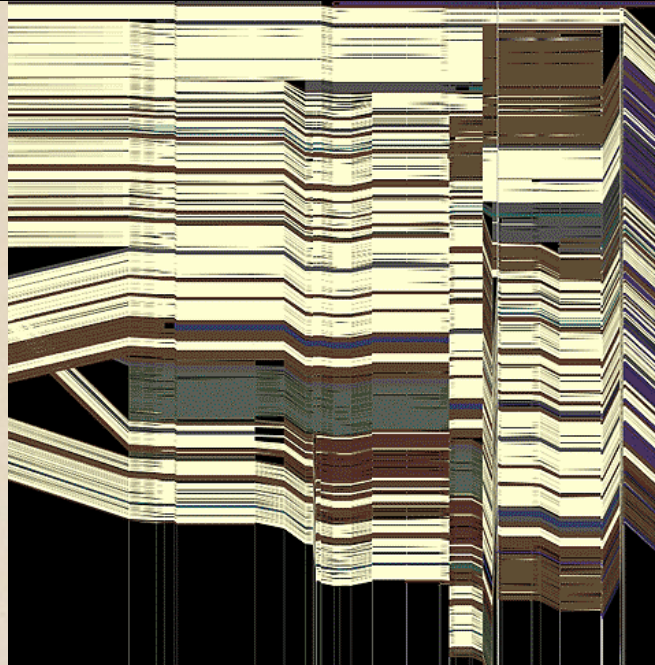
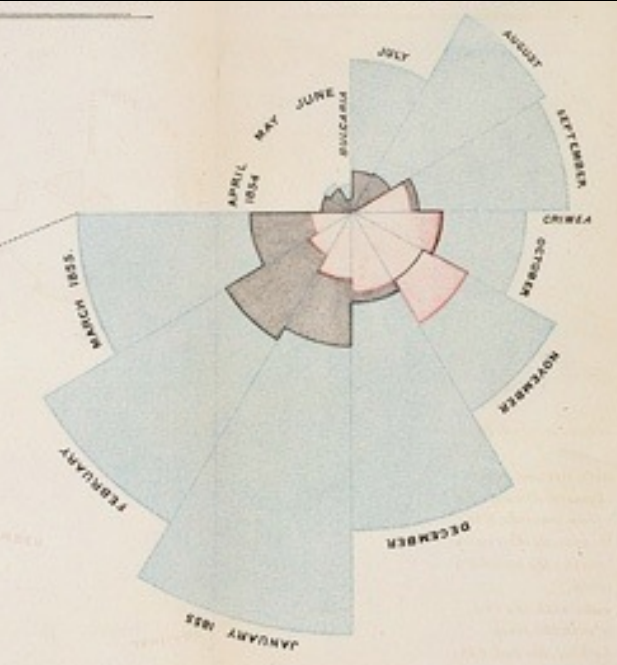


# CSE 412 - Intro to Data Visualization

# Interaction



Jane Hoffswell University of Washington

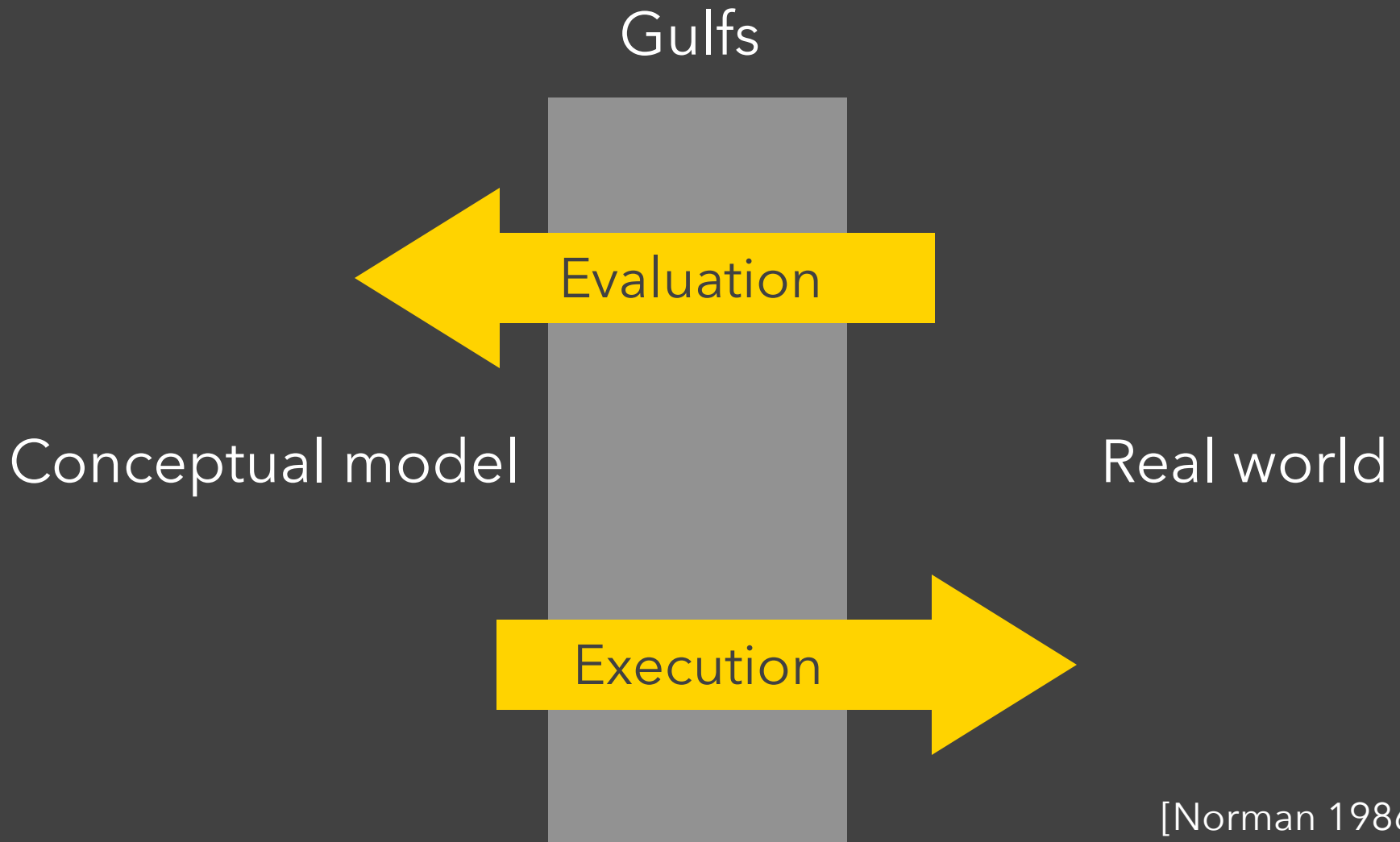
[There is an] apparent challenge that computational artifacts pose to the longstanding distinction between the physical and the social, in the special sense of those things that one designs, builds, and uses, on the one hand, and those things with which one communicates, on the other.

“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.

[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:  
 $x, y$  related?

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

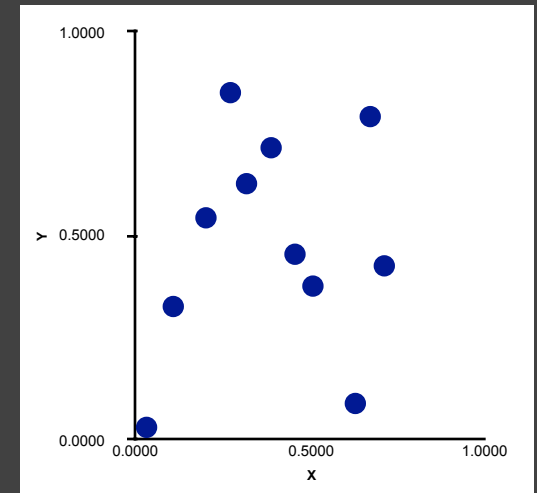
# Gulf of Evaluation

Gulf



Conceptual model:  
 $x, y$  related?

Real world:

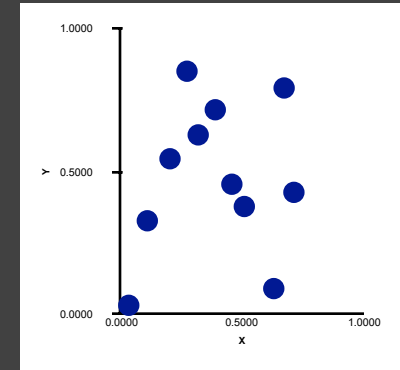
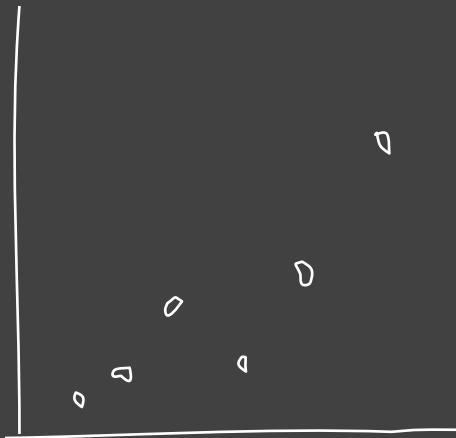




# Gulf of Execution

Gulf

Conceptual model:  
Draw a scatterplot



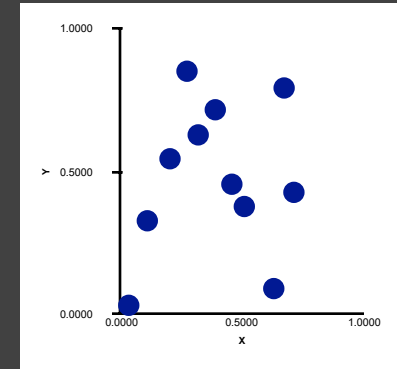
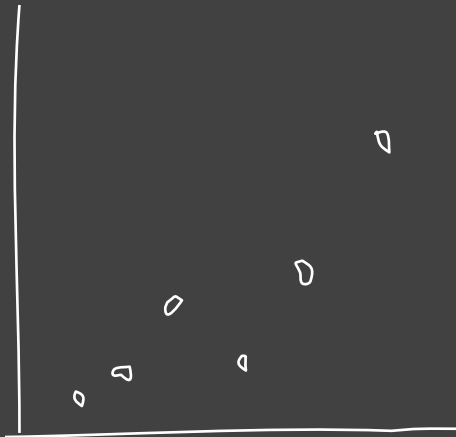
Real world

Move 90 30  
Rotate 35  
Pen down  
...

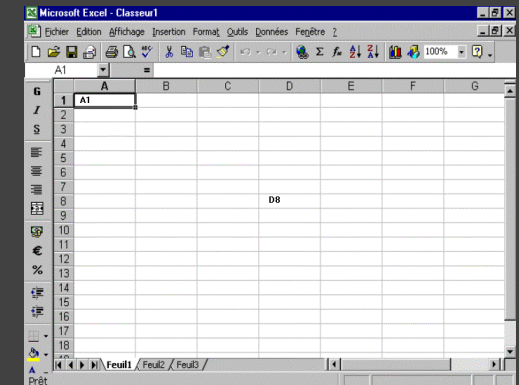
# Gulf of Execution

Gulf

Conceptual model:  
Draw a scatterplot



Real world



## **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]

# Interactive Visualization

# Interaction Techniques

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

# Taxonomy of Interactions

# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive



Show Me

**Data** | Analytics

Sample - Superstore

**Dimensions**

- Customer
  - Customer Name
  - Segment
- Order
- Location
- Product
  - Category
  - Sub-Category
  - Manufacturer
  - Product Name
- Profit (bin)
- Region
- Measure Names

**Measures**

- Discount
- Profit
- Profit Ratio
- Quantity
- Sales
- Latitude (generated)
- Longitude (generated)
- Number of Records
- Measure Values

**Pages**

**Filters**

**Marks**

Automatic

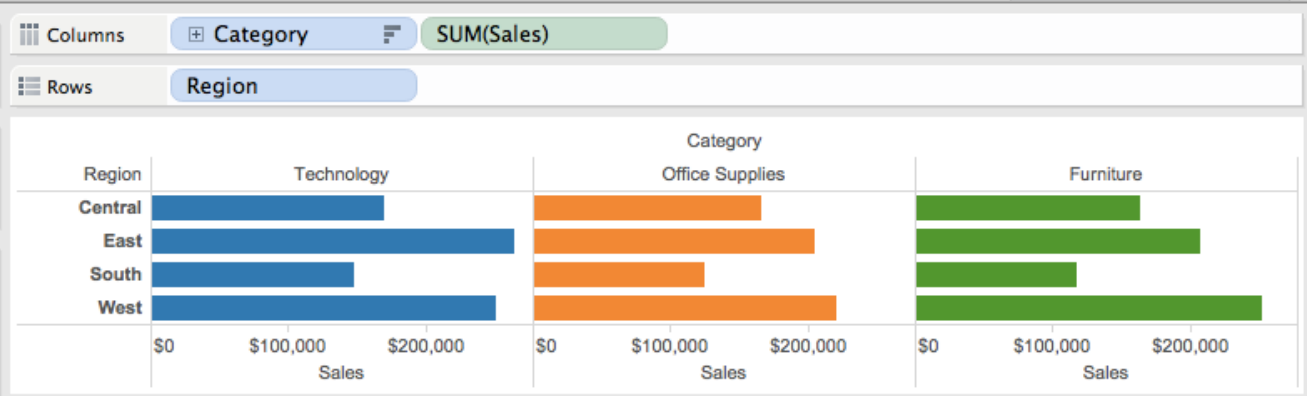
Color Size Label

Detail Tooltip

Category

Category

- Technology
- Office Supplies
- Furniture







Show Me

**Data** | Analytics

Sample - Superstore

**Dimensions**

- Customer
  - Customer Name
  - Segment
- Order
  - Location
- Product
  - Category
  - Sub-Category
  - Manufacturer
  - Product Name
- Profit (bin)
- Region
- Measure Names

**Measures**

- Discount
- Profit
- Profit Ratio
- Quantity
- Sales
- Latitude (generated)
- Longitude (generated)
- Number of Records
- Measure Values

**Pages**

**Columns** | Category | SUM(Sales)

**Rows** | Region

**Filters**

**Marks**

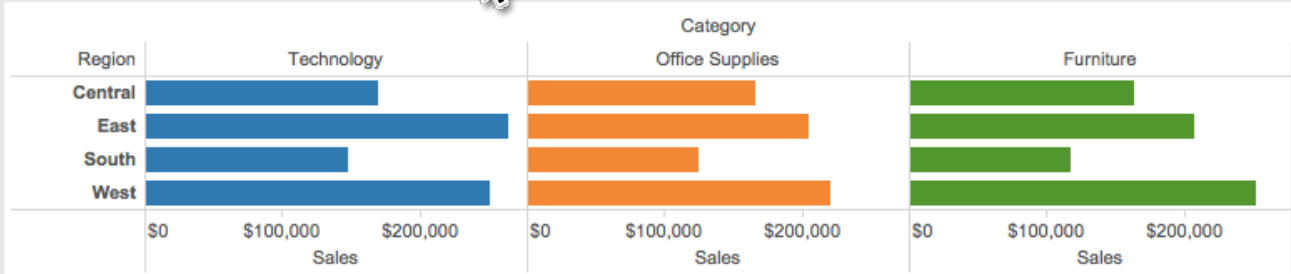
Automatic

Color | Size | Label

Detail | Tooltip

Category

Technology | Office Supplies | Furniture



**Data** | Analytics

Sample - Superstore

**Dimensions**

- Customer
  - Customer Name
  - Segment
- Order
- Location
- Product
  - Category
  - Sub-Category
  - Manufacturer
  - Product Name
- Profit (bin)
- Region
- Measure Names

**Measures**

- Discount
- Profit
- Profit Ratio
- Quantity
- Sales
- Latitude (generated)
- Longitude (generated)
- Number of Records
- Measure Values

**Pages**

**Filters**

**Marks**

Automatic

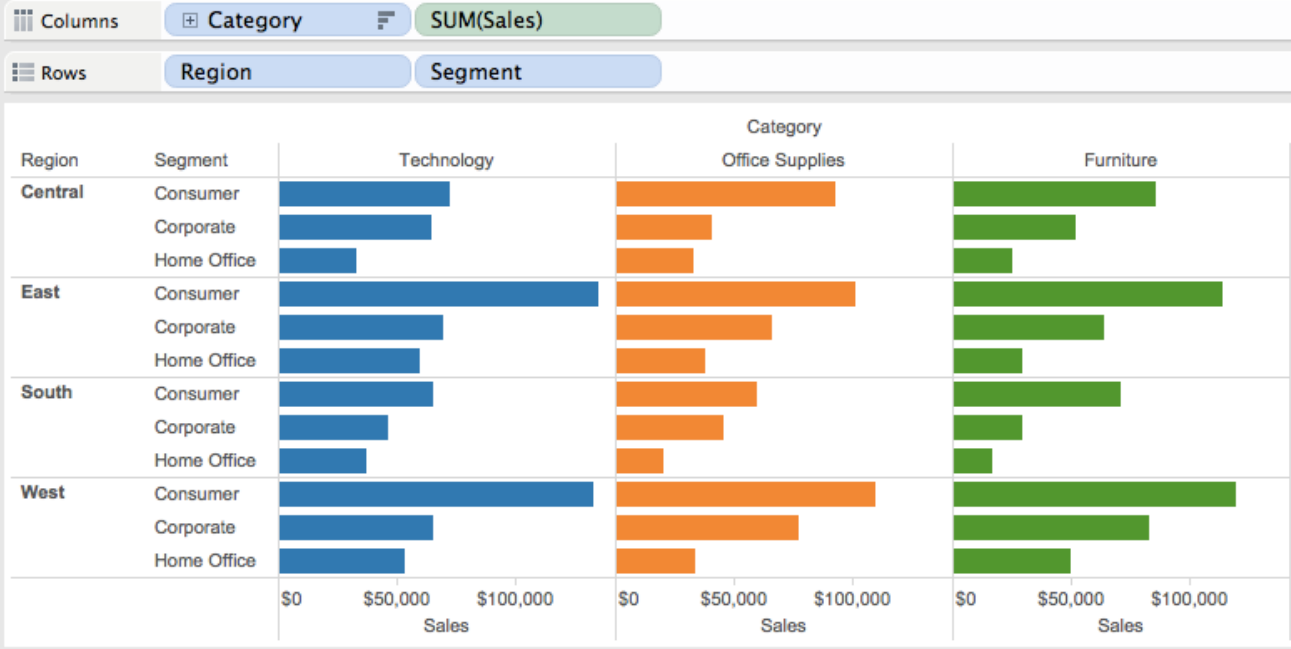
Color Size Label

Detail Tooltip

Category

Category

- Technology
- Office Supplies
- Furniture



**Data** | Analytics

Sample - Superstore

**Dimensions**

- Customer
  - Customer Name
  - Segment
- Order
- Location
- Product
  - Category
  - Sub-Category
  - Manufacturer
  - Product Name
- Profit (bin)
- Region
- Measure Names

**Measures**

- Discount
- Profit
- Profit Ratio
- Quantity
- Sales
- Latitude (generated)
- Longitude (generated)
- Number of Records
- Measure Values

**Pages**

**Filters**

**Marks**

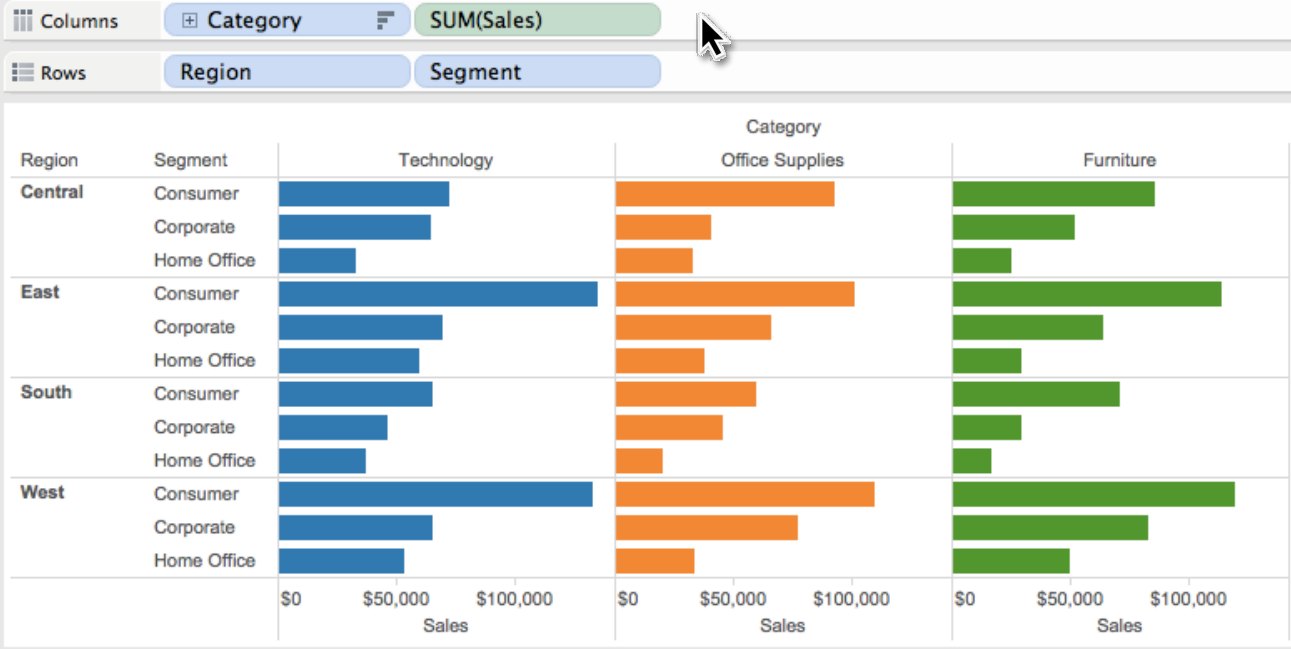
Automatic

Color Size Label

Detail Tooltip

Category

Technology  
Office Supplies  
Furniture



**Data** | Analytics

Sample - Superstore

**Dimensions**

- Customer
  - Customer Name
  - Segment
- Order
- Location
- Product
  - Category
  - Sub-Category
  - Manufacturer
  - Product Name
- Profit (bin)
- Region
- Measure Names

**Measures**

- Discount
- Profit
- Profit Ratio
- Quantity
- Sales
- Latitude (generated)
- Longitude (generated)
- Number of Records
- Measure Values

**Pages**

**Filters**

**Marks**

All

Automatic

Color Size Label

Detail Tooltip

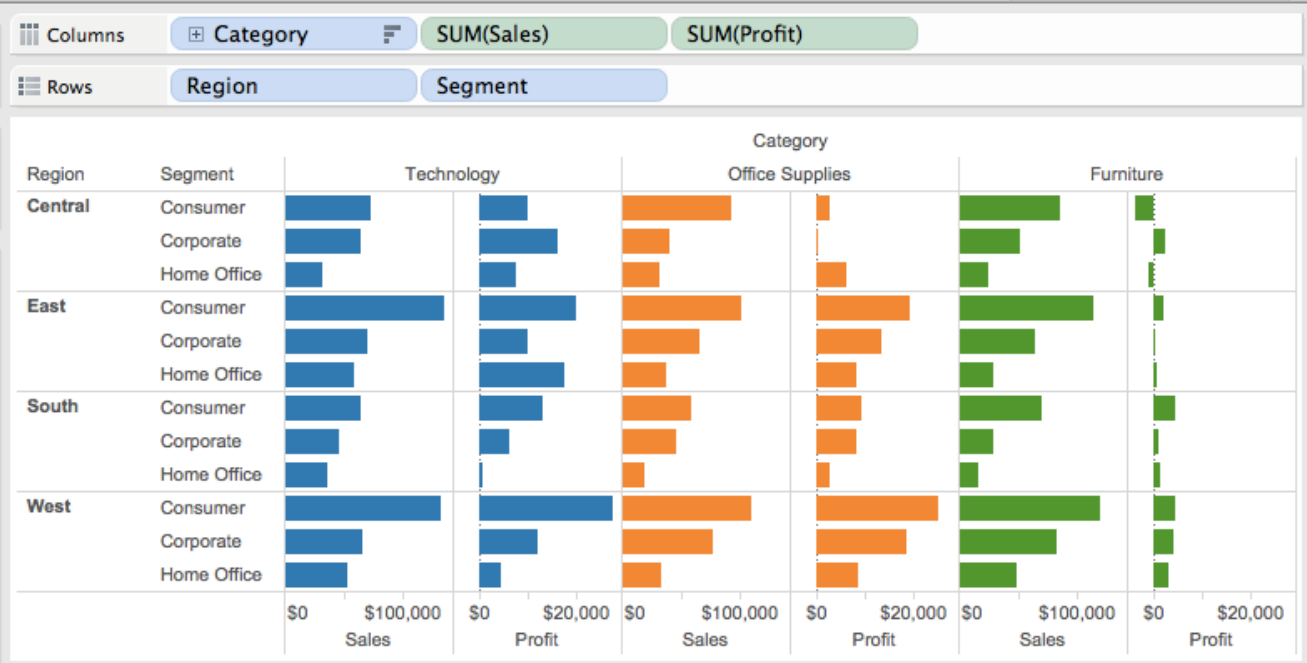
Category

SUM(Sales)

SUM(Profit)

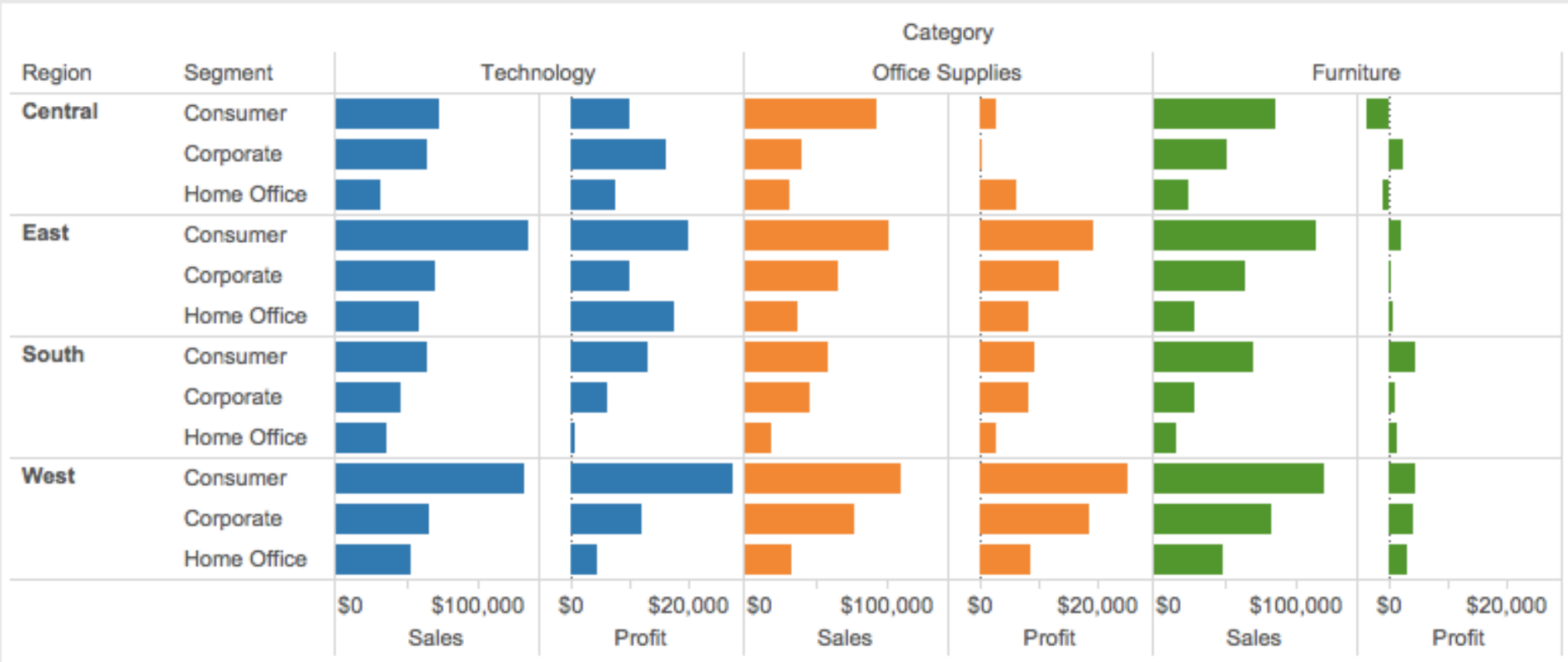
Category

- Technology
- Office Supplies
- Furniture



Columns **Category** ~~SUM(Sales)~~ **SUM(Profit)**

Rows **Region** **Segment**



# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive

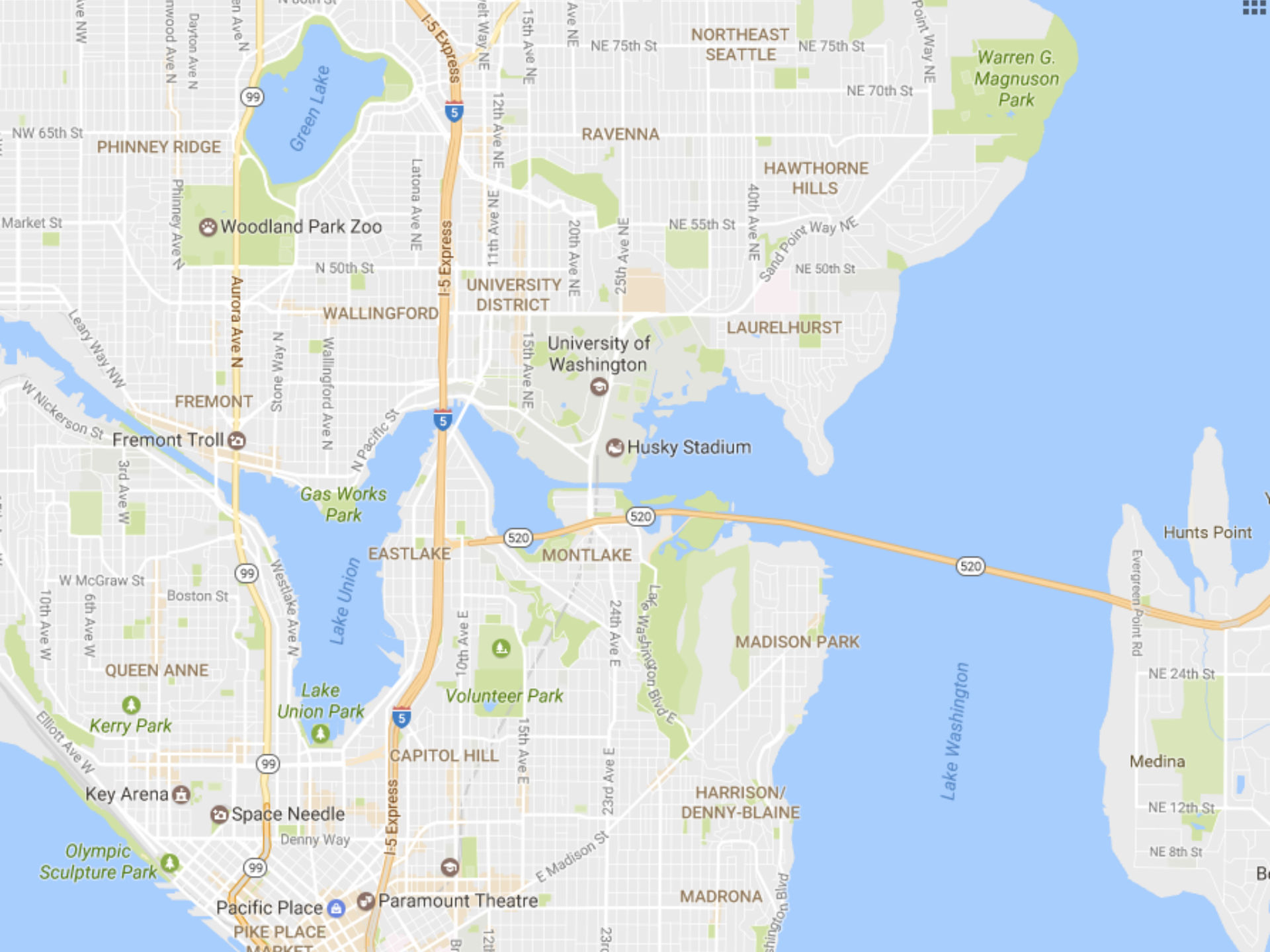
# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive

## View Manipulation

Select, Navigate, Coordinate, Organize



Warren G. Magnuson Park

Woodland Park Zoo

University of Washington

Husky Stadium

Gas Works Park

Lake Union Park

Volunteer Park

Kerry Park

Space Needle

Olympic Sculpture Park

Paramount Theatre

Pacific Place

PIKE PLACE MARKET

NORTHEAST SEATTLE

RAVENNA

HAWTHORNE HILLS

UNIVERSITY DISTRICT

WALLINGFORD

LAURELHURST

FREMONT

EASTLAKE

MONTLAKE

MADISON PARK

QUEEN ANNE

CAPITOL HILL

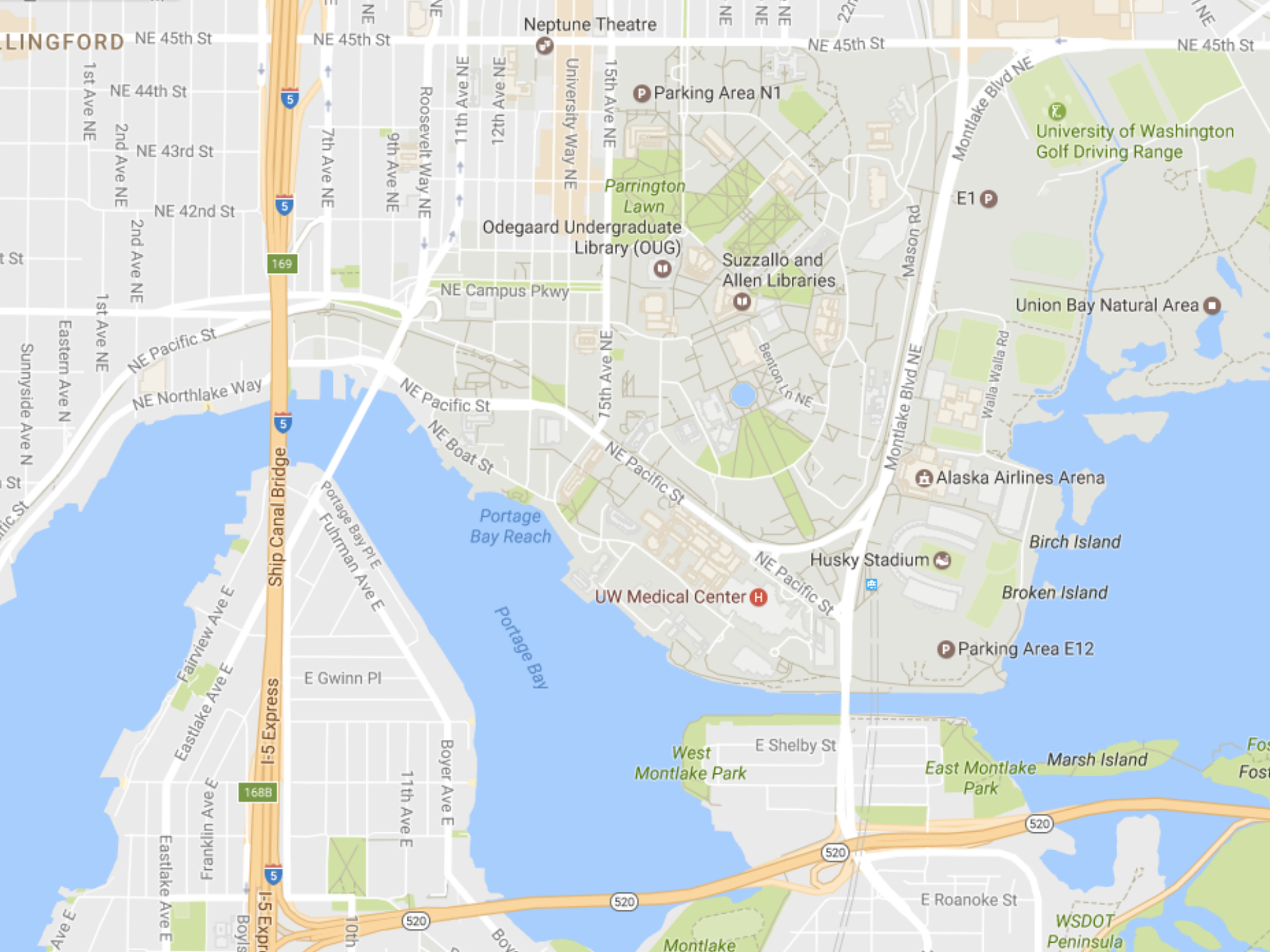
HARRISON/DENNY-BLAINE

MADRONA

Hunts Point

Medina





LINGFORD

Neptune Theatre

University of Washington  
Golf Driving Range

Odegaard Undergraduate  
Library (OUG)

Suzzallo and  
Allen Libraries

Union Bay Natural Area

Alaska Airlines Arena

Husky Stadium

UW Medical Center

Birch Island

Broken Island

Parking Area E12

West  
Montlake Park

East Montlake  
Park

Marsh Island

WSDOT  
Peninsula

169

168B

5

5

520

520

520

520

# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive

## View Manipulation

Select, Navigate, Coordinate, Organize

# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive

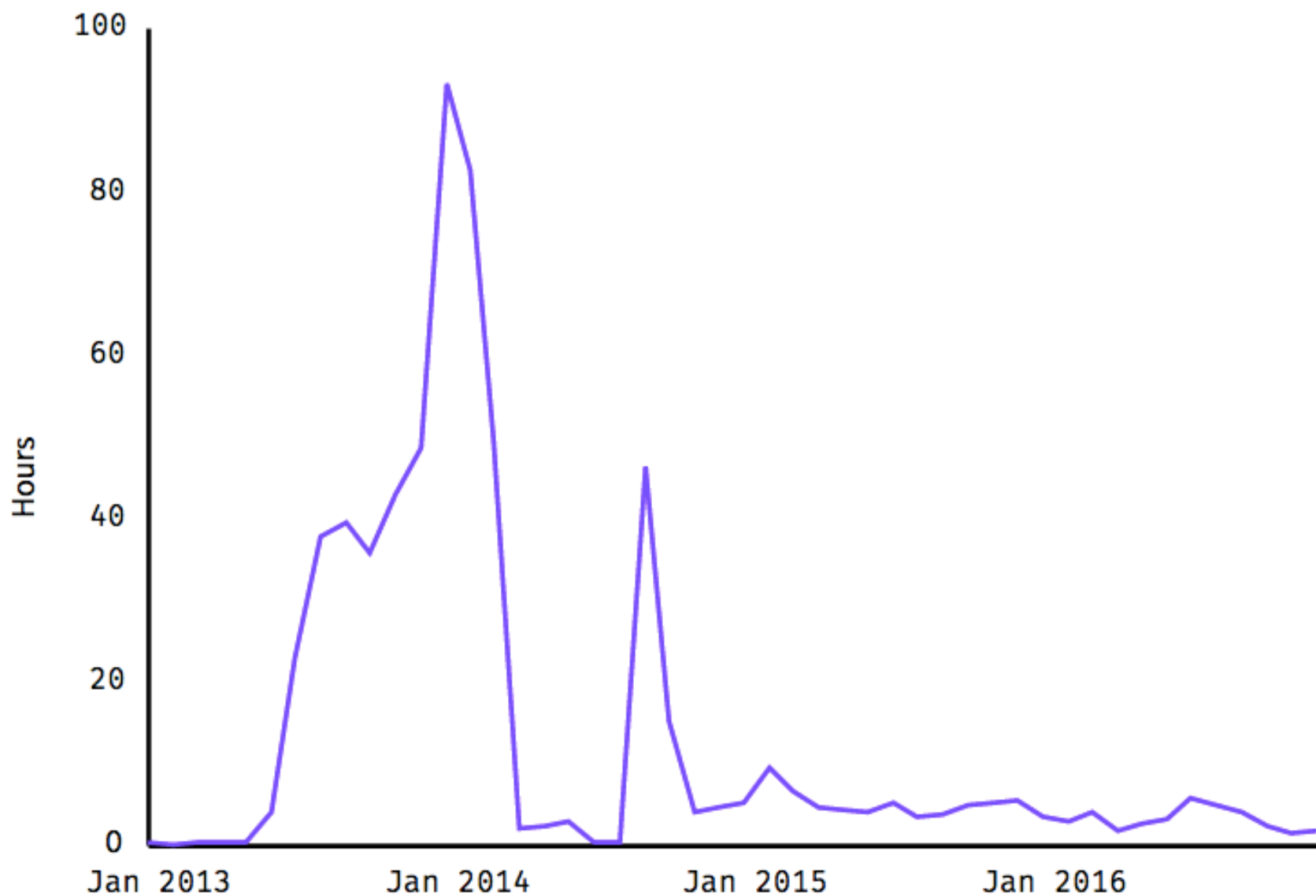
## View Manipulation

Select, Navigate, Coordinate, Organize

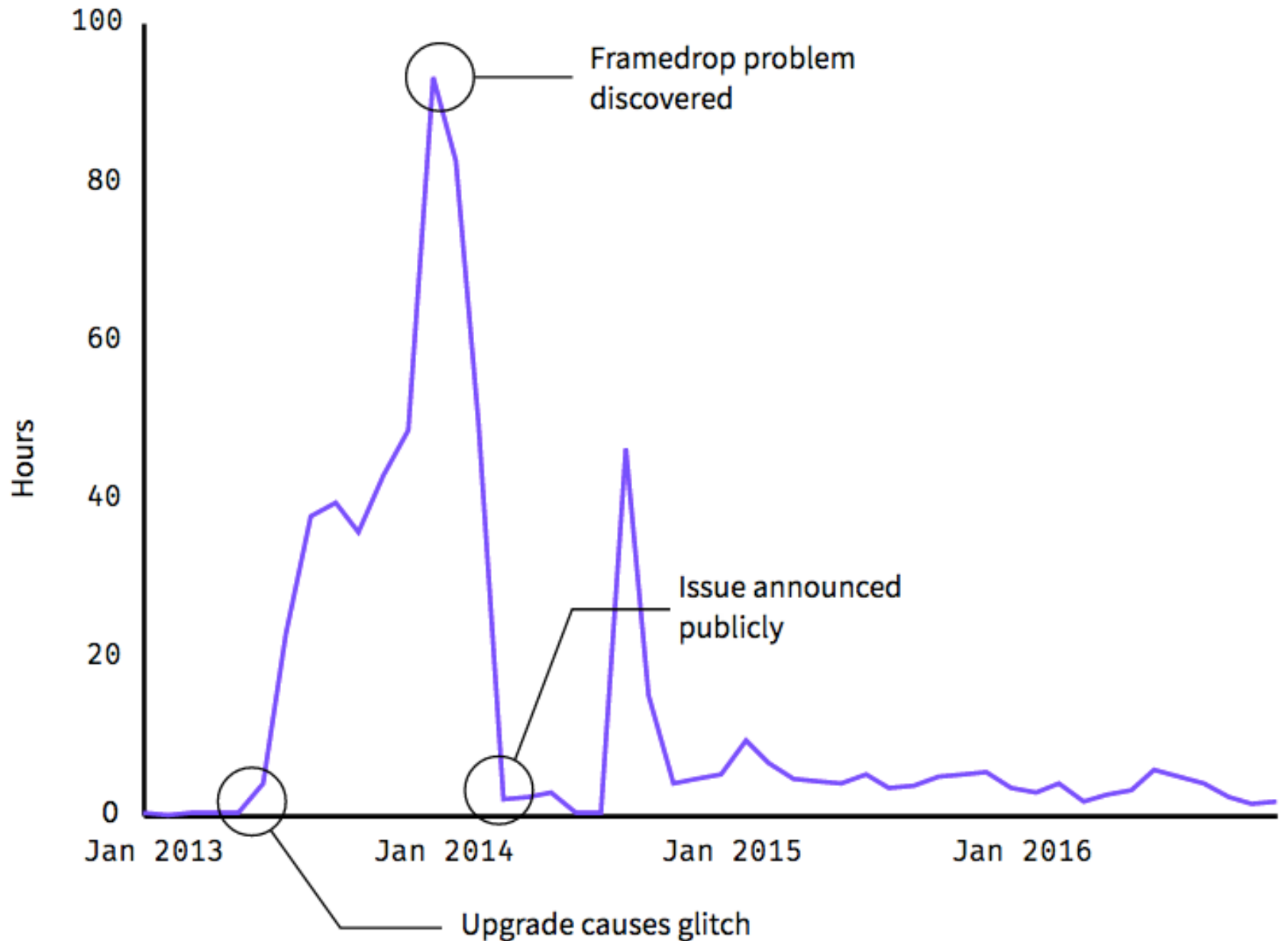
## Process and Provenance

Record, Annotate, Share, Guide

# Hours of footage lost each month due to dropped frames



# Hours of footage lost each month due to dropped frames



# Taxonomy of Interactions

## Data and View Specification

Visualize, Filter, Sort, Derive

## View Manipulation

Select, Navigate, Coordinate, Organize

## Process and Provenance

Record, Annotate, Share, Guide

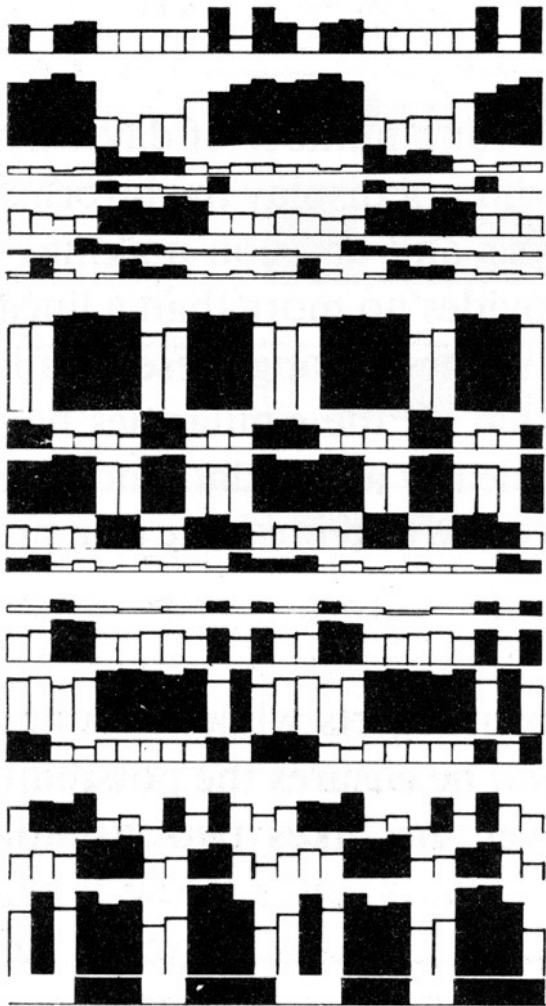
**EXAMPLE:**  
**Bertin's Hotel Data**

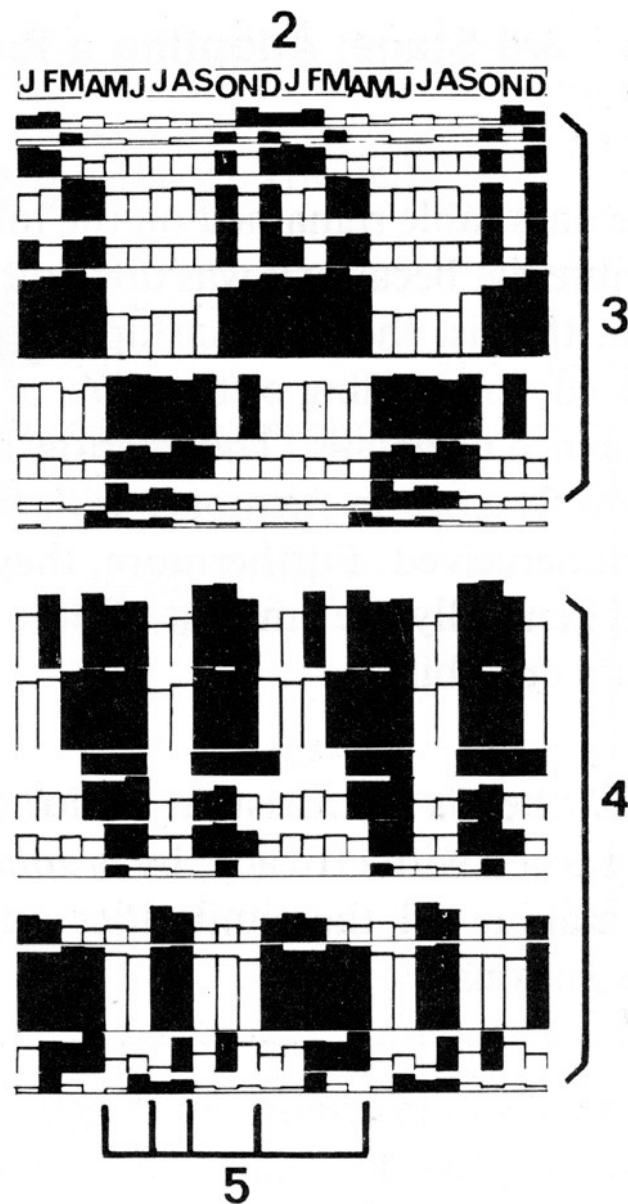
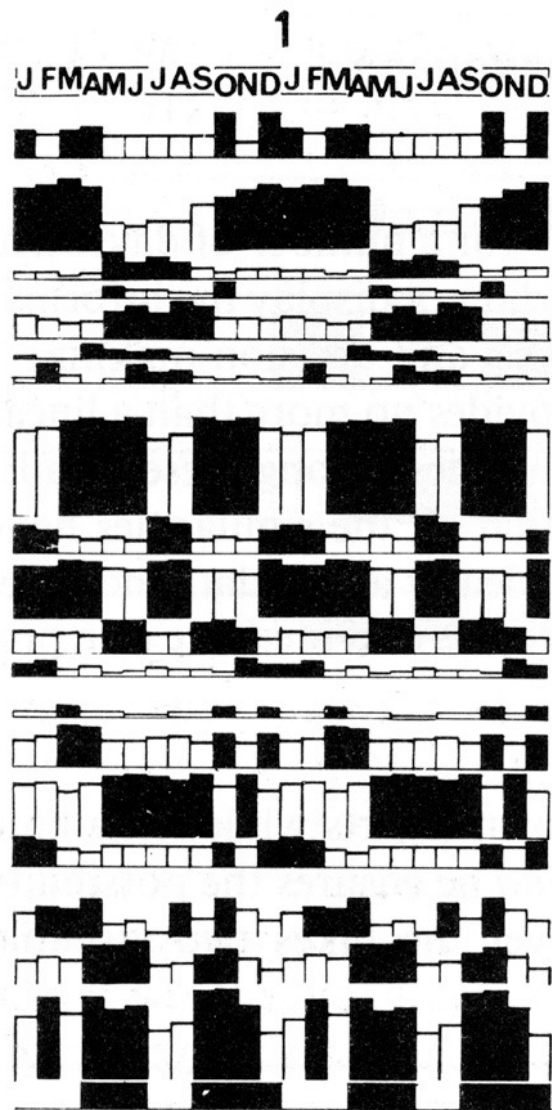
J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —" — LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —" — U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —" — SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —" — EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	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



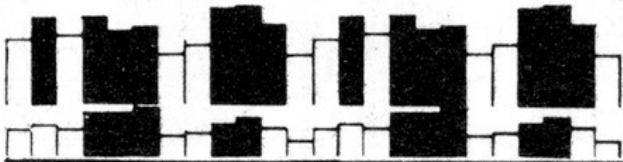
1

J FMAMJ JASONDJ FMAMJ JASOND





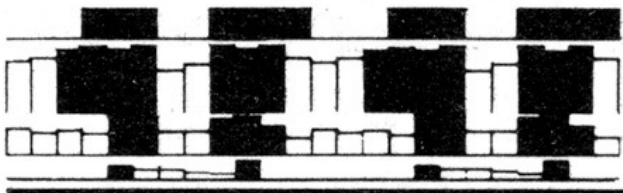
J F M A M J J A S O N D J F M A M J J A S O N D



18 % OCCUPANCY

18 LENGTH OF STAY

ACTIVE AND  
SLOW PERIODS



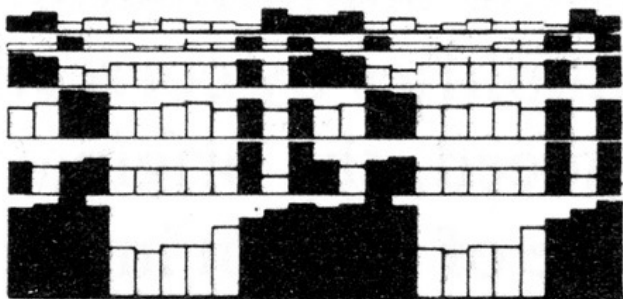
20 CONVENTIONS

8 BUSINESSMEN

11 AGENCY RESERVATIONS

4 SOUTH AMERICA

DISCOVERY FACTORS



18 AIR CREWS

18 CLIENTS UNDER 20 YEARS

18 CLIENTS MORE THAN 55 YEARS

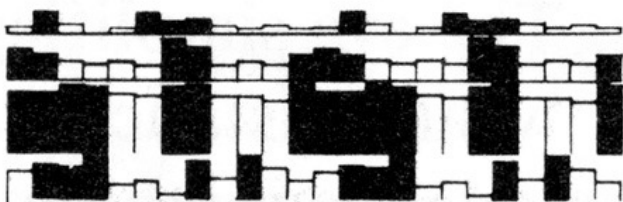
14 CLIENTS FROM 20-35 YEARS

1 FEMALE CLIENTELE

2 LOCAL CLIENTELE

RECOVERY FACTORS

WINTER



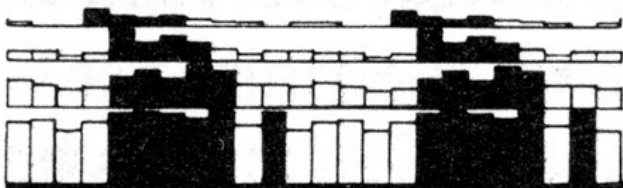
7 ASIA

9 TOURISTS

10 DIRECT RESERVATION

17 PRICE OF ROOMS

WINTER-SUMMER



6 MIDDLE EAST, AFRICA

3 U. S. A.

5 EUROPE

15 CLIENTS FROM 35-55 YEARS

SUMMER



[Graphics and Graphic Information Processing, Bertin 81]



[Graphics and Graphic Information Processing, Bertin 81]



[Graphics and Graphic Information Processing, Bertin 81]

**EXAMPLE:**

**Tukey et al.'s PRIM-9**



PRIM-9, Tukey, Fisherkeller, Friedman 1972



L.



|

|

1 200 400  
175 5

8 175 25 175

1000-200 10 10

7 1 1000

100  
1 1 1000

L,



# Administrivia

# A2: Exploratory Data Analysis

Use visualization software to form & answer questions

## First steps:

Step 1: Pick domain & data

Step 2: Pose questions

Step 3: Profile the data

Iterate as needed

## Create visualizations

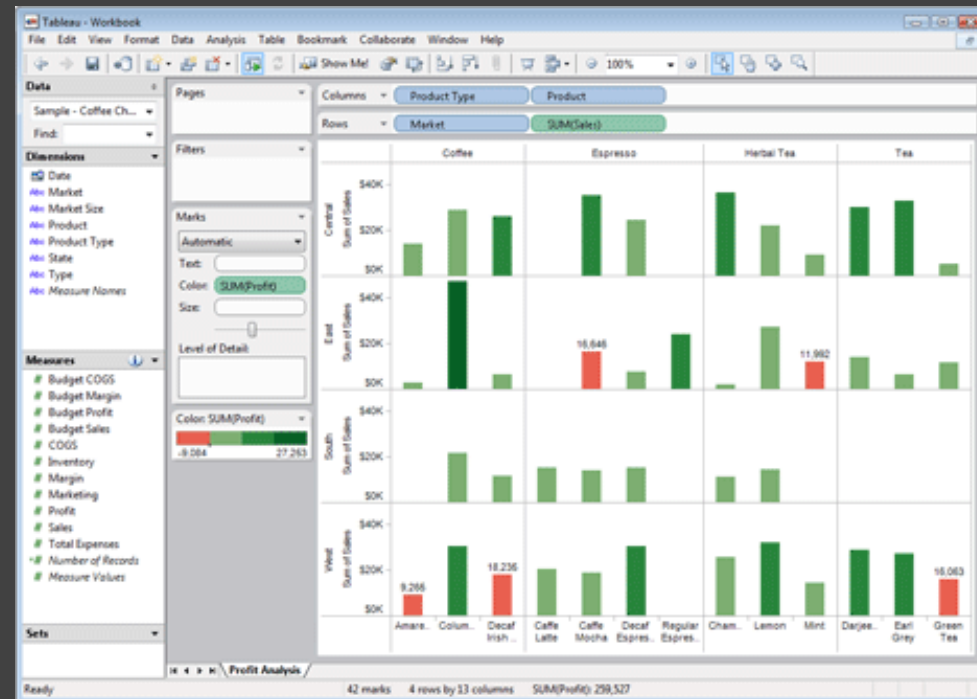
Interact with data

Refine your questions

## Author a report

Screenshots of most insightful views (8+)

Include titles and captions for each view



Due by 11:59pm

**Monday, Apr 19**

# A3: Ethical & Deceptive Visualization

Use visualizations to communicate and influence insights

Design both an ethical and deceptive visualization

**Ethical Visualization:** honestly and transparently communicate the data with an effective and expressive visualization design that is easy to interpret for viewers

**Deceptive Visualization:** intentionally influence viewer's perception to mislead their insights, without revealing it's role as the deceptive design

Due by **11:59 pm PT, Monday May 3rd**

# A3: Ethical & Deceptive Visualization

Use visualizations to communicate and influence insights

Design both an ethical and deceptive visualization

## **Step 1: Pick a dataset**

Consider using the same data for your final project

## **Step 2: Pose question(s) and identify insights**

Use exploratory data analysis to get familiar with the data.

Document your questions in your assignment write-up

## **Step 3: Design visualizations**

Create your ethical and deceptive visualization designs

Consider how visual and narrative elements can be incorporated

# A3: Ethical & Deceptive Visualization

**Deliverables** (upload via Canvas; [see A3 page](#))

Image of your visualization (.png or .jpg format)

Images should be named **ethical** and **deceptive** accordingly

Image itself **should not give away which design is which**

Write-up including a short description + design rationale

Due by **11:59 pm PT, Monday May 3rd**

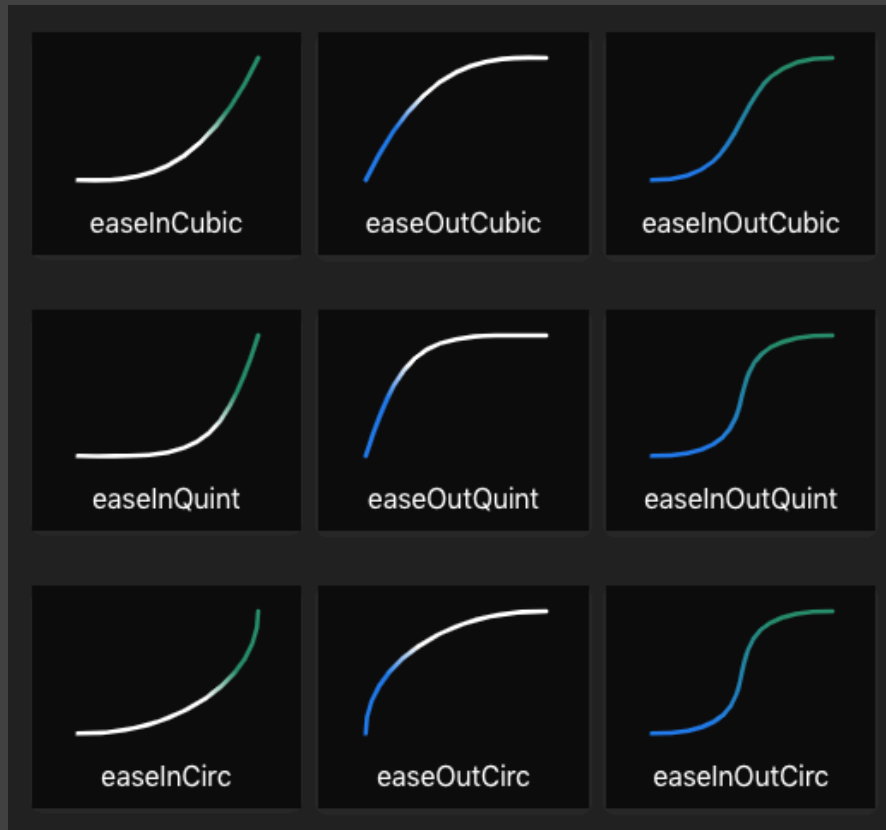
**Assignment A3b: Peer Evaluation** ([see course website](#))

Provide constructive feedback on **four peer designs**

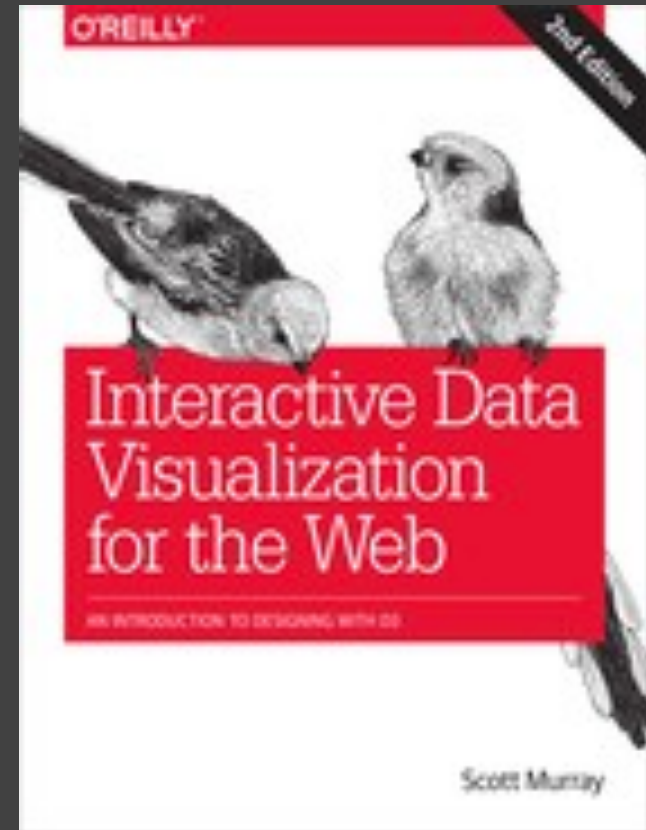
Guess which visualization designs are deceptive and ethical

Due by 11:59pm PT, Monday May 10th (the following Monday)

# Required Readings for Wed 4/21



Easing Functions Cheat Sheet.



Chapters 11, 12 in Interactive Data Visualization for the Web. Scott Murray.



# Selection

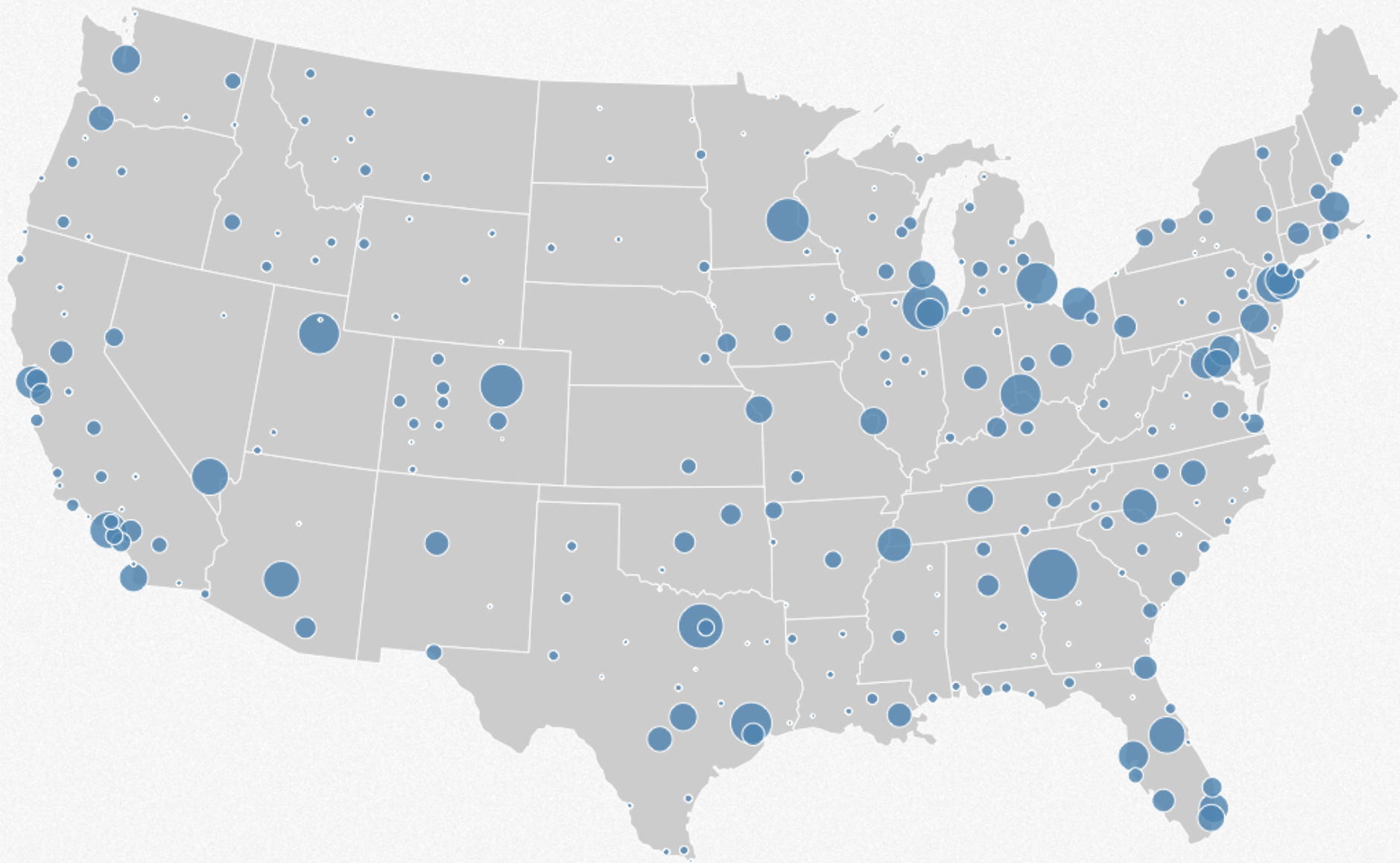
# Basic Selection Methods

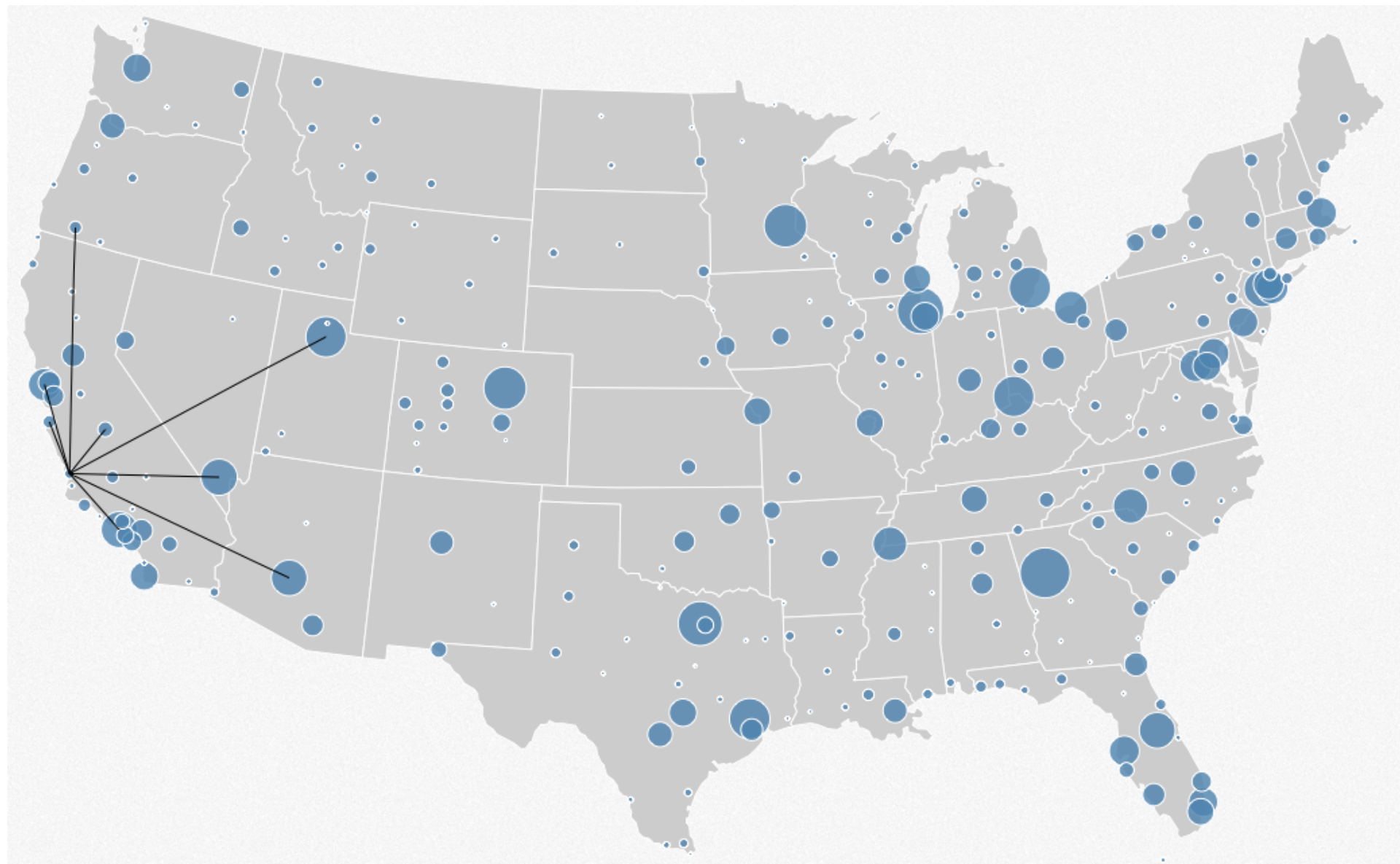
## Point Selection

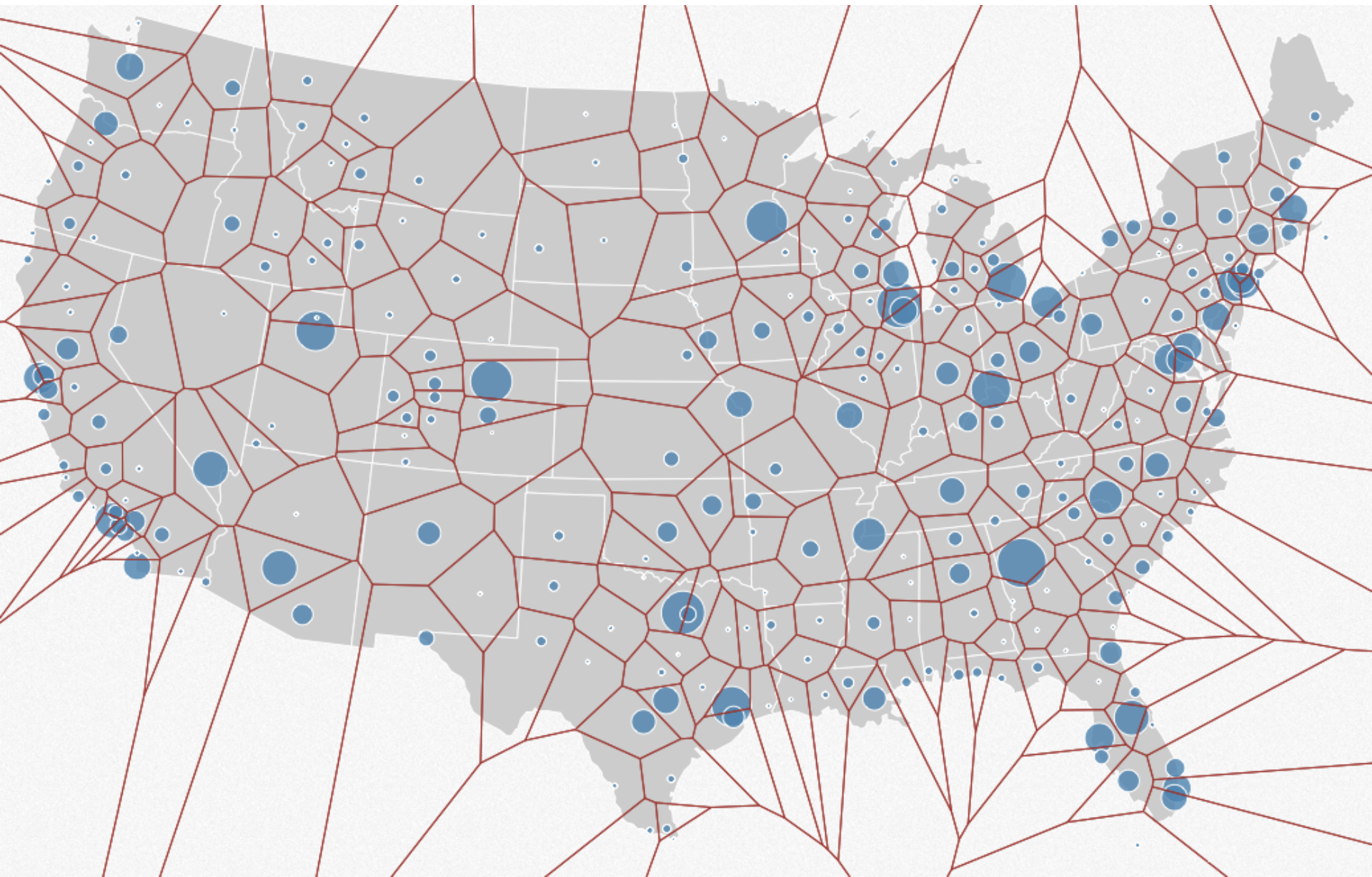
Mouse Hover / Click

Touch / Tap

Select Nearby Element (e.g., Bubble Cursor)







# Basic Selection Methods

## Point Selection

Mouse Hover / Click

Touch / Tap

Select Nearby Element (e.g., Bubble Cursor)

## Region Selection

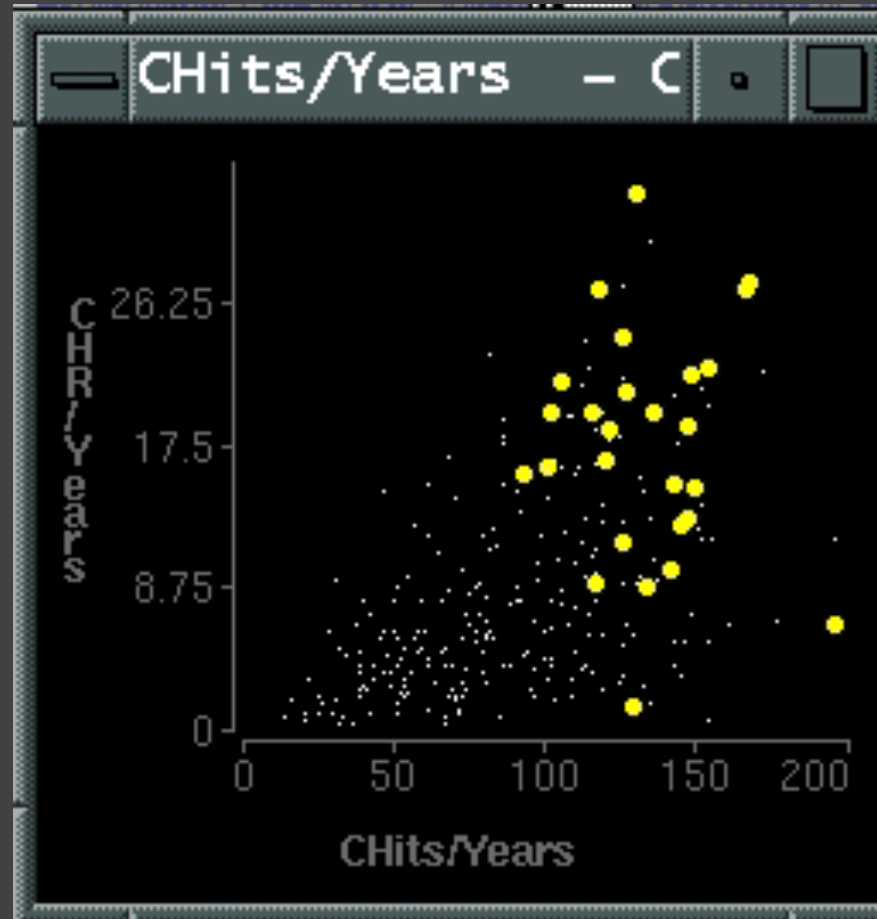
Rubber-band (rectangular) or Lasso (freehand)

Area cursors ("brushes")

# Brushing & Linking

# Brushing

Direct attention to a subset of data [Wills 95]

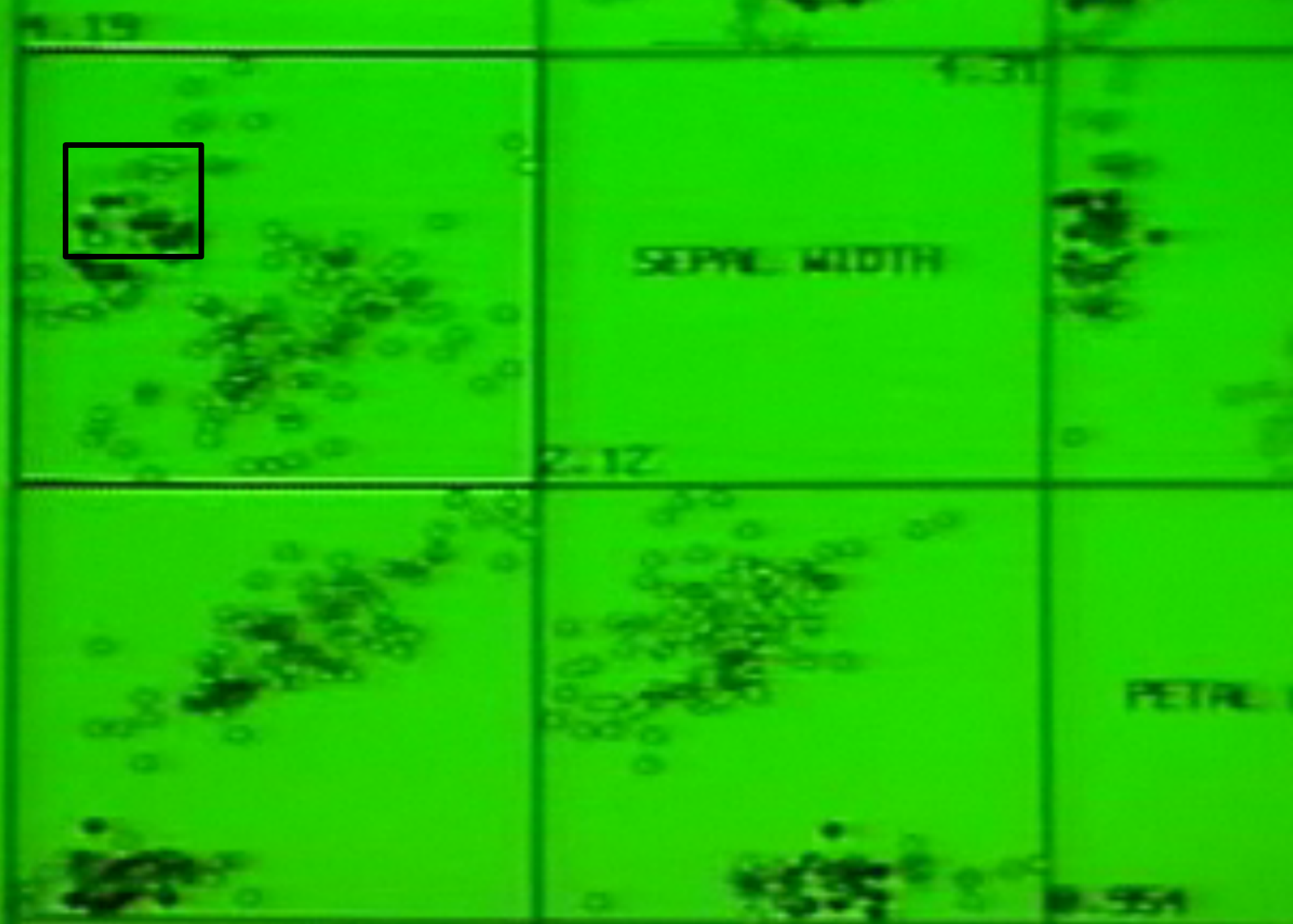




# Brushing & Linking

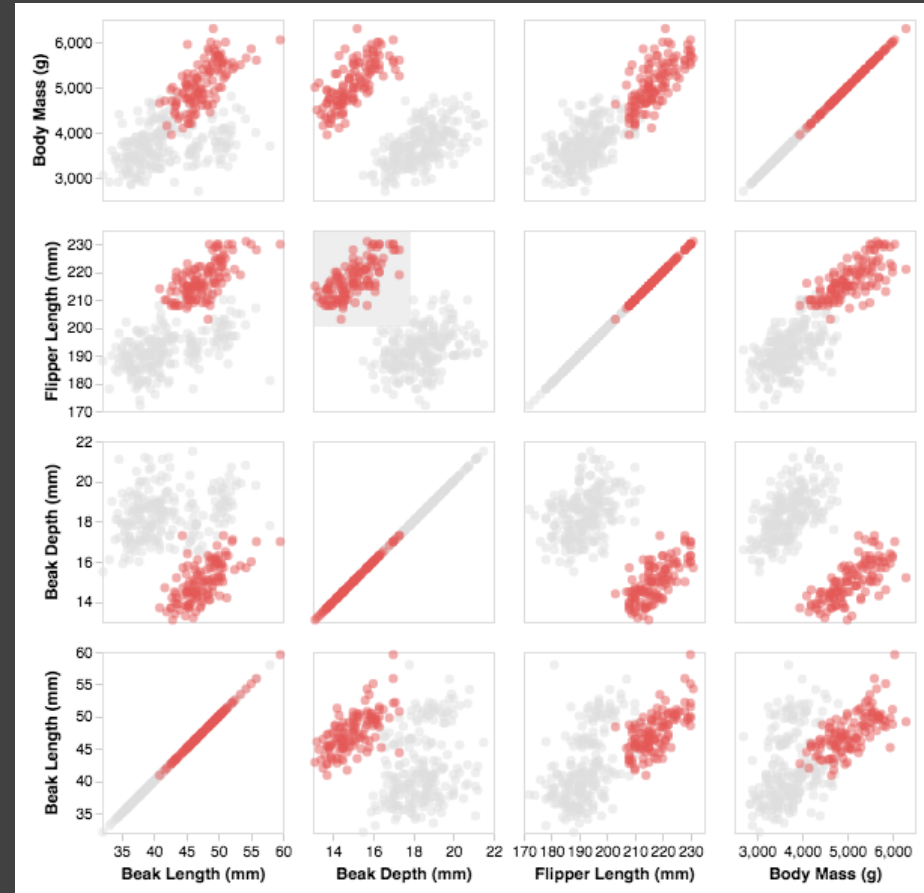
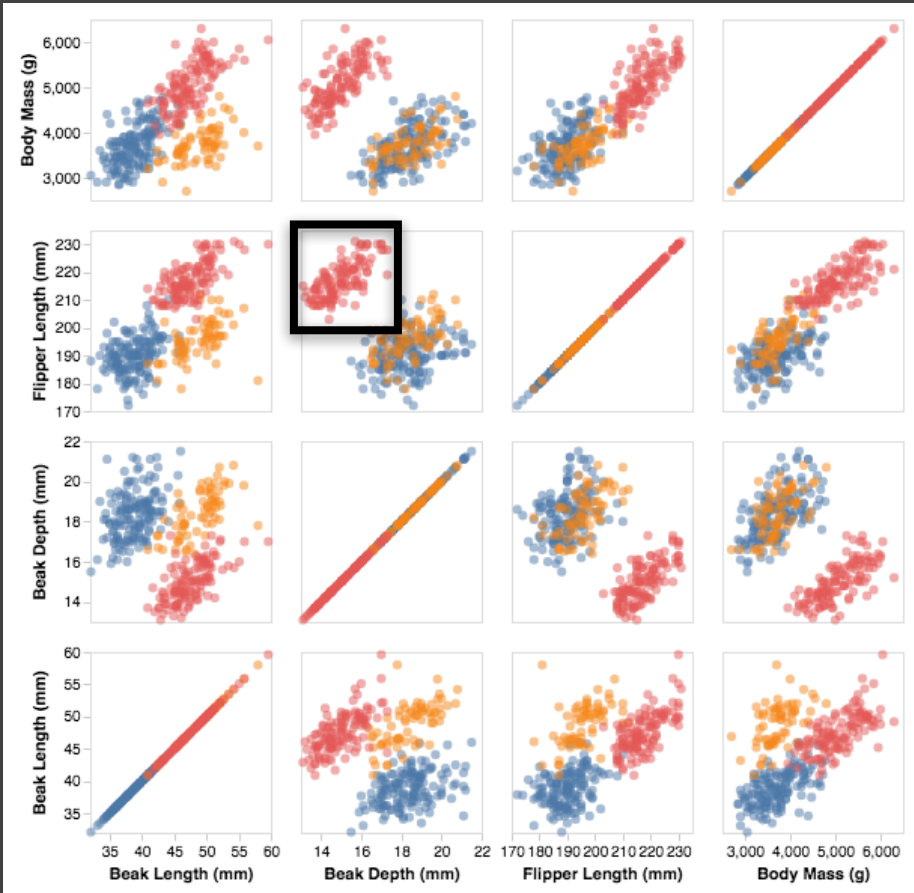
Select ("**brush**") a subset of data  
See selected data in other views

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



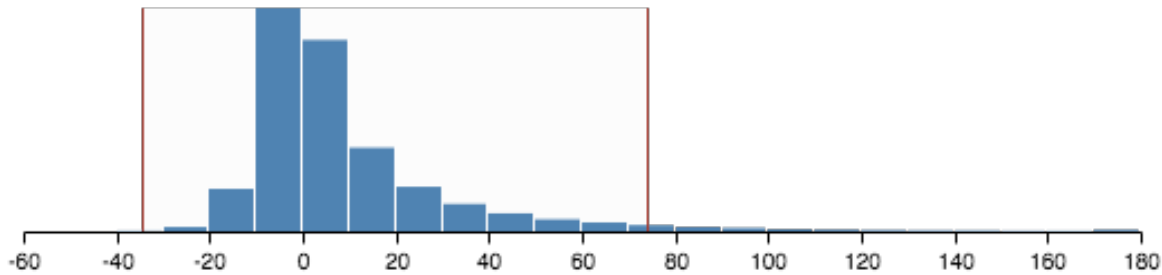
Brushing Scatterplots, Becker & Cleveland 1982

# Brushing Scatterplots

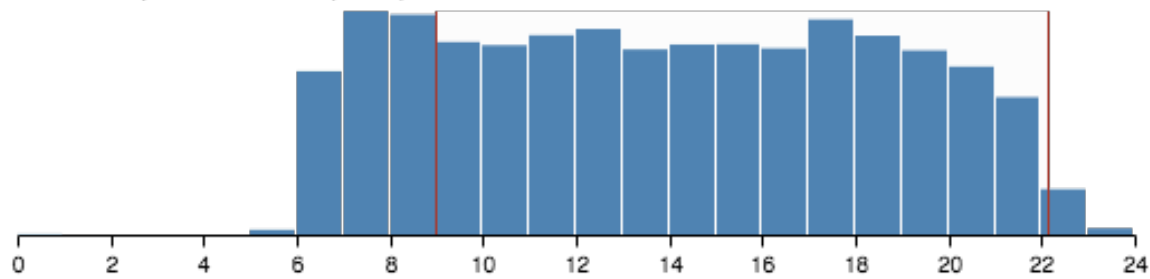


# Cross-Filtering

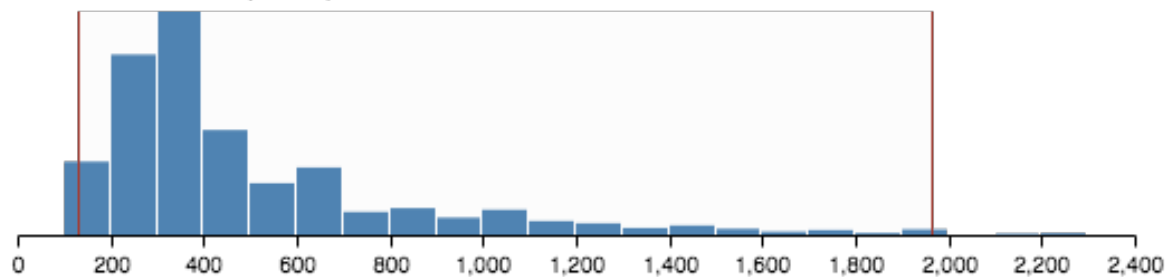
Arrival Delay (min)



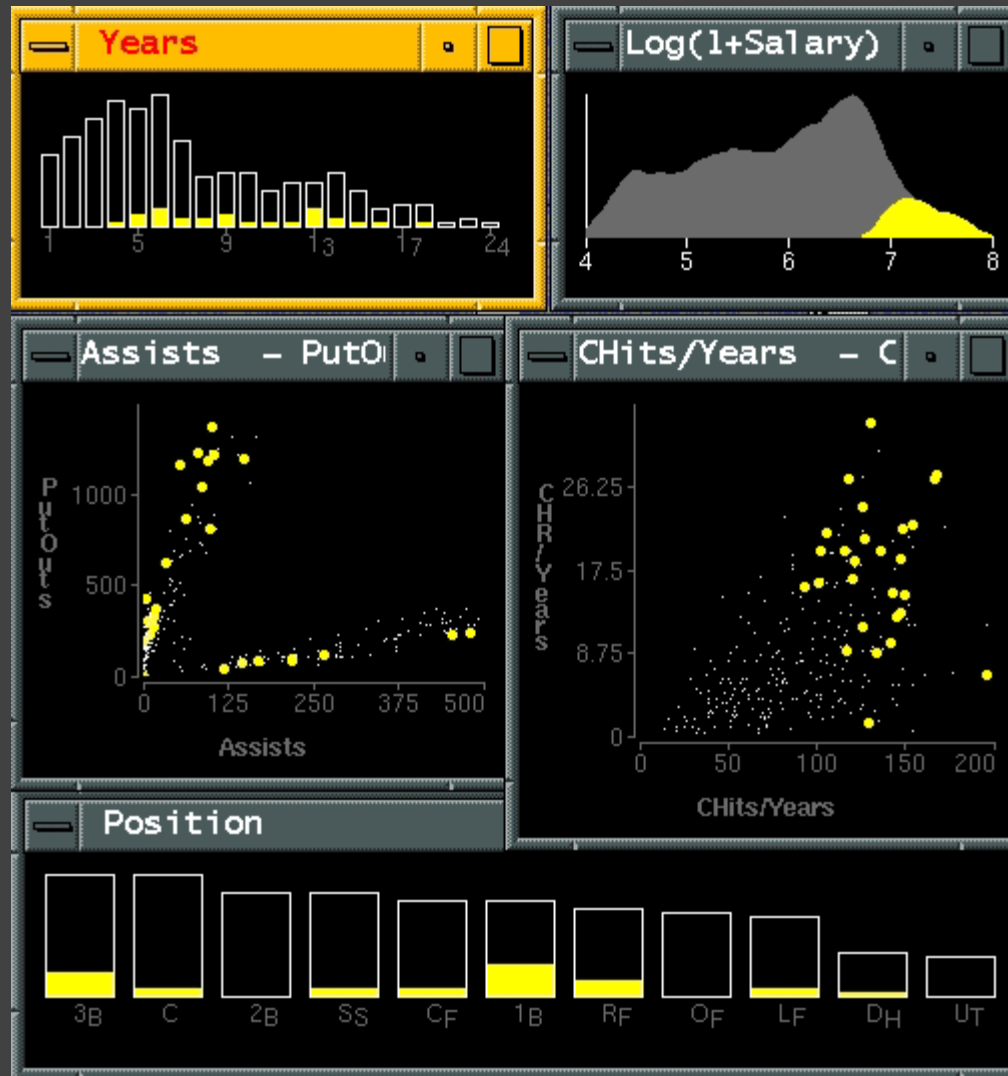
Local Departure Time (hour)



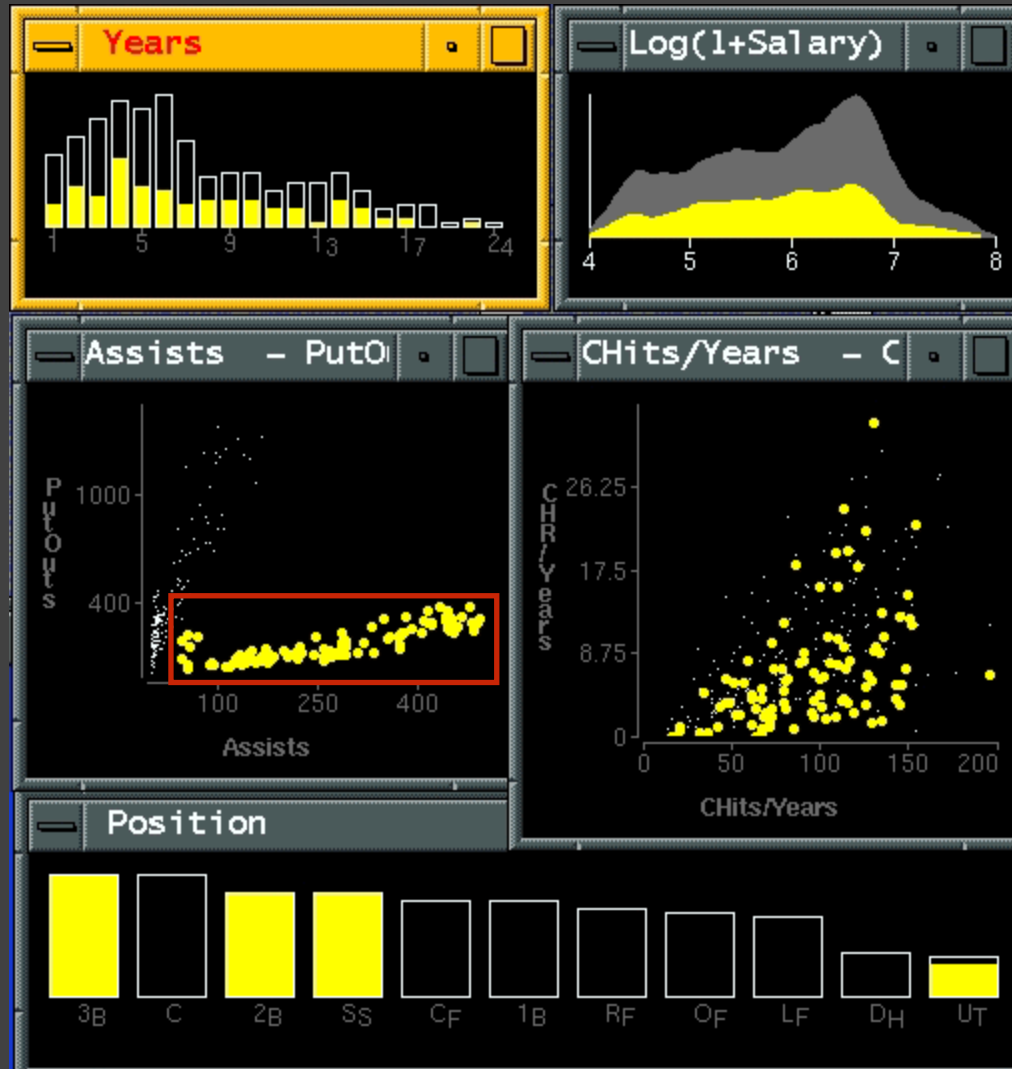
Travel Distance (miles)



# Baseball Statistics [Wills 95]



# Linking Assists to Positions



# Dynamic Queries

# Query & Results

```
SELECT house FROM seattle_homes
```

```
WHERE price < 1,000,000 AND bedrooms > 2
```

```
ORDER BY price
```

Dynamic Browser : DC Home Finder

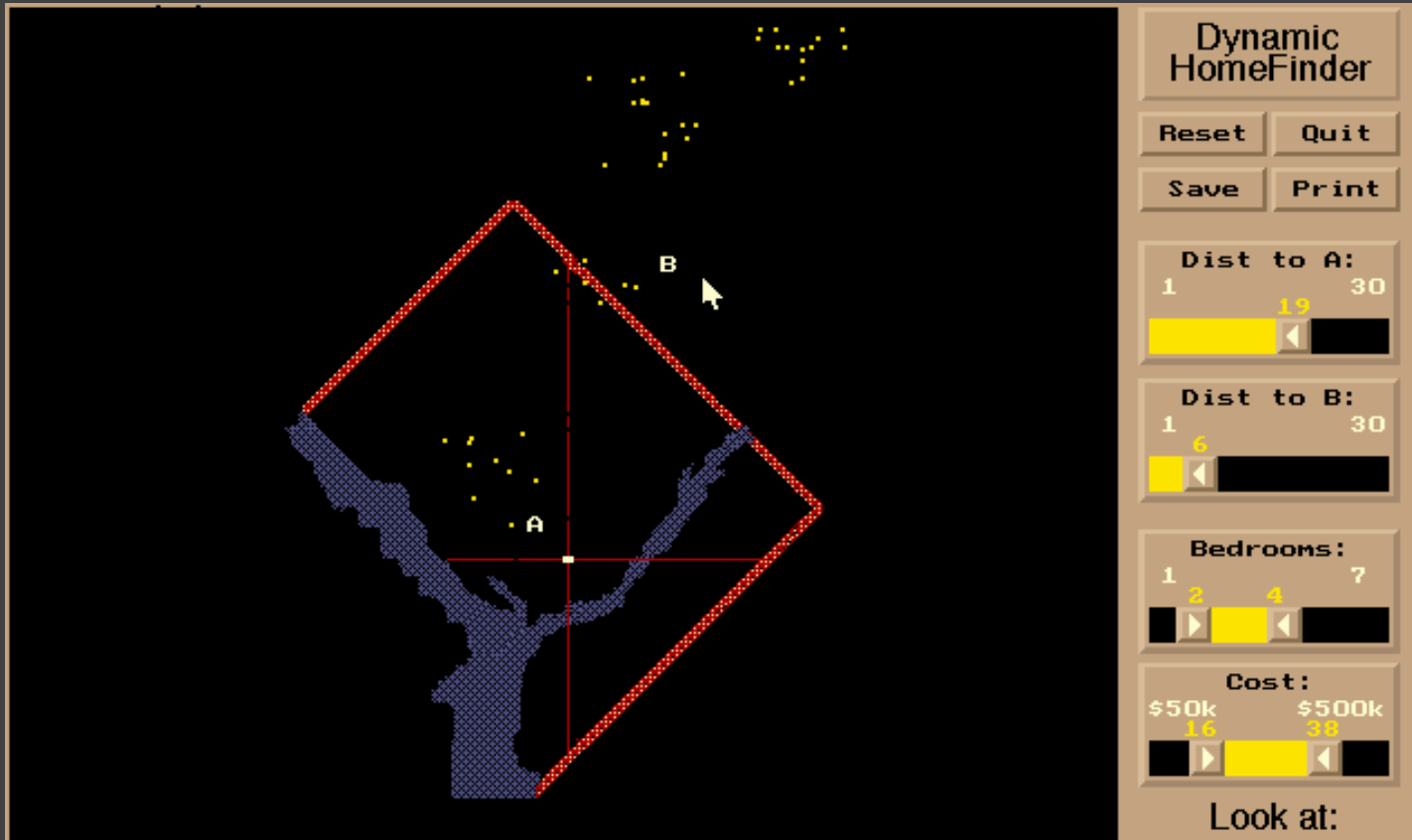
IdNumber	Dwelling	Address	City
2	House	5256 S. Capitol St.	Beltsville, MD
4	House	5536 S. Lincoln St.	Beltsville, MD
5	House	5165 Jones Street	Beltsville, MD
8	House	5007 Jones Street	Beltsville, MD
9	House	4872 Jones Street	Beltsville, MD
17	House	5408 S. Capitol St.	Beltsville, MD
20	House	5496 S. Capitol St.	Beltsville, MD
85	Condo	5459 S. Lincoln St.	Laurel, MD
86	Condo	5051 S. Lincoln St.	Laurel, MD
88	Condo	5159 Hamilton Street	Laurel, MD
92	Condo	5132 Hamilton Street	Laurel, MD
93	Condo	5221 S. Lincoln St.	Laurel, MD
94	Condo	5043 S. Lincoln St.	Laurel, MD
95	Condo	4970 Jones Street	Laurel, MD
97	Condo	4677 Jones Street	Laurel, MD
98	Condo	4896 S. Capitol St.	Laurel, MD
99	Condo	5048 S. Capitol St.	Laurel, MD
100	Condo	4597 31st Street	Laurel, MD
101	Condo	5306 S. Lincoln St.	Laurel, MD
103	Condo	5562 Glass Road	Laurel, MD
105	Condo	5546 Hamilton Street	Laurel, MD
152	House	7670 31st Street	Upper Marlboro, MD



# Issues with Textual Queries

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



The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it.

You may drag the 'A' and 'B' distance markers to your office or any other location you want to live near.

Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right.

Select specific home types and services by pressing the labeled buttons on the right.

**Dynamic HomeFinder**

Reset Quit

Save Print

Dist to A:  
1 30  
19

Dist to B:  
1 30  
6

Bedrooms:  
1 2 4 7

Cost:  
\$50k \$500k  
16 38

Look at:  
Hse TH Cnd

Features:  
Grg Fp1  
CAC New

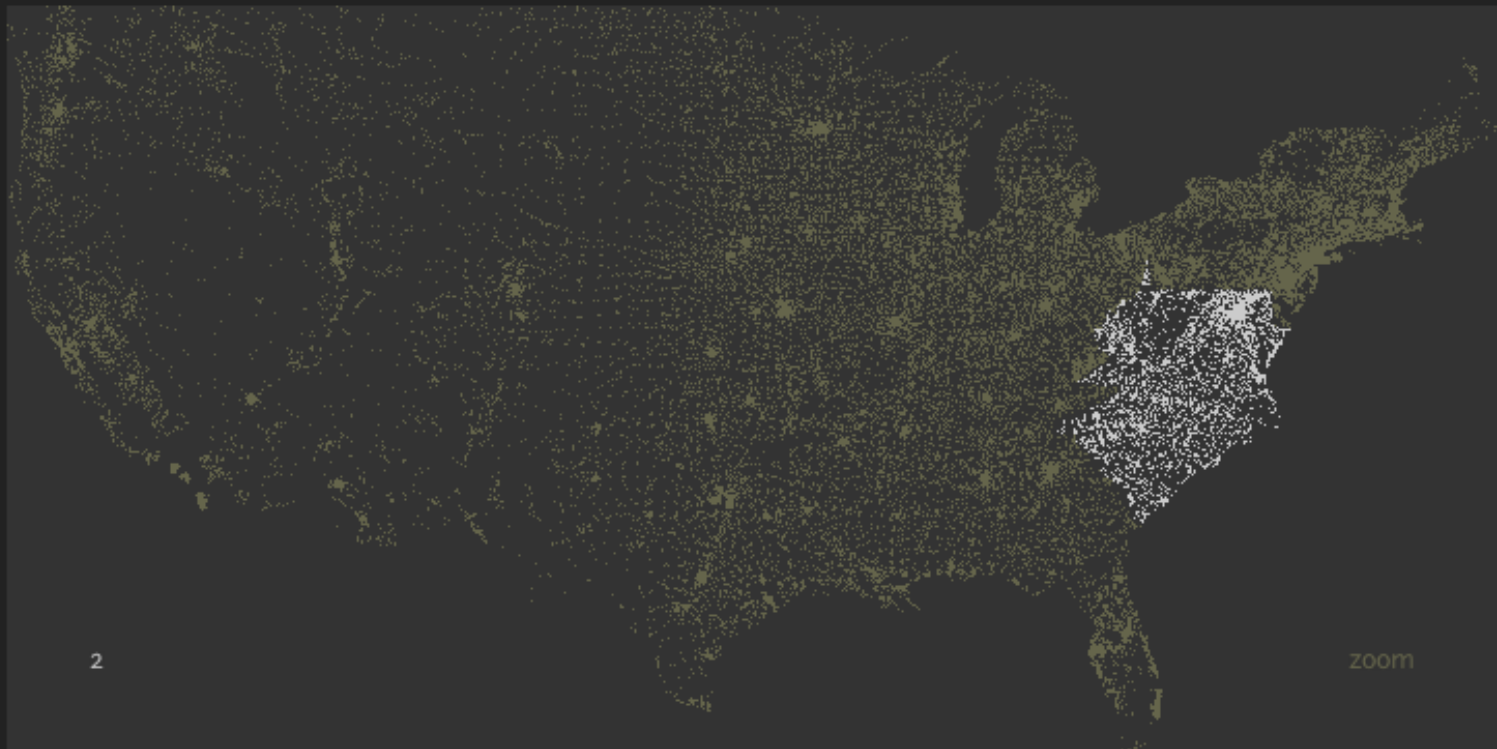
[Williamson and Shneiderman 92]

# 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

- The Attribute Explorer

# Zipdecode [Fry 04]

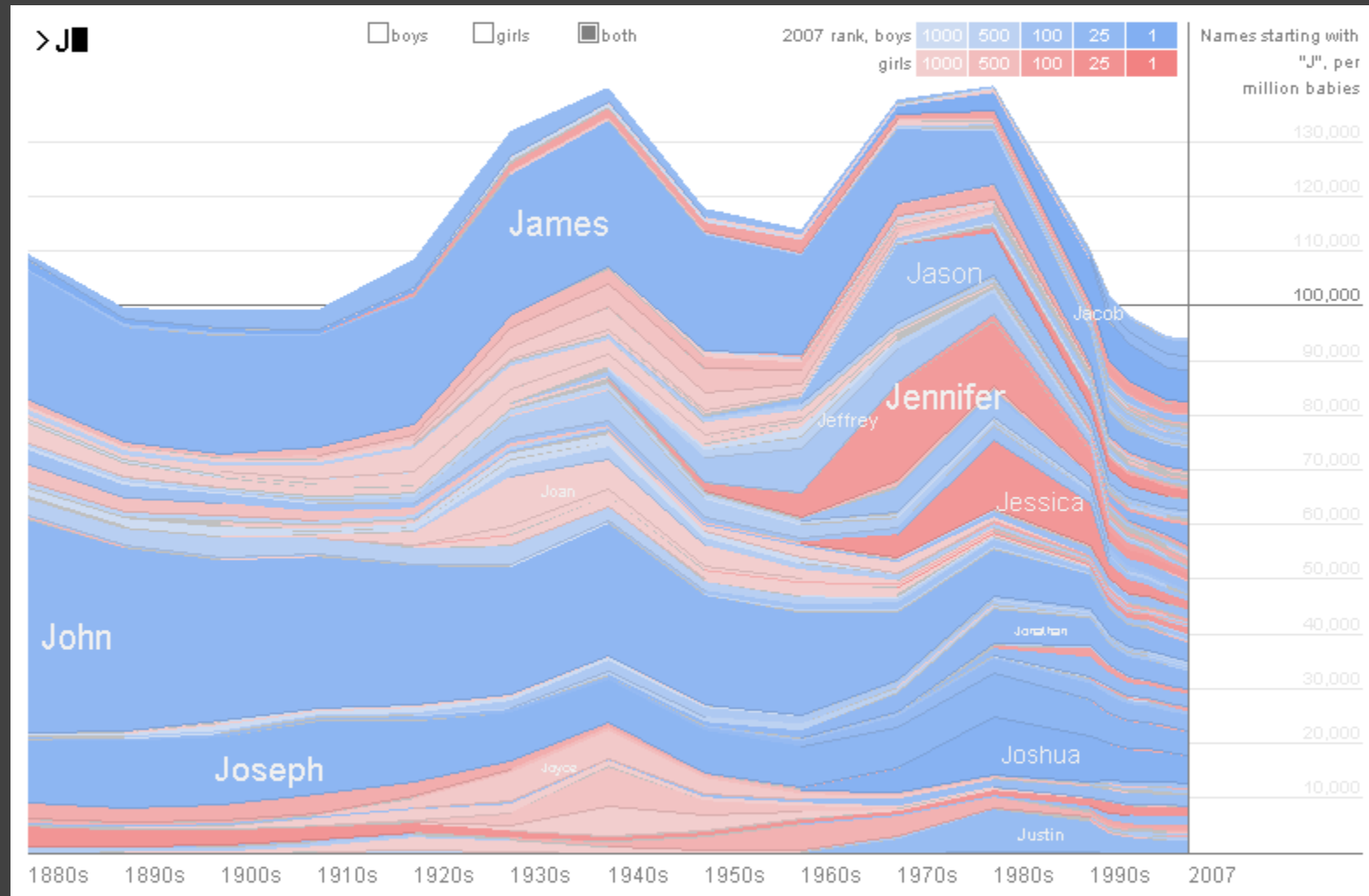


Hit the letter **z**, or click the word **zoom** to enable or disable zooming.

Hold down **shift** while typing a number to replace the previous number (U.S. keyboards only).

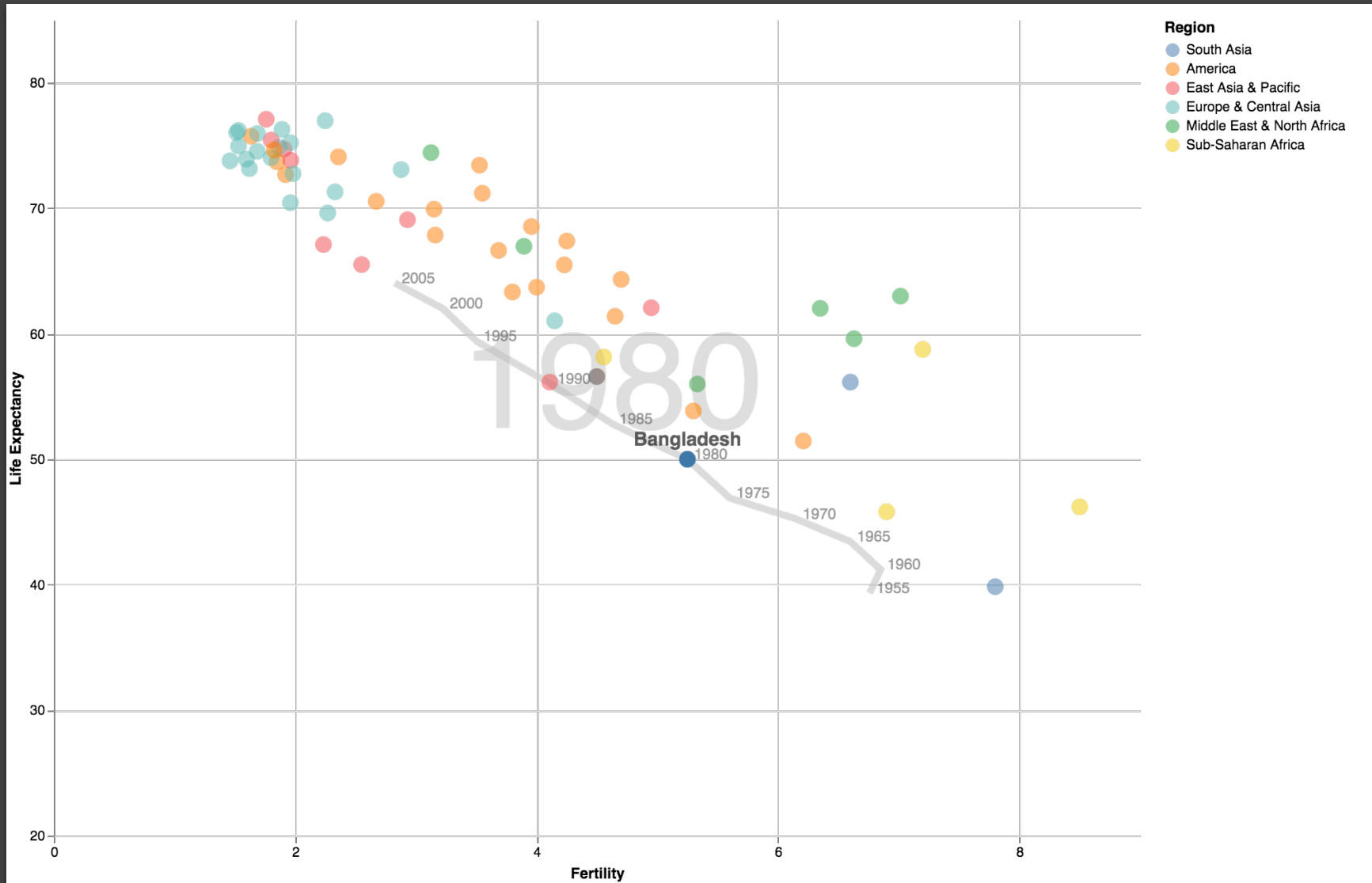
<http://benfry.com/zipdecode/>

# NameVoyager [Wattenberg 06]

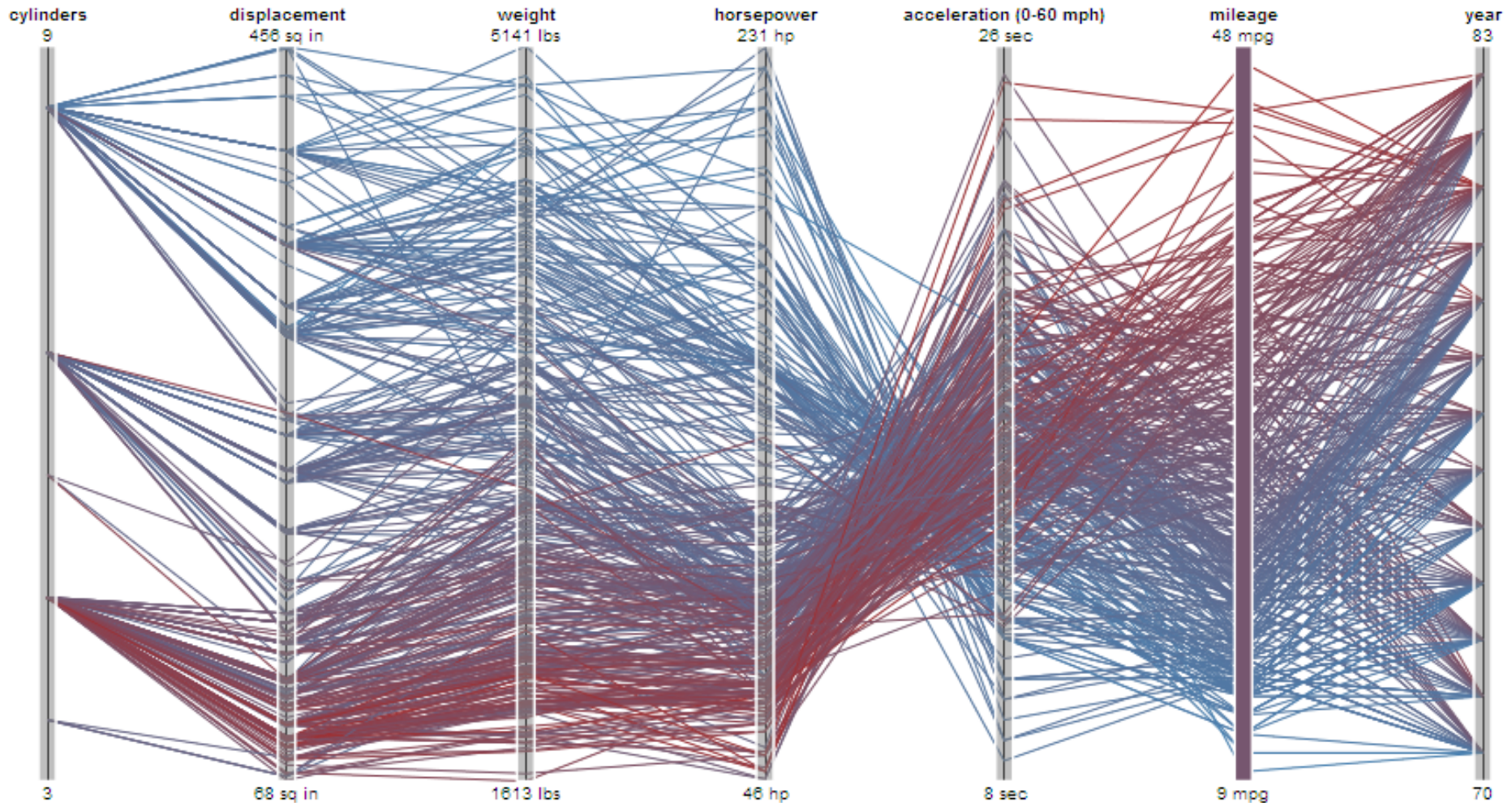


<http://www.babynamewizard.com/voyager>

# DimpVis [Kondo 14]

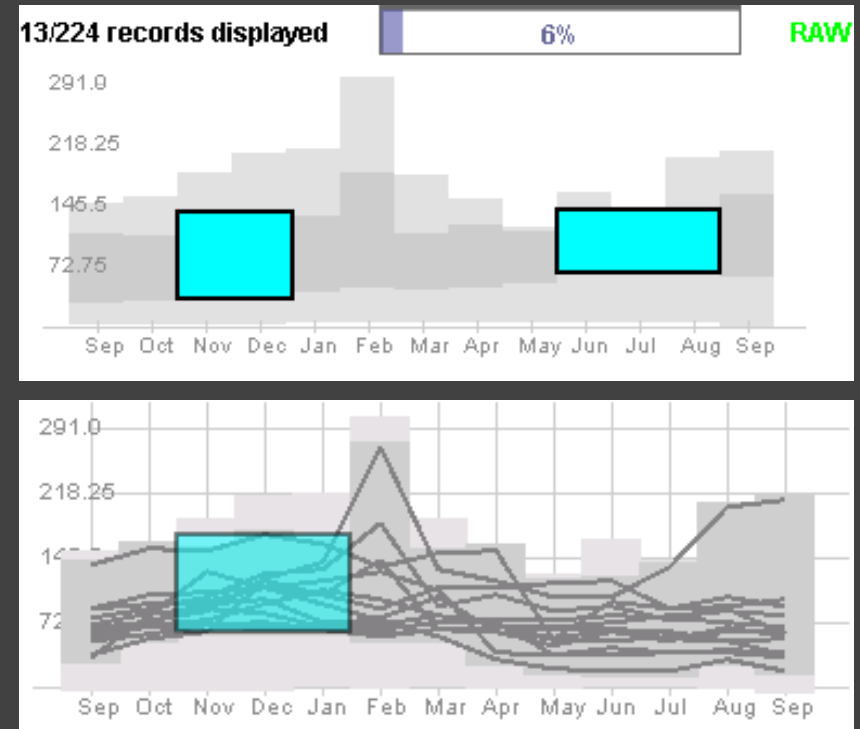
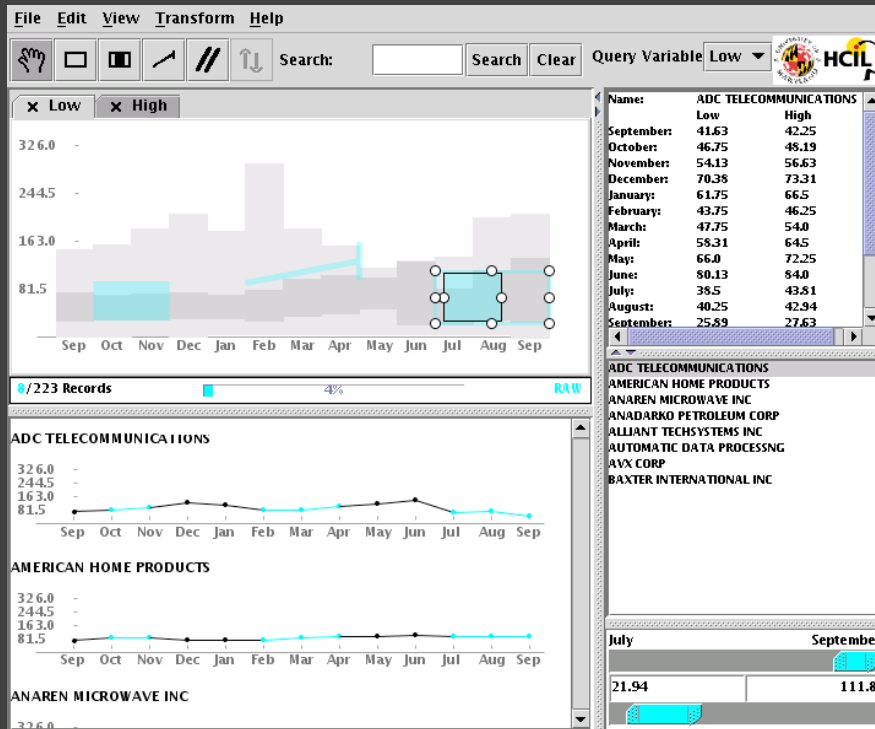


# Parallel Coordinates [Inselberg]





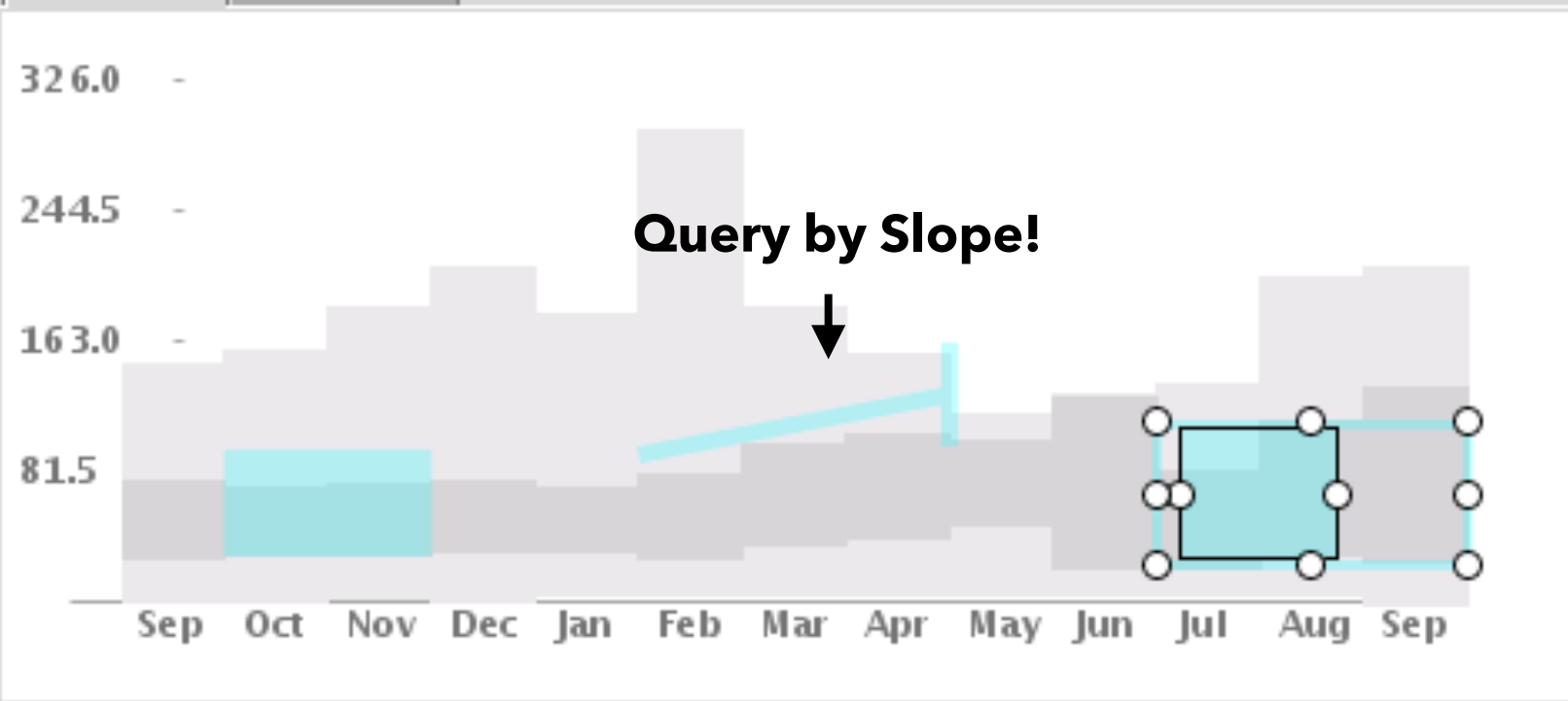
# TimeSearcher [Hocheiser 02]



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

X Low

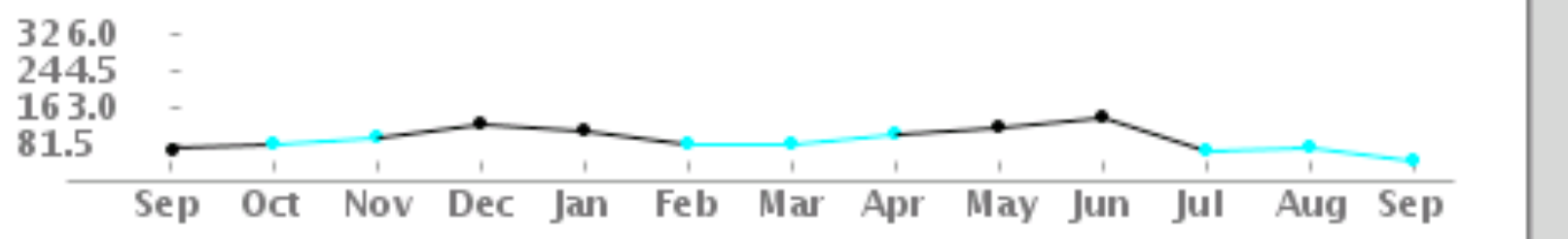
X High



- Name:
- September:
- October:
- November:
- December:
- January:
- February:
- March:
- April:
- May:
- June:
- July:
- August:
- September:

8/223 Records ■ 4% RAW

**ADC TELECOMMUNICATIONS**



**AMERICAN HOME PRODUCTS**



- ADC TELECOMM
- AMERICAN HOM
- ANAREN MICRO
- ANADARKO PET
- ALLIANT TECHS
- AUTOMATIC DA
- AVX CORP
- BAXTER INTERN

# Pros & Cons

## Pros

Controls useful for both novices and experts

Quick way to explore data

# Pros & 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?

# 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