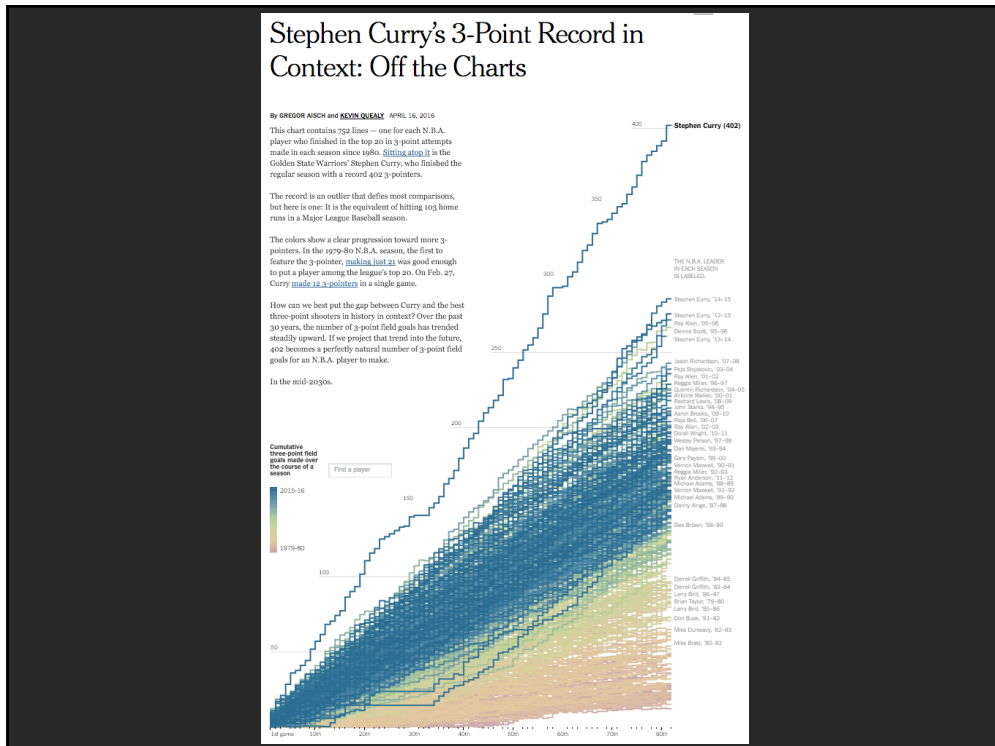


# Interaction

Maneesh Agrawala

CS 448B: Visualization  
Winter 2020

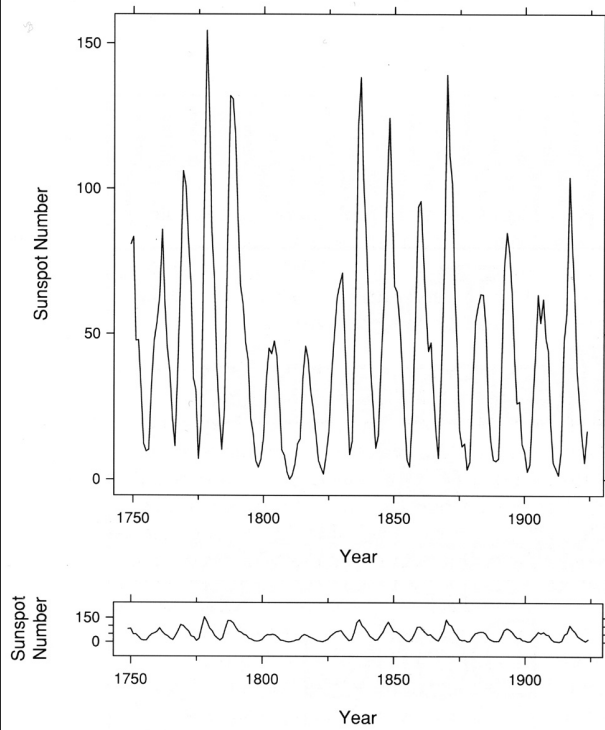
1



2

# Last Time: Using Space Effectively

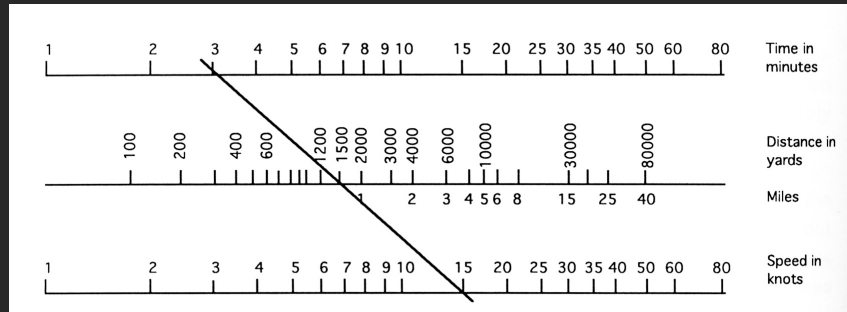
4



William S. Cleveland  
*The Elements of  
Graphing Data*

5

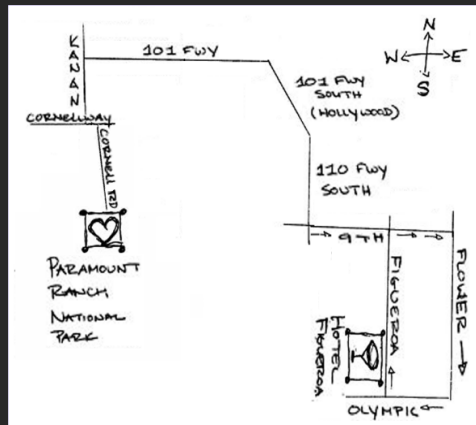
# Nomograms



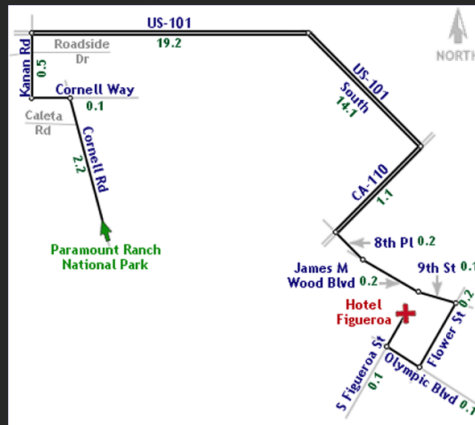
1. Compute in any direction; fix n-1 params and read nth param
2. Illustrate sensitivity to perturbation of inputs
3. Clearly show domain of validity of computation

6

# LineDrive [Agrawala & Stolte 2001]



Hand-drawn route map

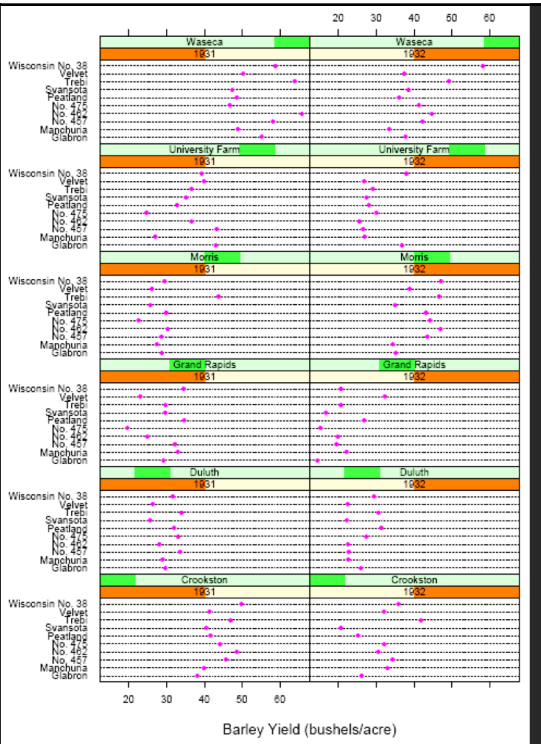


LineDrive route map

7

# Trellis

[Becker, Cleveland, and Shyu 96]



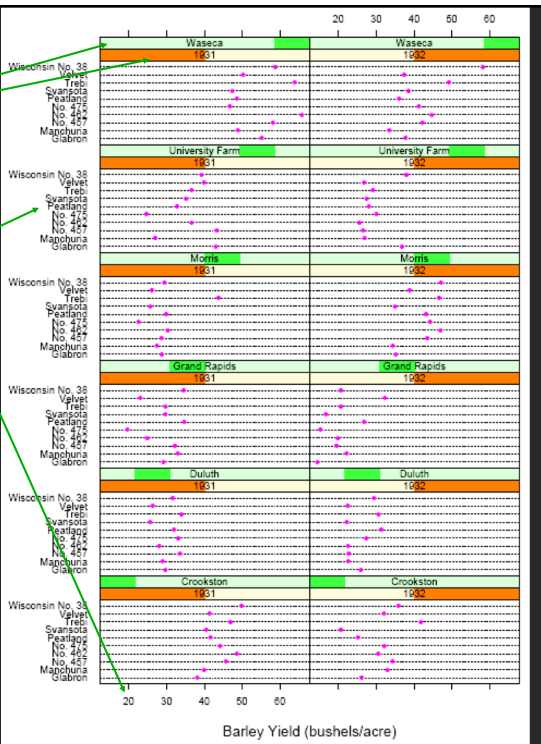
8

Condition variables  
location, year

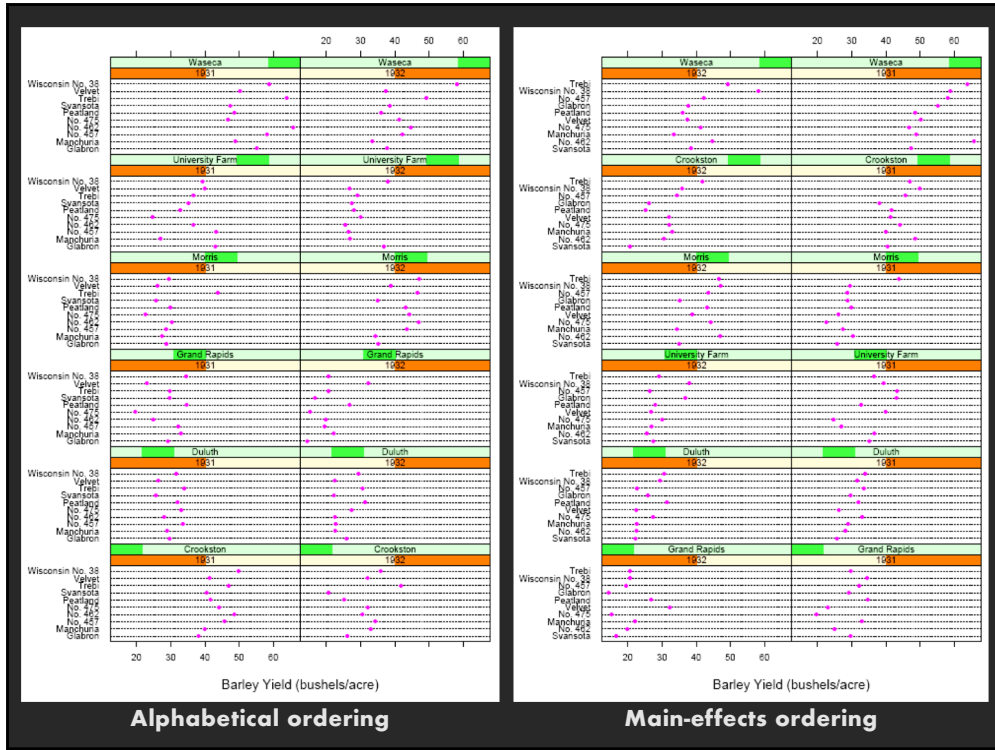
Panel variables  
type, yield

# Trellis

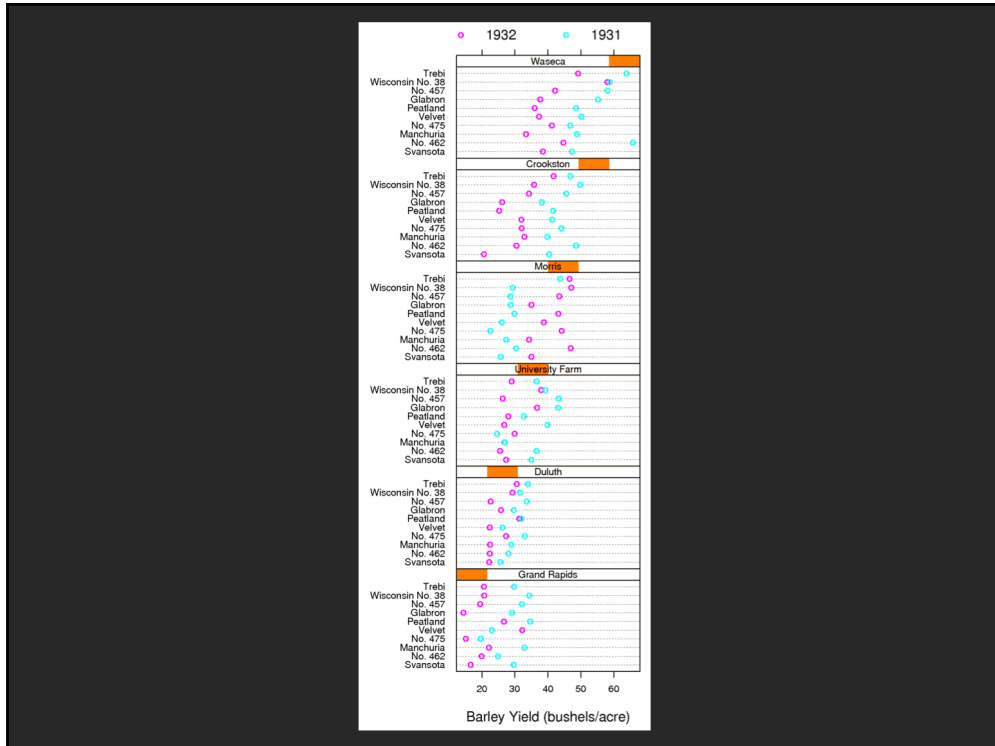
[Becker, Cleveland, and Shyu 96]



9



10



11

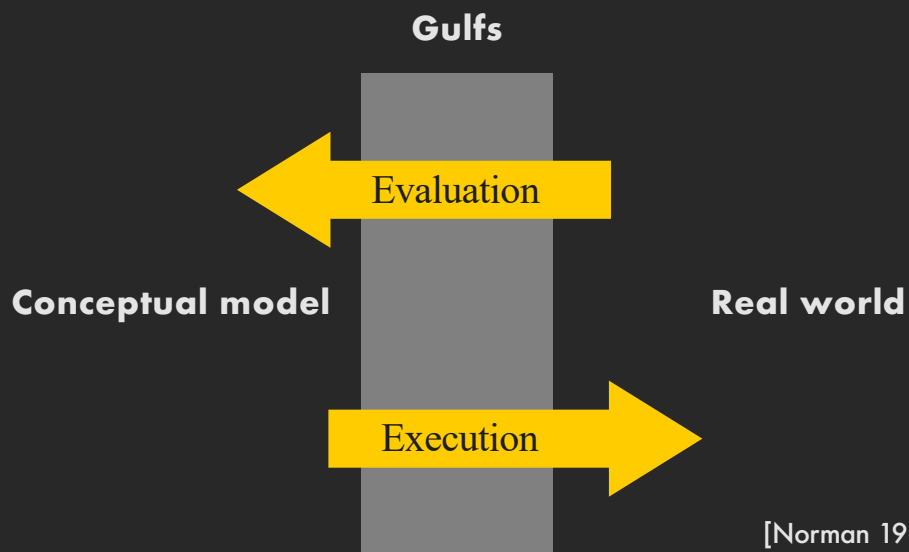
# Interaction

12

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

13

# Gulfs of execution & evaluation



14

## 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]

15

# 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

16

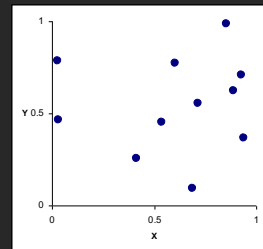
# Gulf of evaluation

Gulf



Conceptual model:  
 $x, y$  correlated?

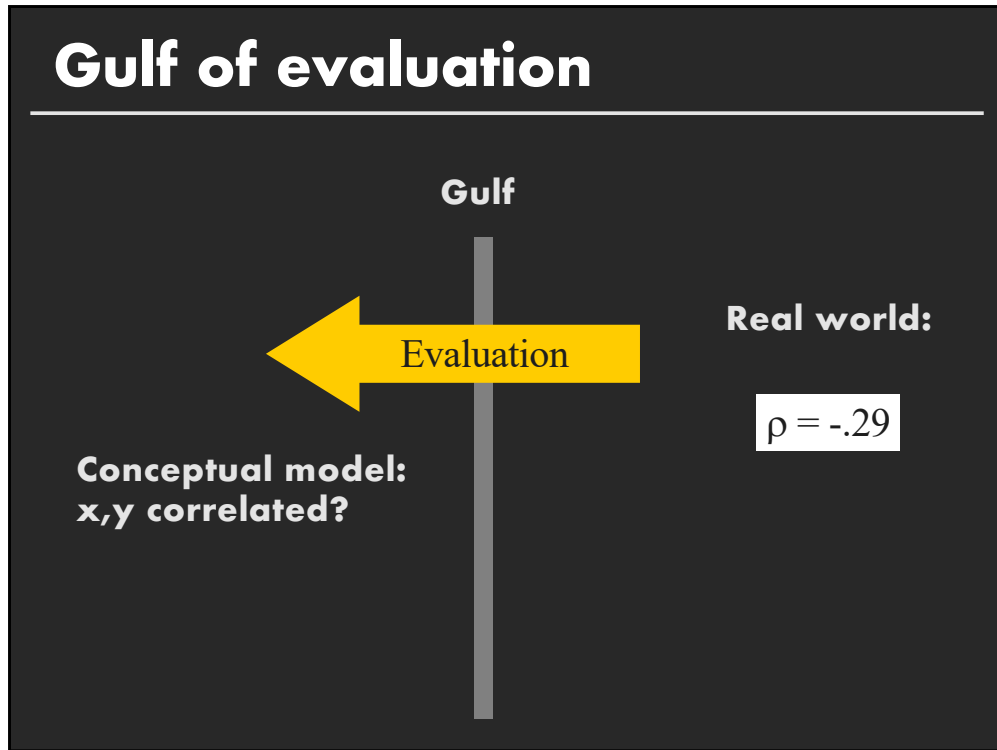
Real world:



17

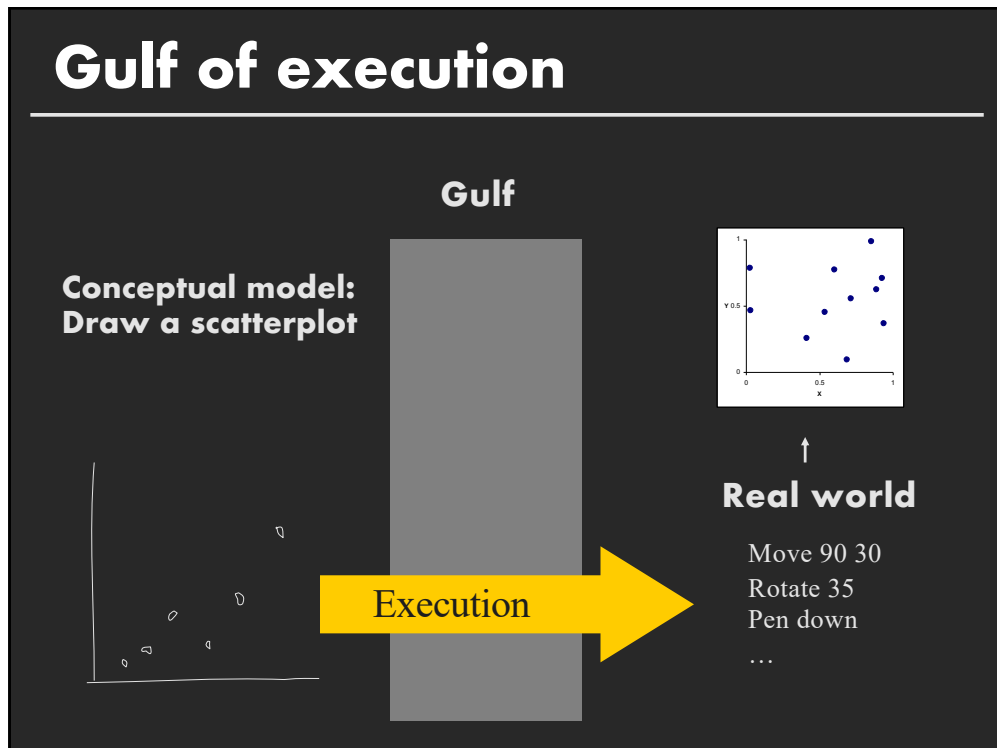


# Gulf of evaluation



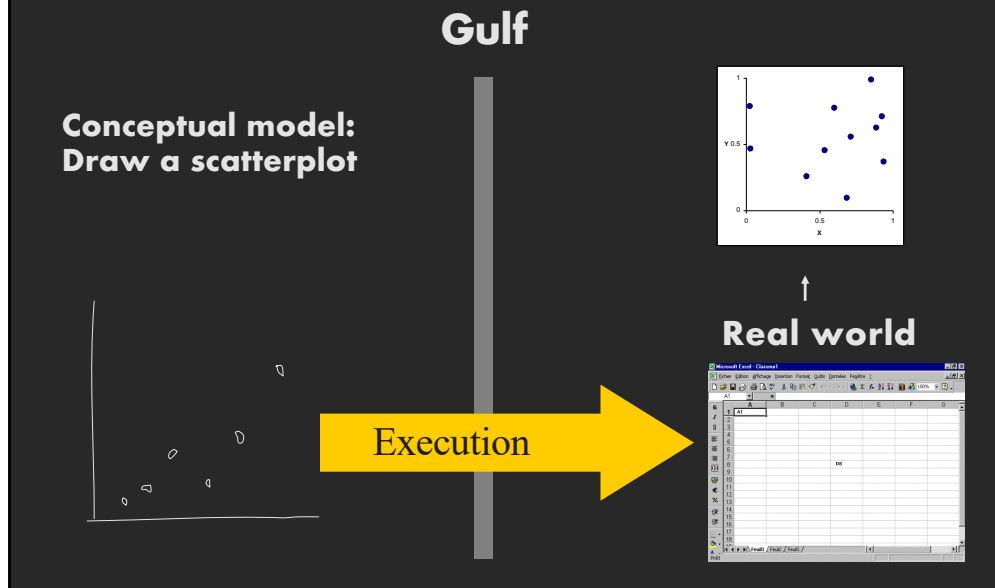
18

# Gulf of execution



19

# Gulf of execution



20

## 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]

21

## **Topics**

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**Early interactive systems**

**Brushing and linking**

**Dynamic queries**

**Generalized selections**

22

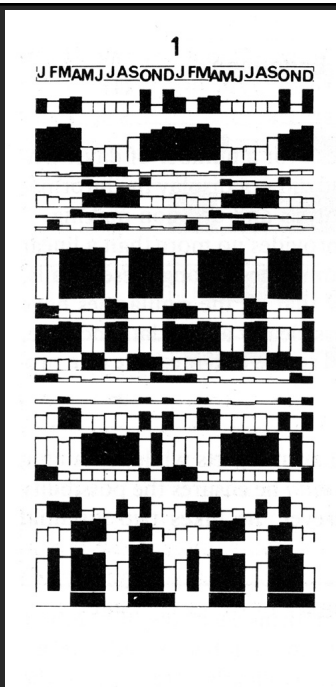
## **Early Systems**

23

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	57	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

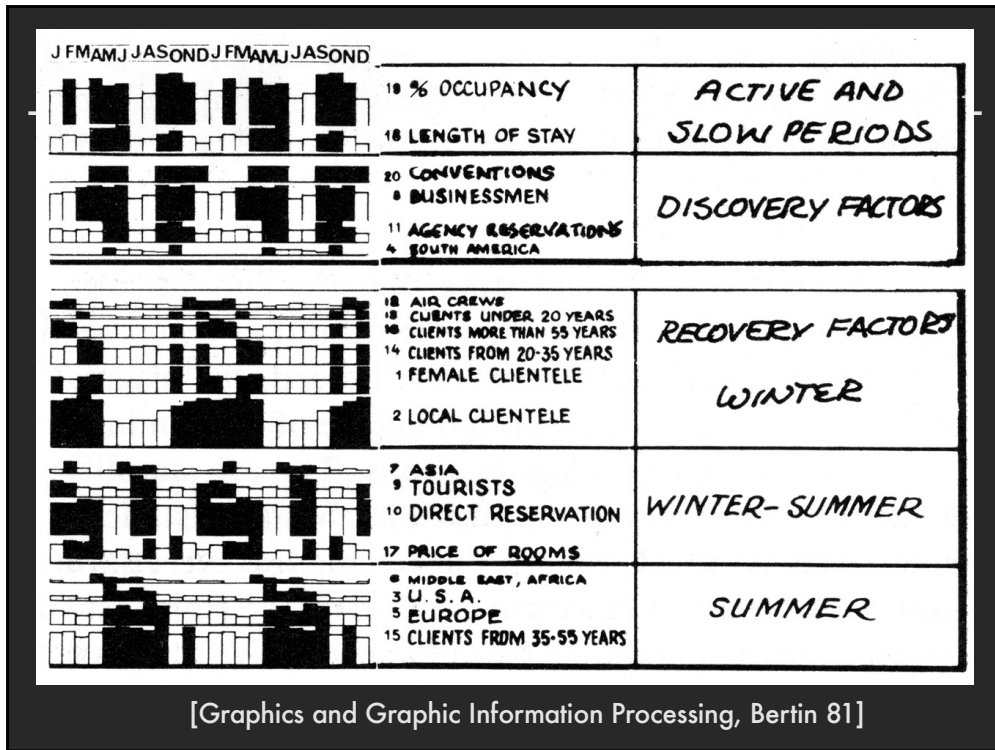
[Graphics and Graphic Information Processing, Bertin 81]

24



[Graphics and Graphic Information Processing, Bertin 81]

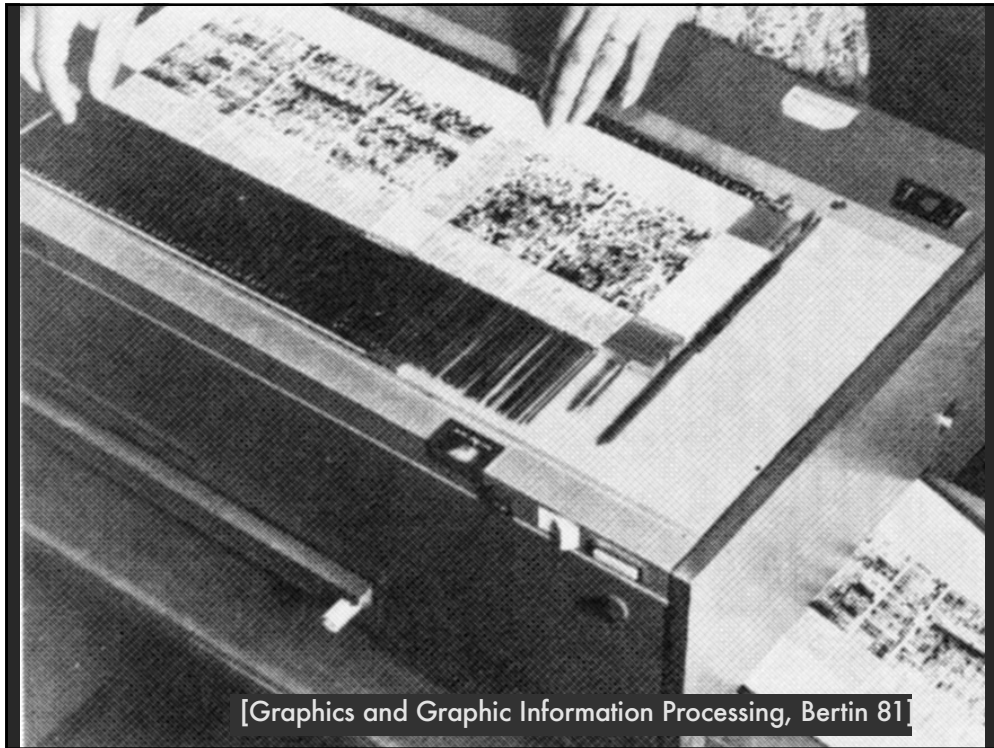
26



28



29



30



31

	Bel	Cze	Den	Fin	Fra	Ger	Gre	Ita	Nor	Pol	Por	Rus	Spa	Swe	Uni
Household in	26	61	69	24	62	57	28	72	20	42	31	41	53	19	31
Women's suf	19	41	92	19	19	0	94	19	19	5	19	19	19	19	19
Against coha	12	42	4	18	8	20	30	46	12	39	17	39	16	6	19
Belief in God	61	36	63	69	52	63	93	91	56	96	86	77	76	46	65
Confidence	32	21	55	42	34	29	22	28	51	23	30	60	35	54	19
Confidence	50	34	72	83	73	58	70	75	57	63	75	73	57	41	89
Confidence	36	20	63	47	41	40	52	67	44	65	67	67	31	39	36
Confidence	91	42	75	73	78	34	39	54	74	44	58	51	79	75	80
Confidence	50	35	87	73	56	58	50	36	78	44	48	41	42	69	51
Important in	60	85	54	58	58	73	94	76	56	93	88	93	77	52	75
Against abo	56	51	28	40	44	60	65	72	42	75	61	63	57	25	57
Not as a nei	7	22	5	12	5	16	30	21	6	52	21	61	5	7	10
Attend churc	15	13	5	7	11	12	19	35	9	54	25	8	21	9	17

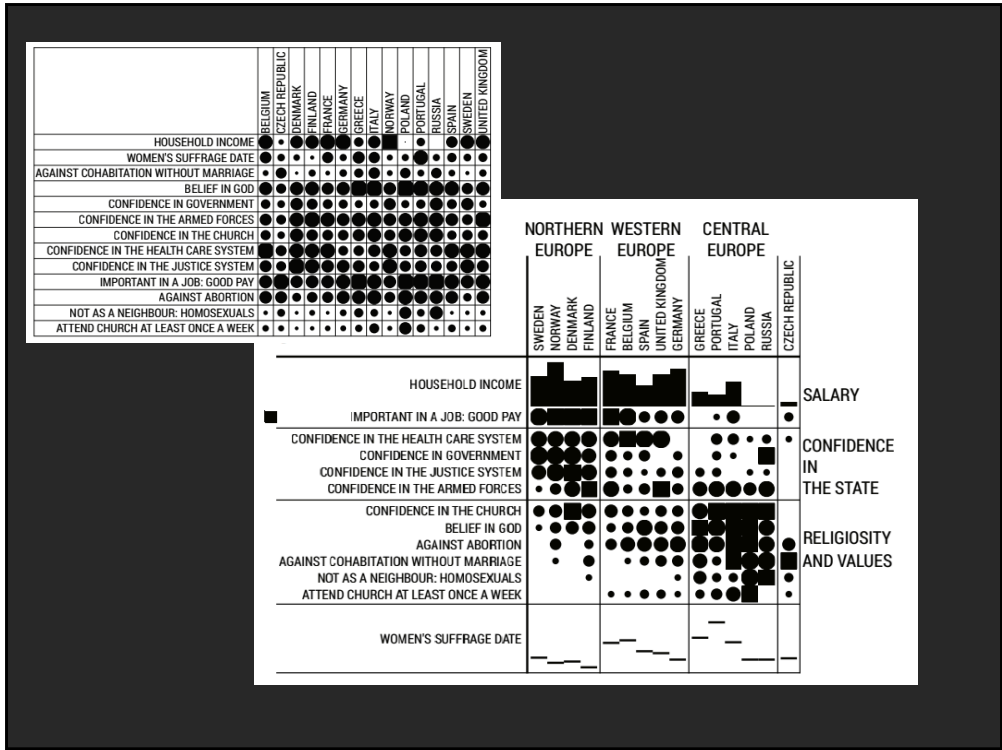
Bertifier [Perin 2014]

32

	BELGIUM	CZECH REPUBLIC	DENMARK	FINLAND	FRANCE	GERMANY	GREECE	ITALY	NORWAY	POLAND	PORTUGAL	RUSSIA	SPAIN	SWEDEN	UNITED KINGDOM
HOUSEHOLD INCOME	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WOMEN'S SUFFRAGE DATE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
AGAINST COHABITATION WITHOUT MARRIAGE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BELIEF IN GOD	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CONFIDENCE IN GOVERNMENT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CONFIDENCE IN THE ARMED FORCES	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CONFIDENCE IN THE CHURCH	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CONFIDENCE IN THE HEALTH CARE SYSTEM	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CONFIDENCE IN THE JUSTICE SYSTEM	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
IMPORTANT IN A JOB: GOOD PAY	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
AGAINST ABORTION	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NOT AS A NEIGHBOUR: HOMOSEXUALS	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
ATTEND CHURCH AT LEAST ONCE A WEEK	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Bertifier [Perin 2014]

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34



40



# Basic Pointing Methods

---

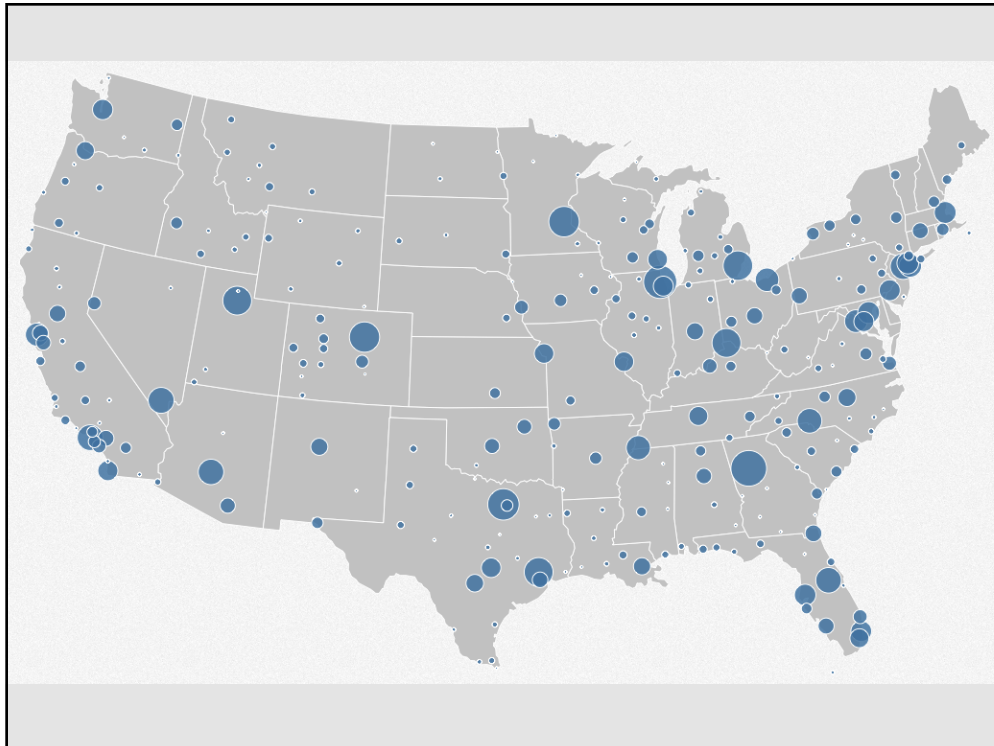
**Point Selection**

**Mouse Hover / Click**

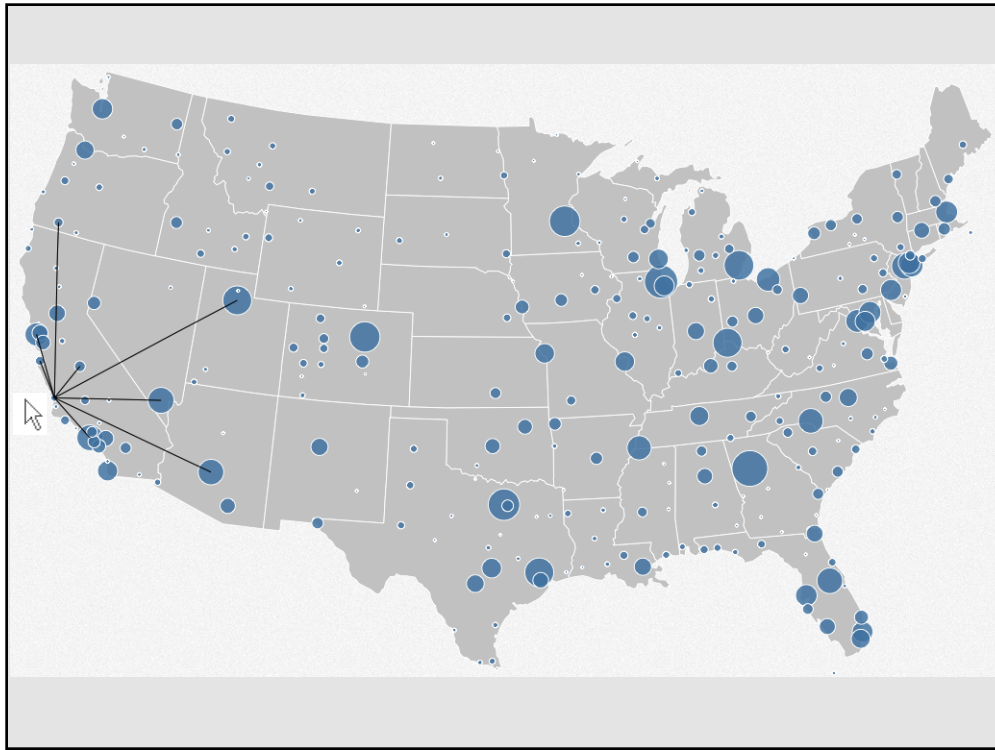
**Touch / Tap**

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

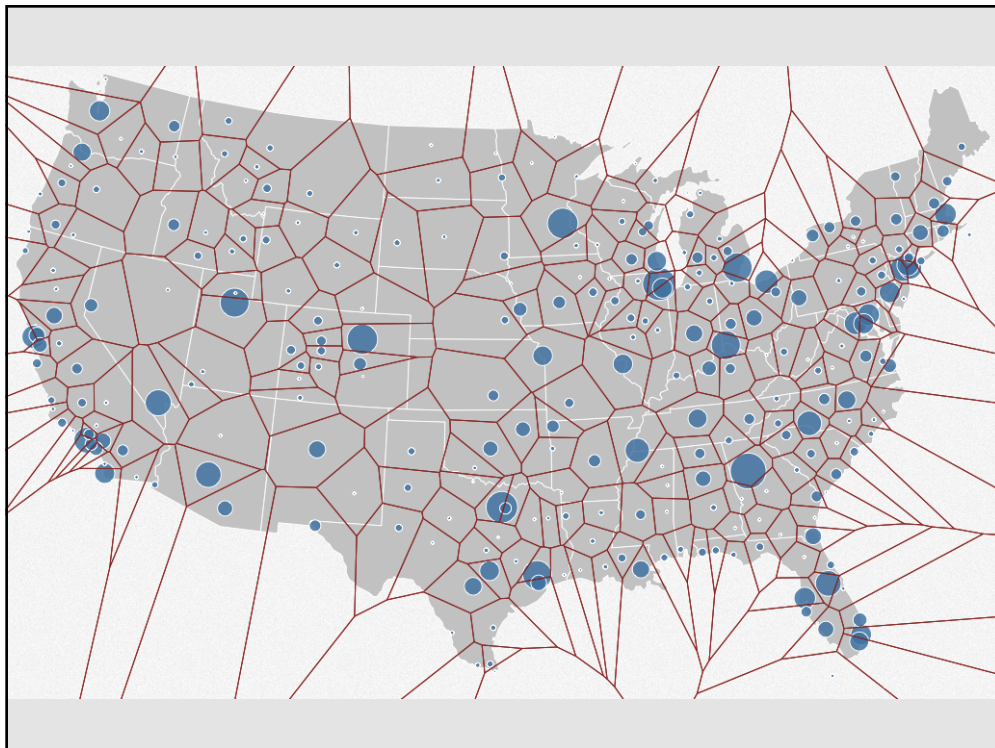
41



42



43



44

## **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")**

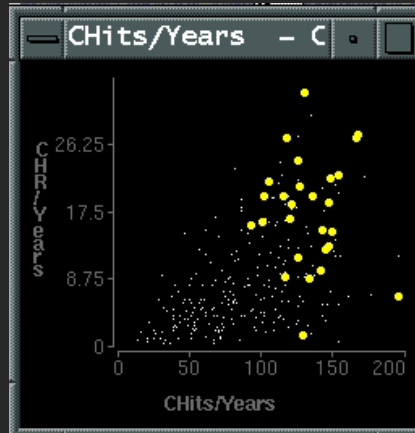
45

## **Brushing and Linking**

46

# Highlighting

Focus user attention on a subset of the data within one graph [from Wills 95]



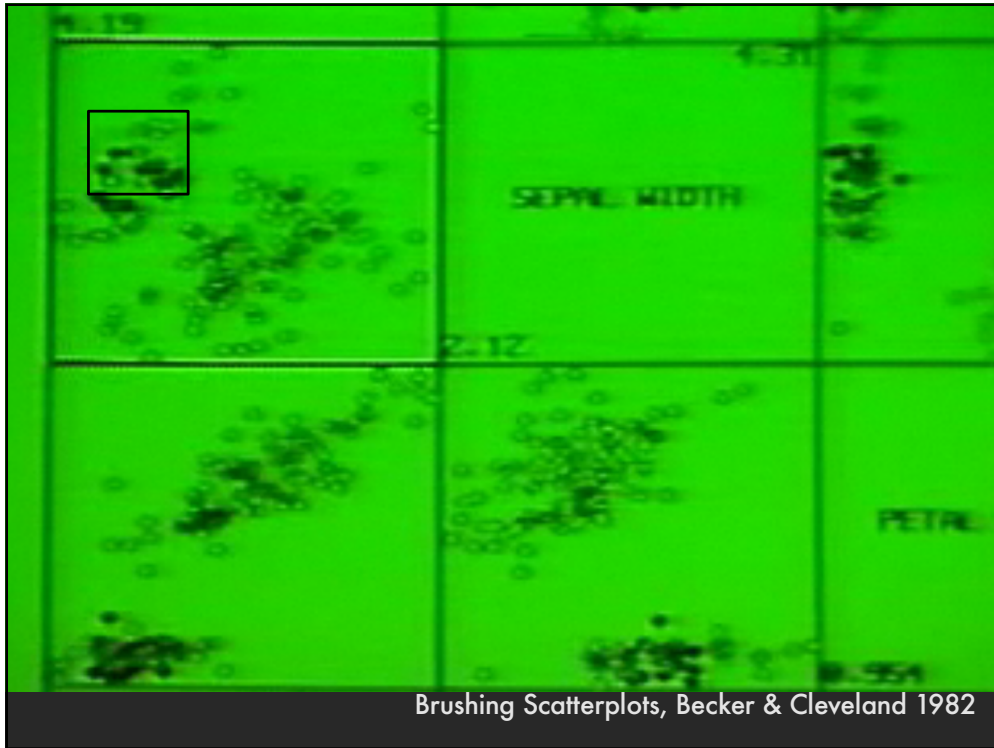
47

# Brushing and Linking

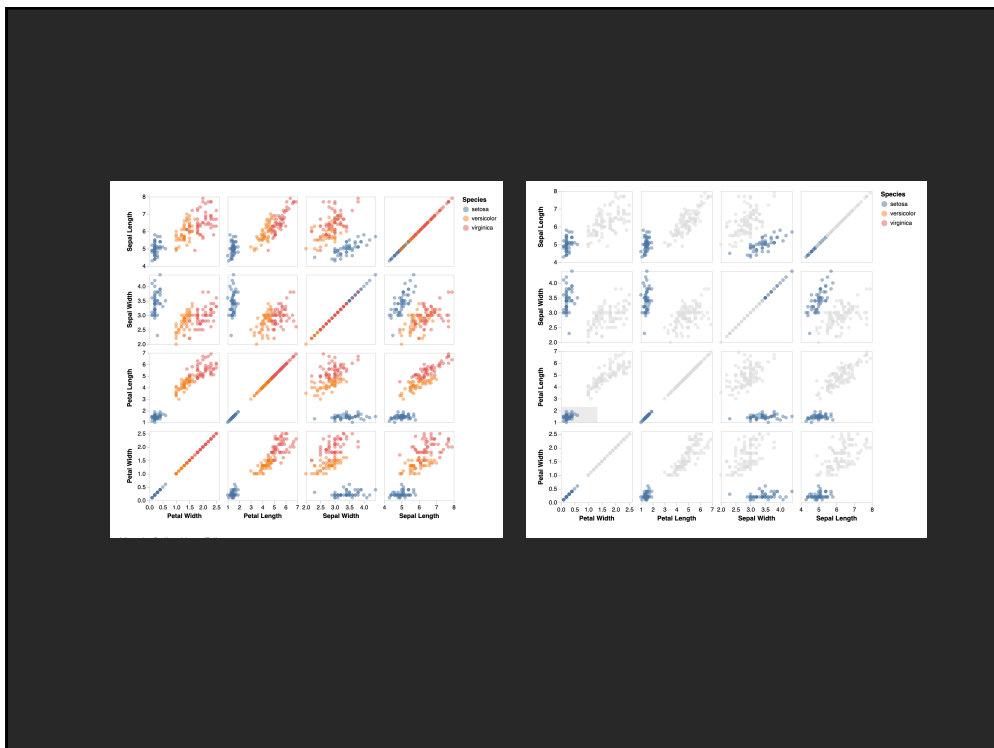
Select ("*brush*") a subset of data  
See selected data in other views

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

48

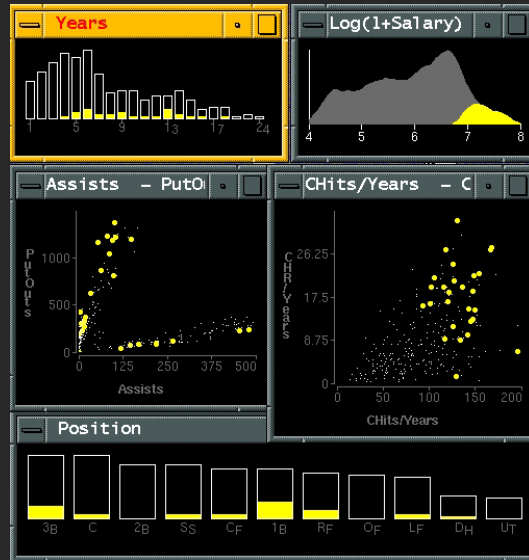


49



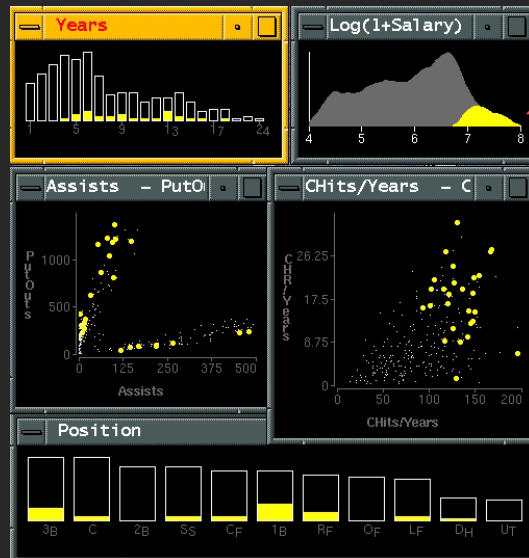
50

# Baseball statistics [from Wills 95]



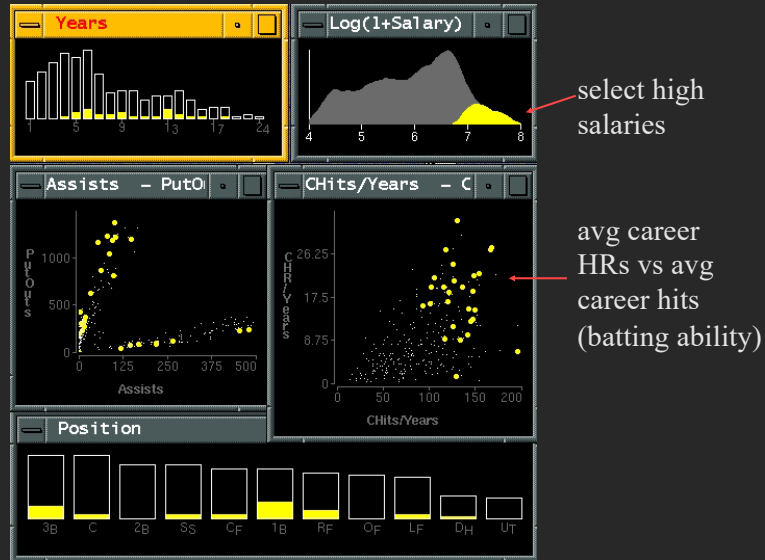
51

# Baseball statistics [from Wills 95]



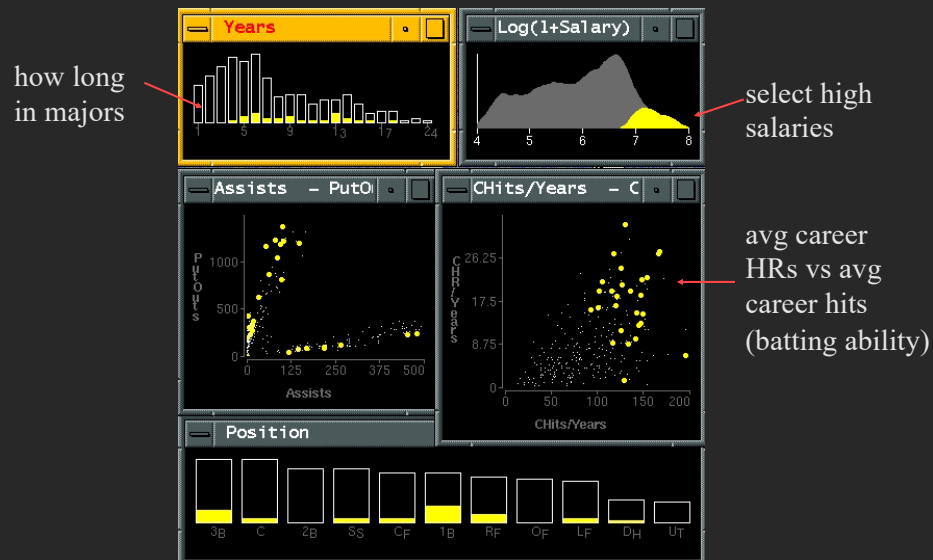
52

# Baseball statistics [from Wills 95]



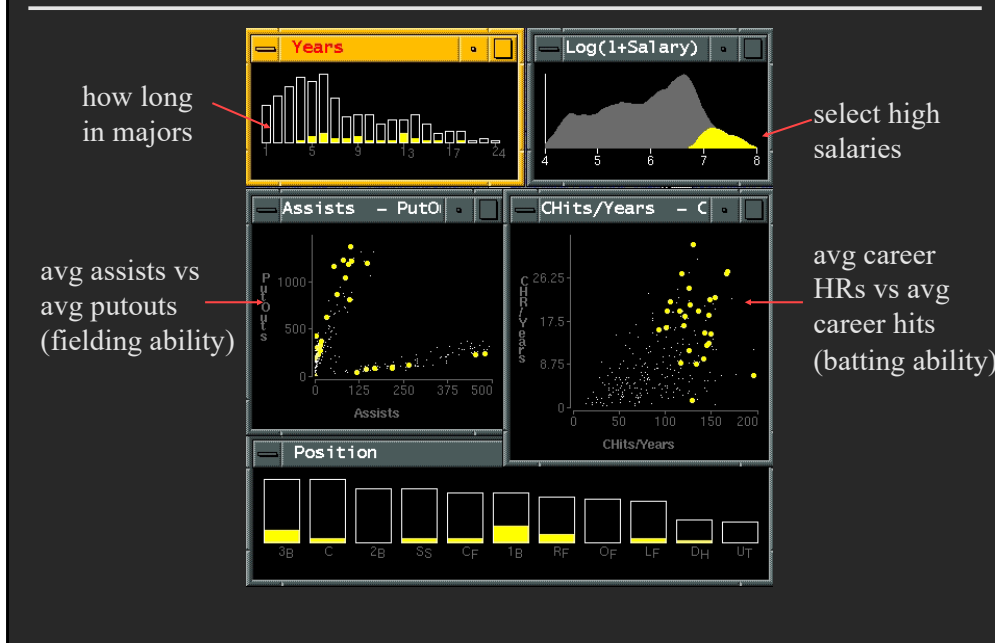
53

# Baseball statistics [from Wills 95]



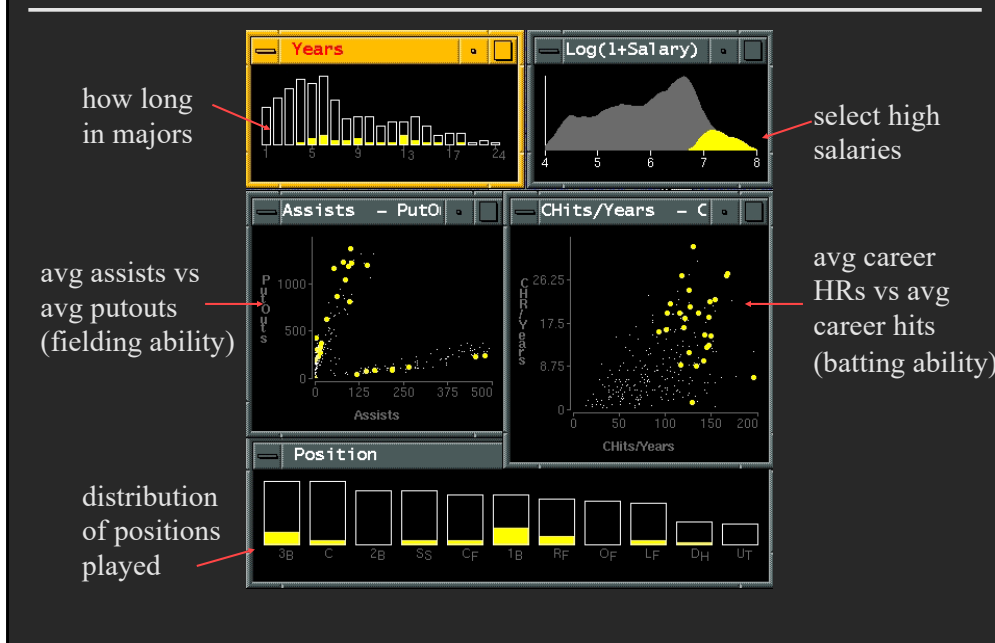
54

# Baseball statistics [from Wills 95]



55

# Baseball statistics [from Wills 95]



56

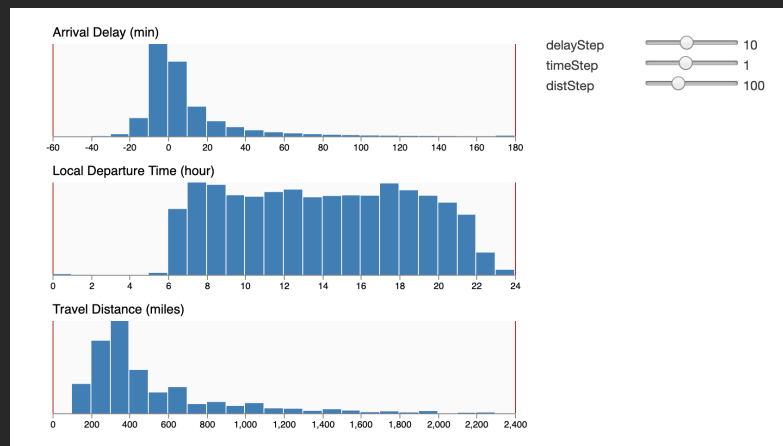


# Linking assists to positions



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# CrossFiltering



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# Dynamic Queries

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## Query and results

```
SELECT house  
FROM east bay  
WHERE price < 1,000,000 AND bedrooms > 2  
ORDER BY price
```

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

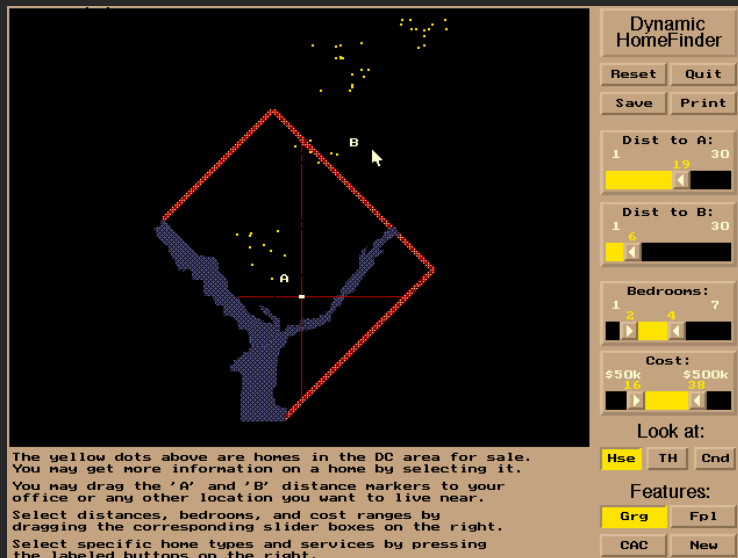
61

# 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

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# 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.

[Ahlberg and Schneiderman 92]

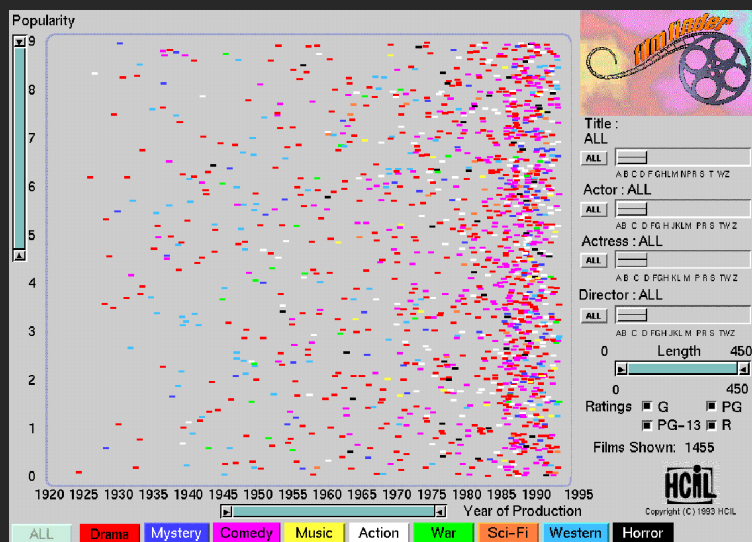
63

# 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

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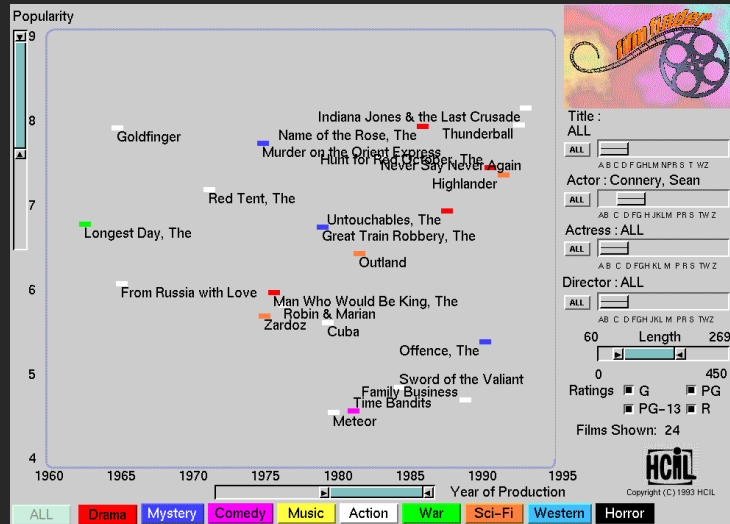
# FilmFinder



[Ahlberg and Schneiderman 93]

65

# FilmFinder



[Ahlberg and Schneiderman 93]

66

# Alphaslider

Title :  
Moonstruck

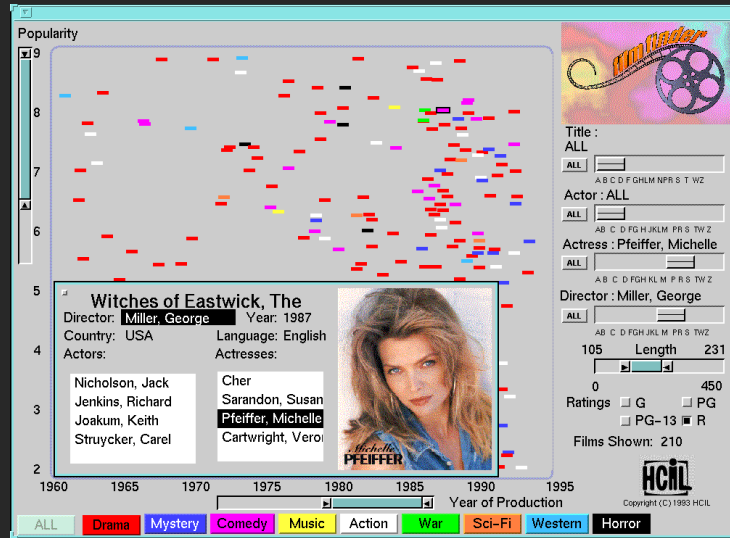
ALL

A B C D F G H L M N P R S T W Z

[Ahlberg and Schneiderman 94]

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# FilmFinder



[Ahlberg and Schneiderman 93]

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# Announcements

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## Assignment 3: Dynamic Queries

Create a **small** interactive dynamic query application similar to Homefinder, but for South Bay Restaurant Data.

1. Implement interface
2. Submit the application and a short write-up on canvas

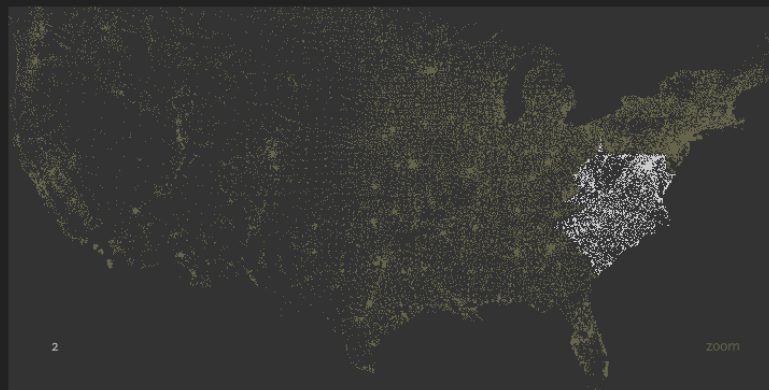


Can work alone or in pairs  
Due before class on **Feb 10, 2020**

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## Zipdecode [from Fry 04]

<< ben fry

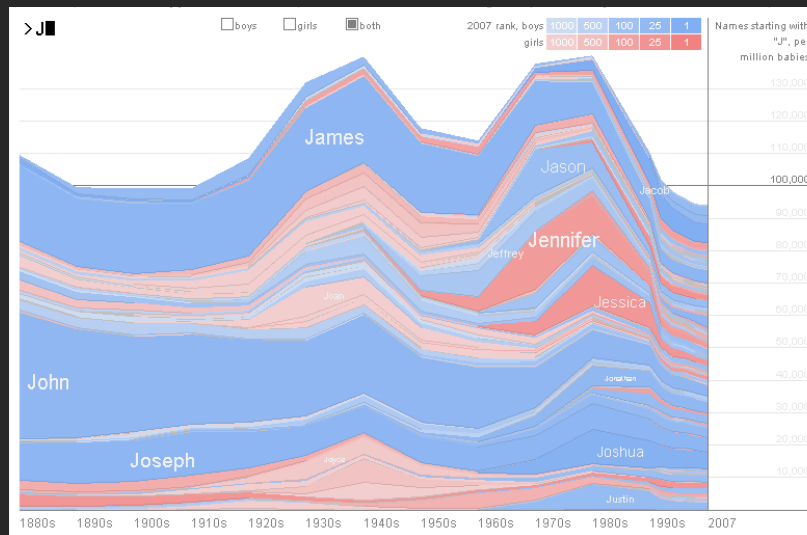


Hit the letter z, or click the word zoom to enable or disable zooming.  
Hold down shift while typing a number to replace the previous number  
(U.S. keyboards only).

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

73

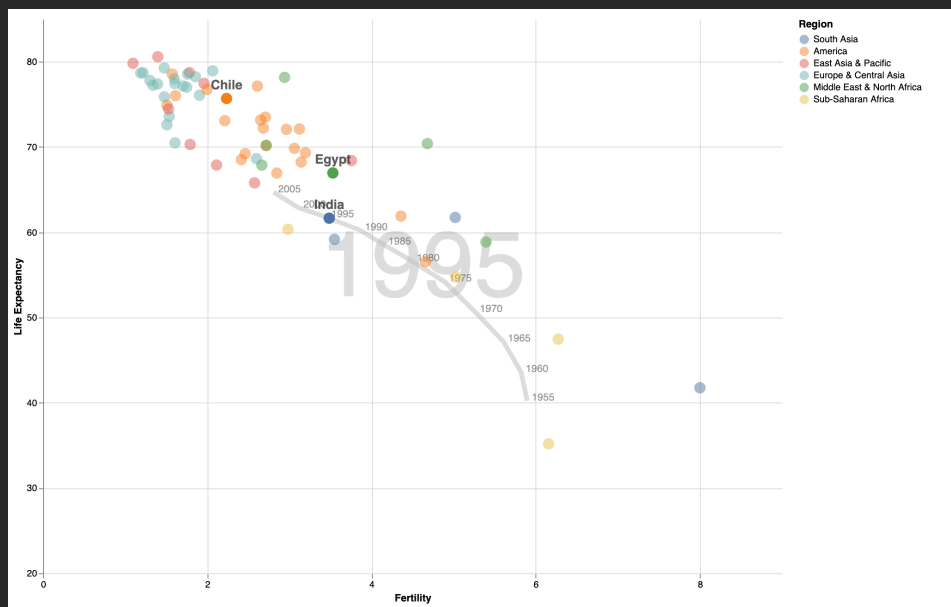
# NameVoyager



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

74

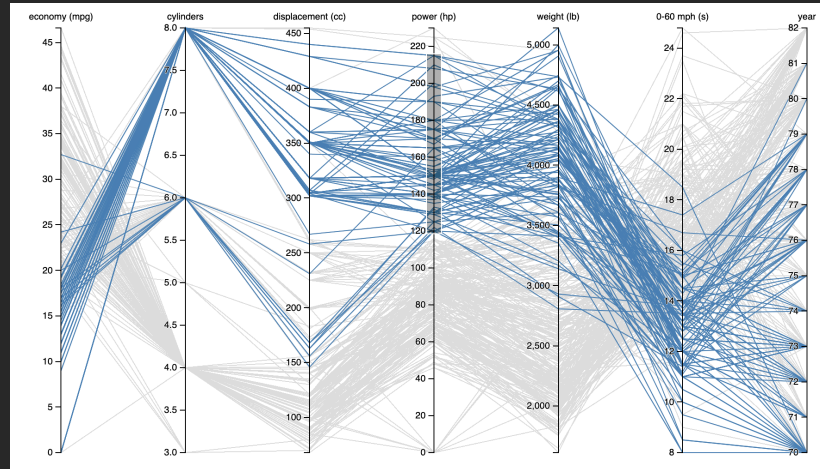
# DimpVis [Kondo 14]



75

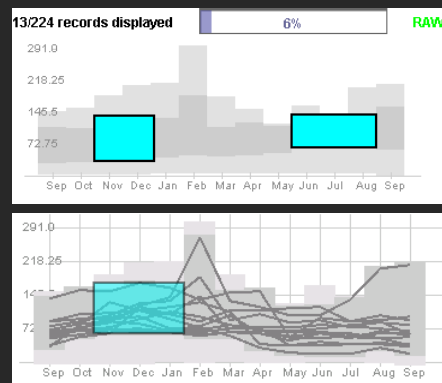
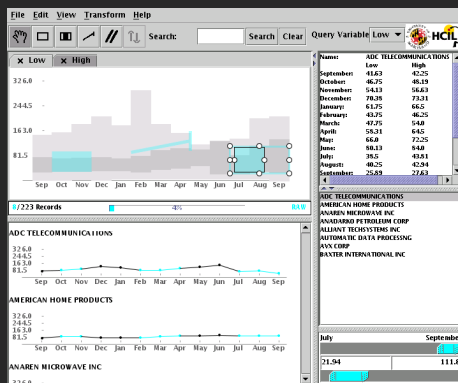


# Parallel Coordinates [Inselberg]



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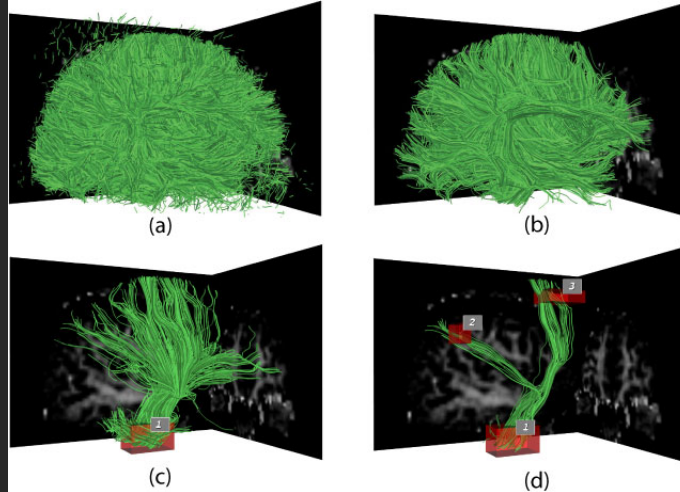
# TimeSearcher [Hochheiser & Schneiderman 02]



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

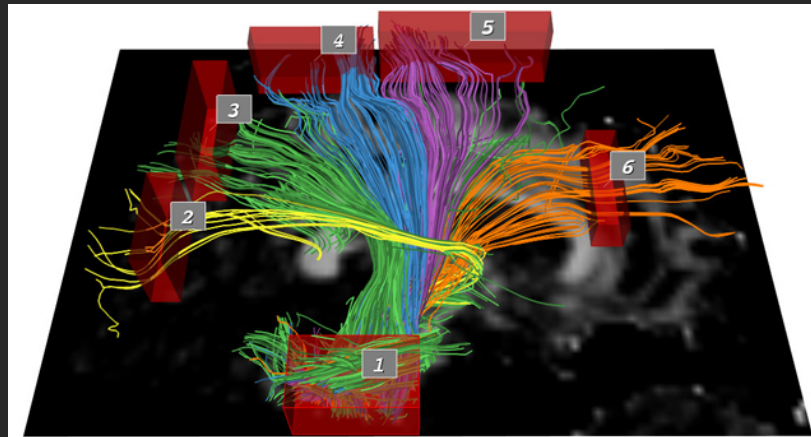
77

## 3D dynamic queries [Akers et al. 04]



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## 3D dynamic queries [Akers et al. 04]



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## Pros and cons

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### 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?**

80

## Summary

---

### **Most visualizations are interactive**

- Even passive media elicit interactions

### **Good visualizations are task dependent**

- Pick the right interaction technique

### **Fundamental interaction techniques**

- Selection / Annotation, Brushing & Linking, Dynamic Queries

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