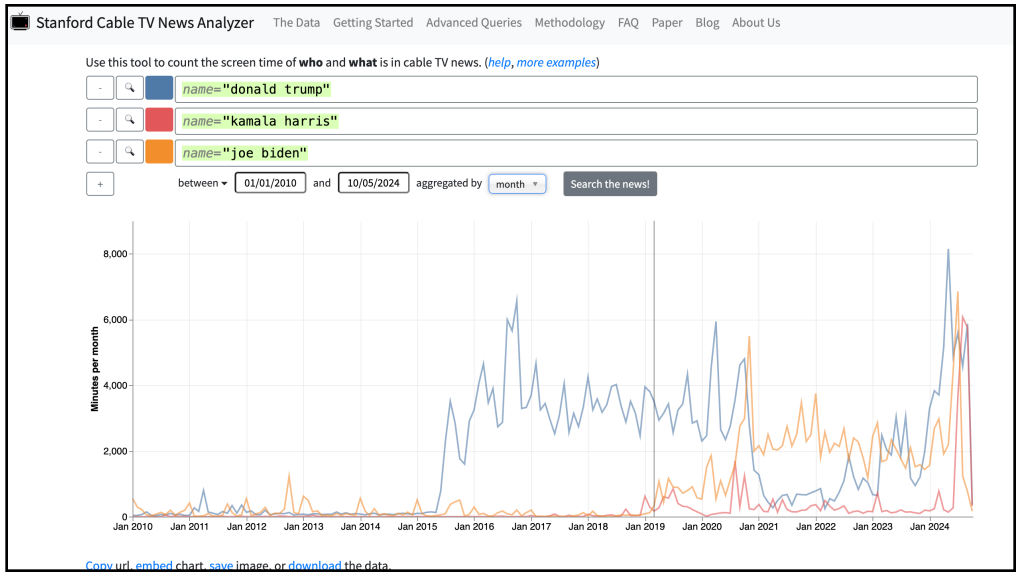
INTERACTION

CS 448B | Fall 2025

MANEESH AGRAWALA

1



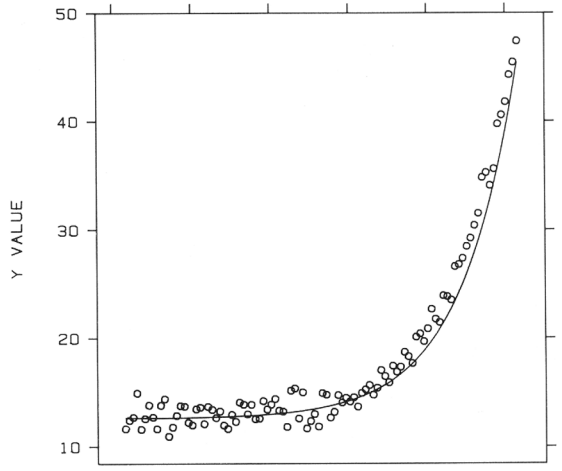
2

LAST TIME: CHART DESIGN

3

TRANSFORMING DATA

How well does curve fit data?



[Cleveland 85]

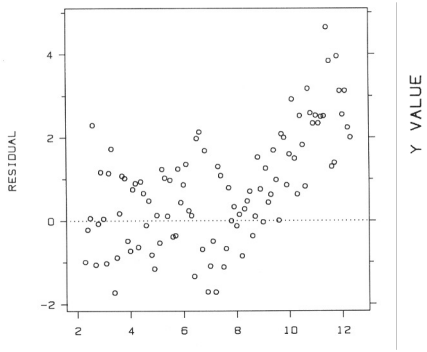
4

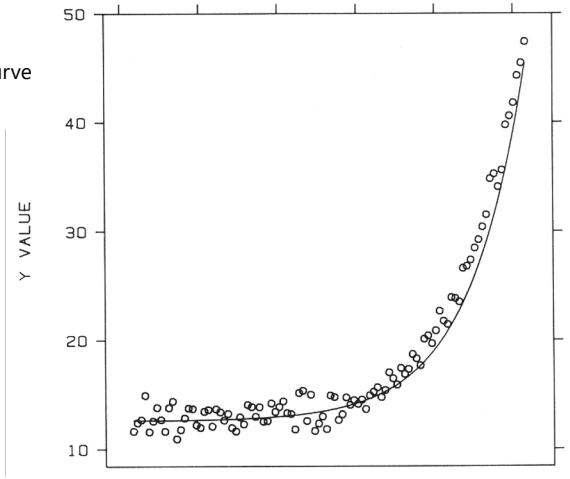
TRANSFORMING DATA

Residual graph

Plot vertical distance from best fit curve

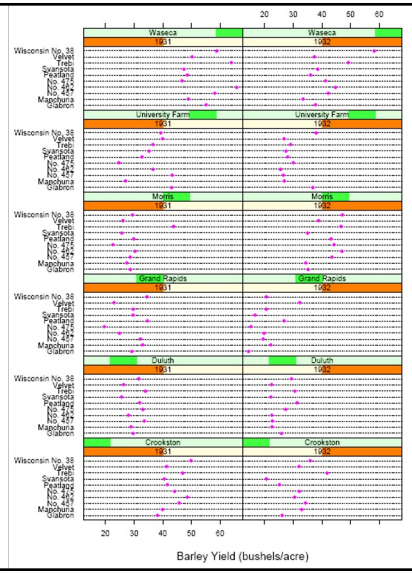
Residual graph shows accuracy of fit





[Cleveland 85]

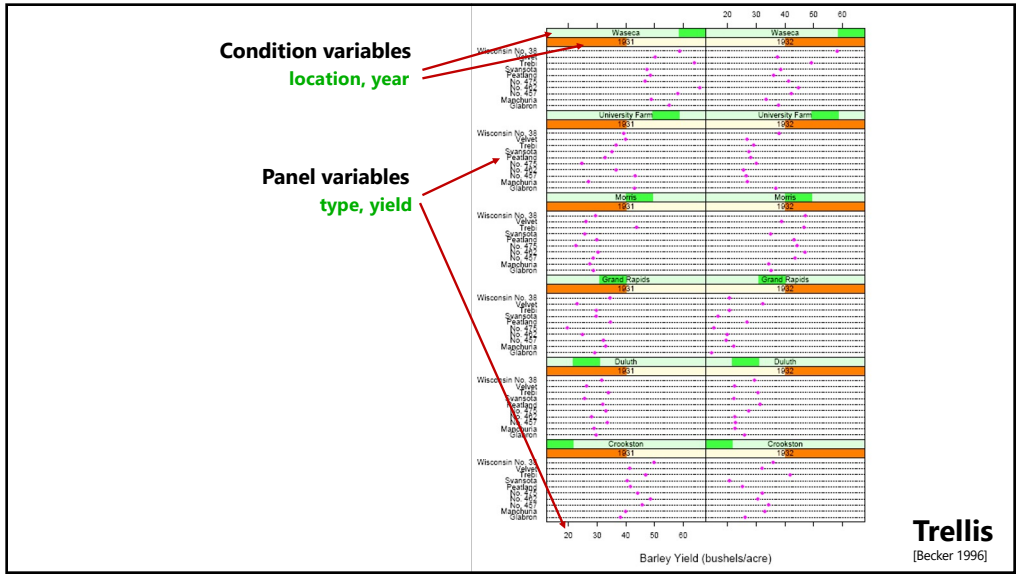
5



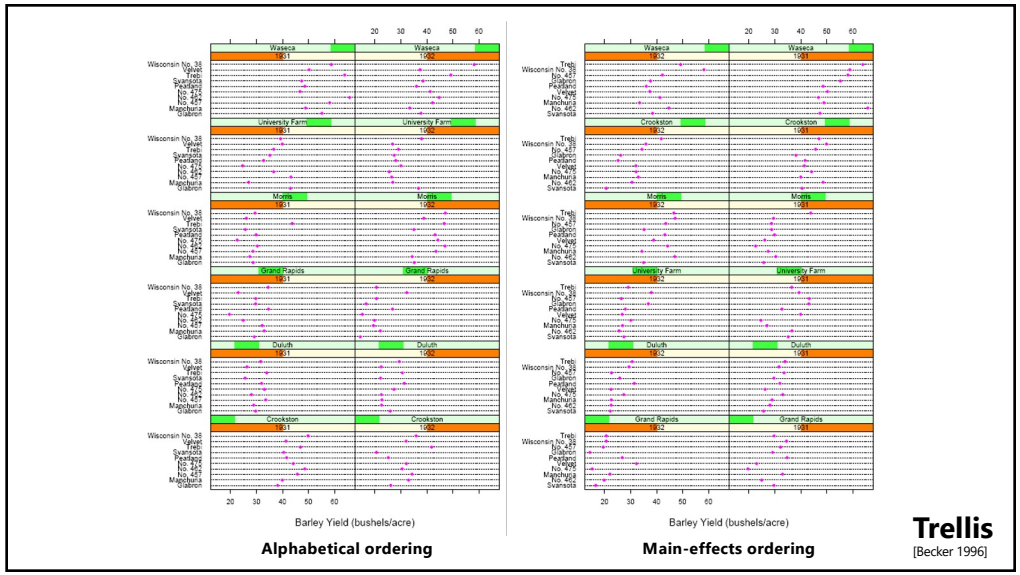
Trellis

[Becker 1996]

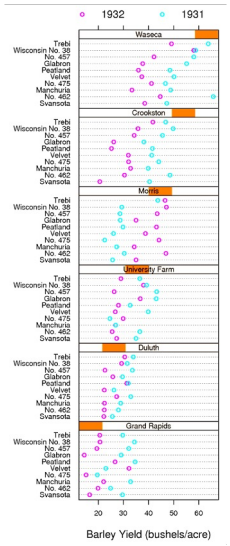
6


Condition variables
location, year
Panel variables
type, yield
Waseca
1931
1932
University Farm
Morris
Grand Rapids
Duluth
Crookston
Wisconsin No. 38
Velvet
Trebi
Svansota
Peatland
No. 457
No. 462
No. 475
Manchuria
Glabron
20
30
40
50
60
Barley Yield (bushels/acre)
Trellis
[Becker 1996]

7


Barley Yield (bushels/acre)
Alphabetical ordering
Main-effects ordering
Trellis
[Becker 1996]

8



Trellis
[Becker 1996]

9

SUMMARY

Well designed visualizations

- Use *expressive* and *effective* encodings
- Avoid *over-encoding*
- Emphasize features of the data most relevant to the task

Rarely does a single visualization answer all questions.
Instead, the ability to generate appropriate visualizations quickly is critical!

10

TODAY

Learning Objectives

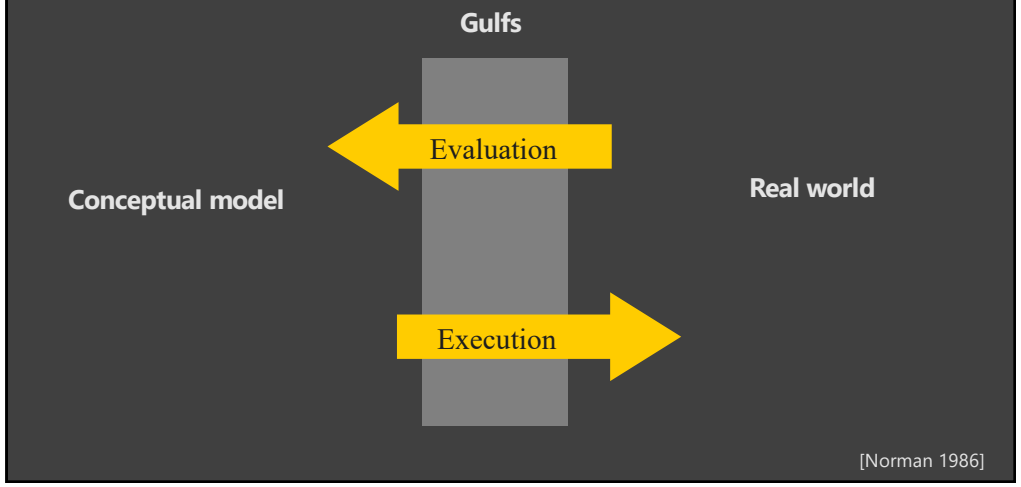
1. Conceptual models, system models and the gulfs of execution and evaluation
2. Common interaction techniques: Selection, Brushing and Linking and Dynamic Queries

11

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

12

GULFS OF EXECUTION AND EVALUATION



[Norman 1986]

13

Gulf of Execution

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

[Norman 1986]

14

Gulf of Execution

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

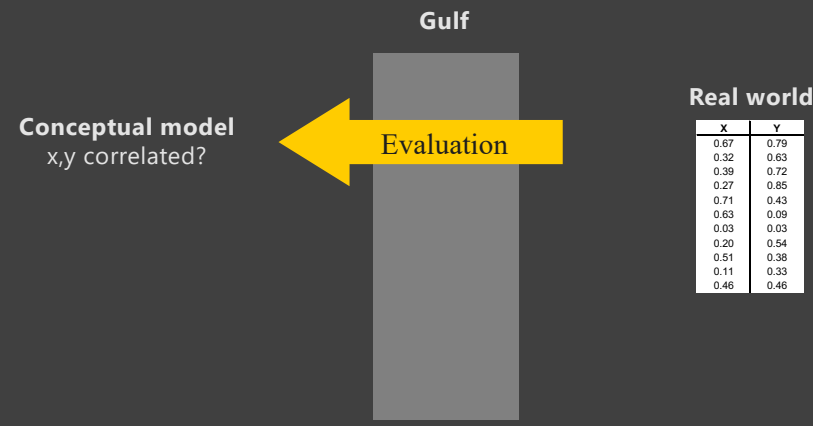
Gulf of Evaluation

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



16

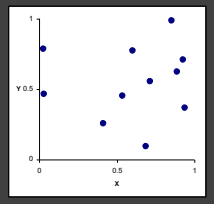
GULF OF EVALUATION

Gulf

Conceptual model
x,y correlated?

Evaluation

Real world



17

GULF OF EVALUATION

Gulf

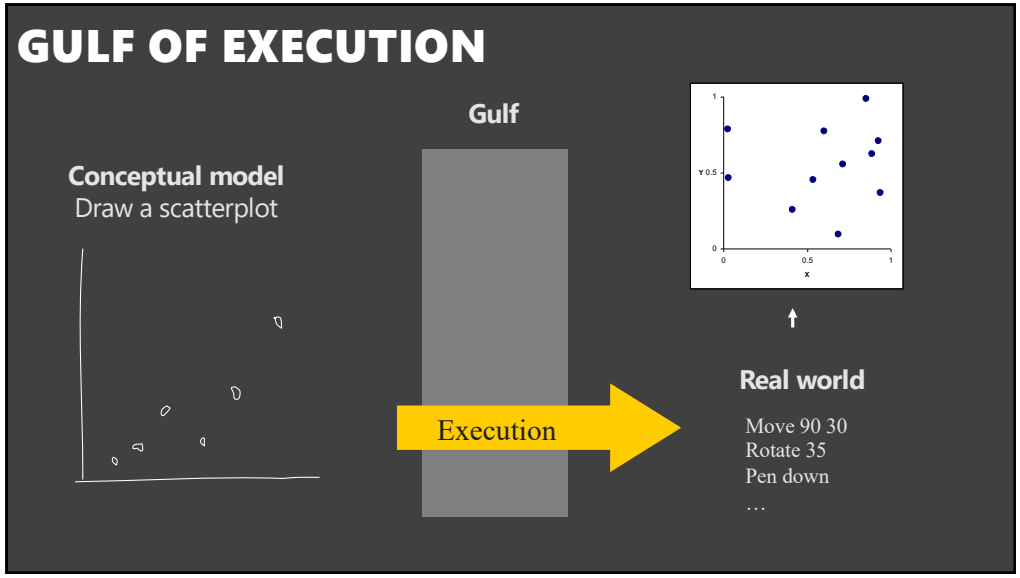
Conceptual model
x,y correlated?

Evaluation

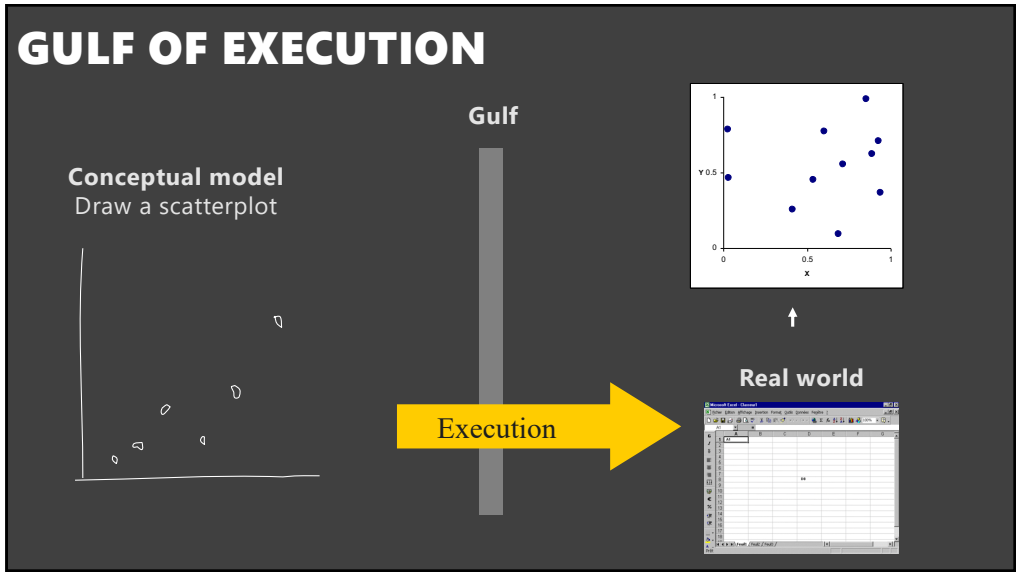
Real world

$\rho = -.29$

18


GULF OF EXECUTION
Gulf
Conceptual model
Draw a scatterplot
Execution
Real world
Move 90 30
Rotate 35
Pen down
…

19


GULF OF EXECUTION
Gulf
Conceptual model
Draw a scatterplot
Execution
Real world

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

EARLY SYSTEMS

22

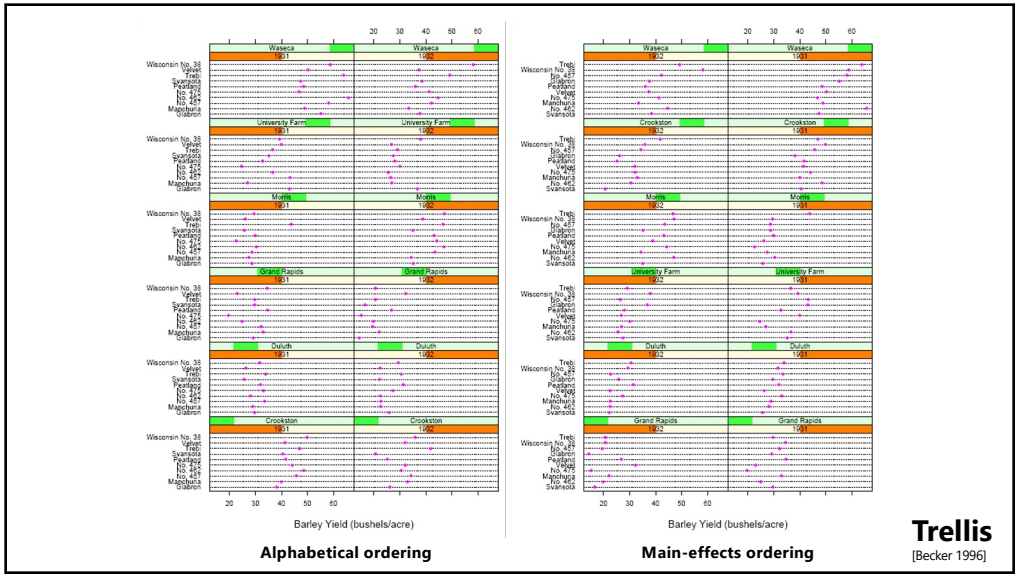
J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —〃— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —〃— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —〃— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —〃— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —〃— 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	76	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]

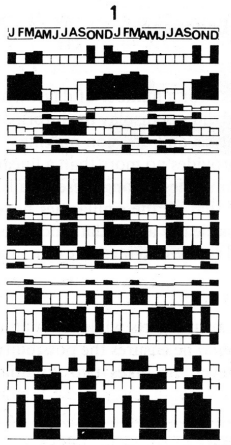
23

How might we **graphically analyze** the table **without focusing on** the specific **numbers**?

24



25



Graphics and Graphic Information Processing [Bertin 81]

26

GROUP SIMILAR ROWS AND COLUMNS

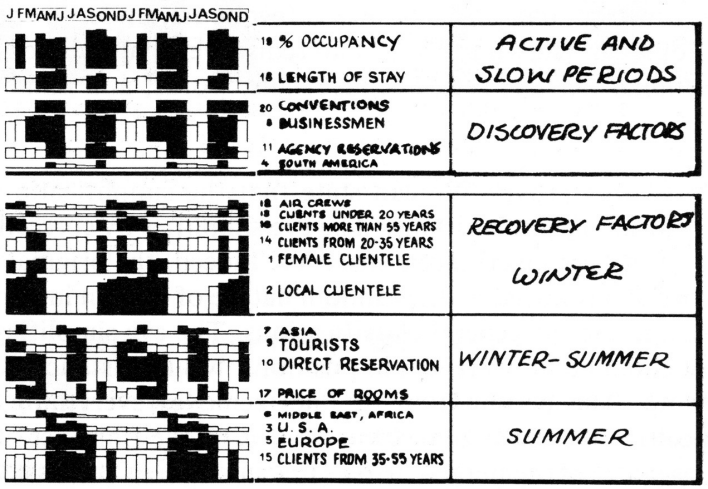
Choose a row with a particular visual aspect
Move to extremity of matrix

Move similar rows close, opposite rows to bottom
Creates two opposing groups and a middle group

Repeat for columns (can only do this with some kinds of data)

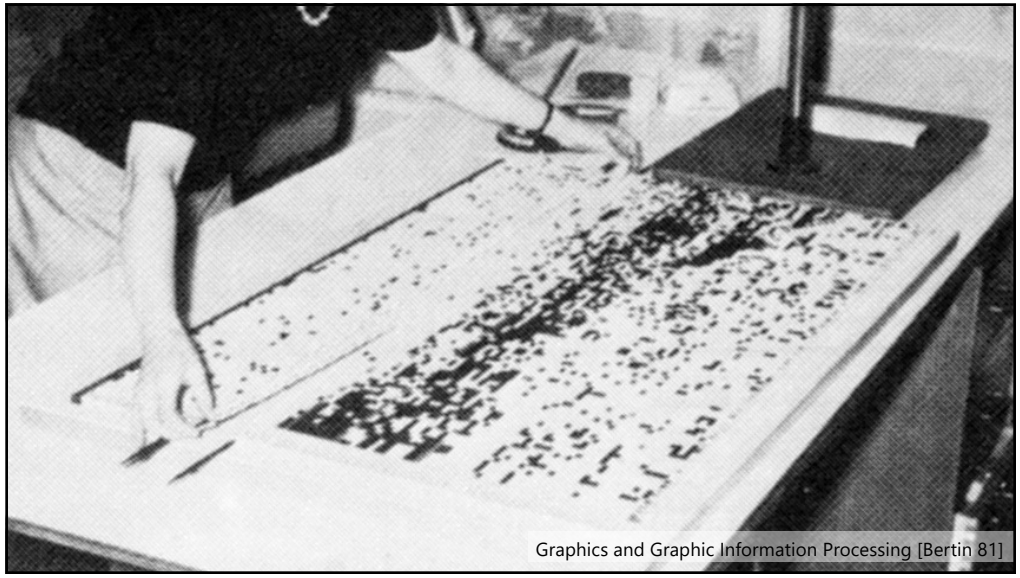
Iterate

27



Graphics and Graphic Information Processing [Bertin 81]

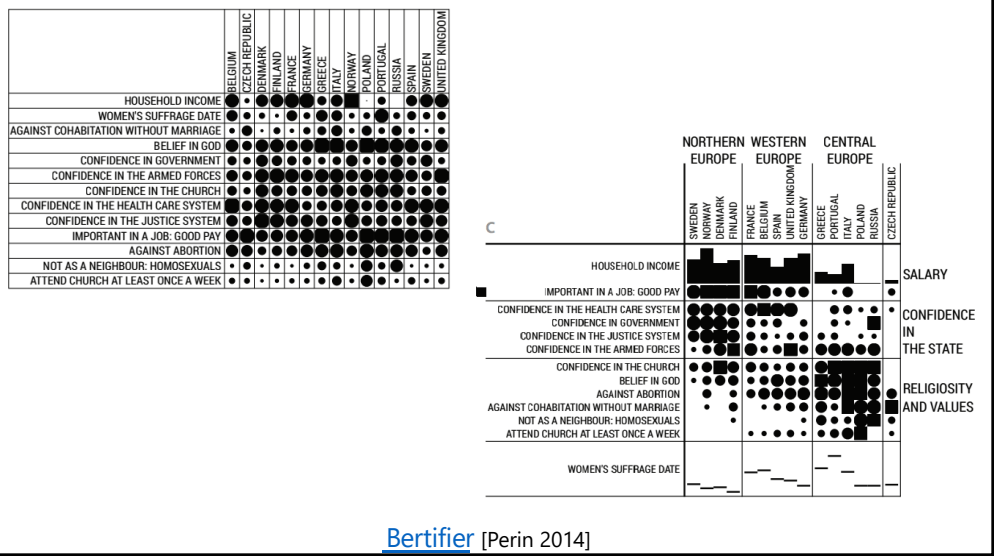
28


Graphics and Graphic Information Processing [Bertin 81]

29


Graphics and Graphic Information Processing [Bertin 81]

31



Bertifier [Perin 2014]

34

ANNOUNCEMENTS

40

ASSIGNMENT 2: EXP. DATA ANALYSIS

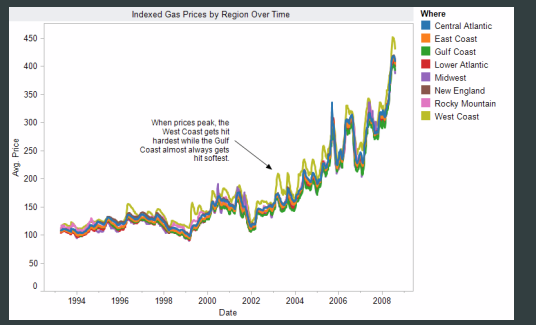
Due 10/13 10:30am

Use Tableau or Vega-Lite to formulate & answer data questions

First steps
- Step 1: Pick domain & data
- Step 2: Pose questions
- Step 3: Profile data
- Iterate as needed

Create visualizations
- See different views of data
- Refine questions

Author a report
- Screenshots of most insightful views (8+)
- Include titles and captions for each view

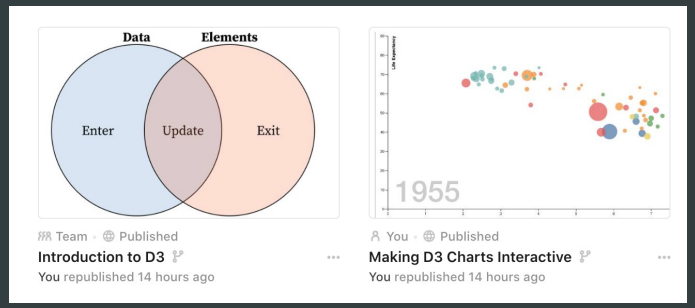


41

SELECTION

43

D3 NOTEBOOKS NEXT MON & WED

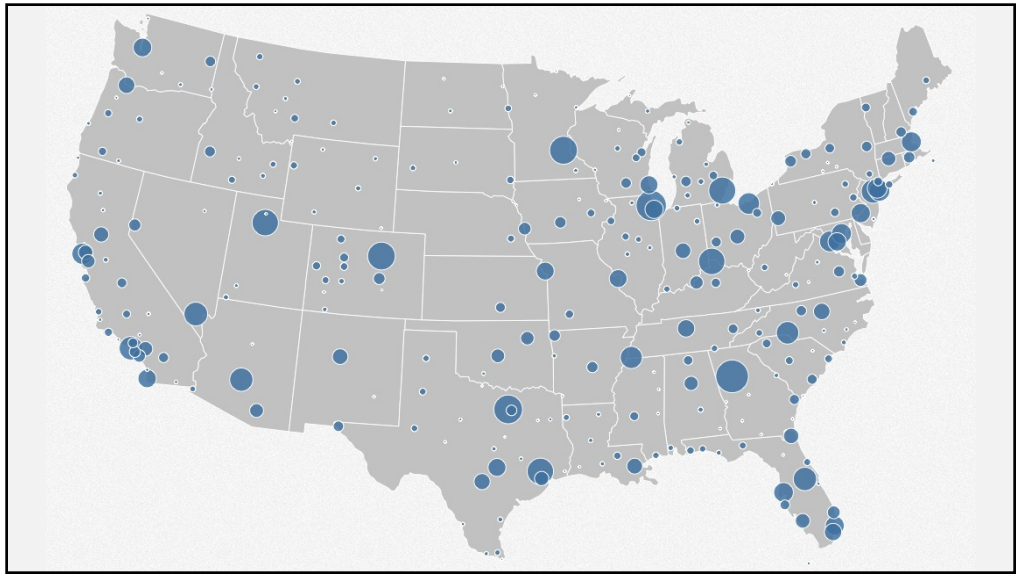


44

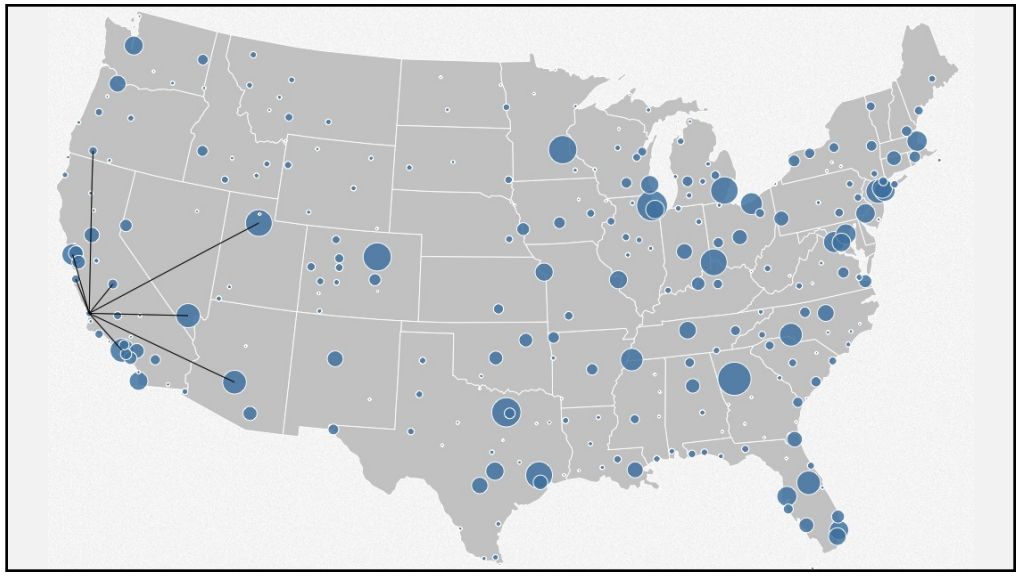
BASIC SELECTION METHODS

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

45



46



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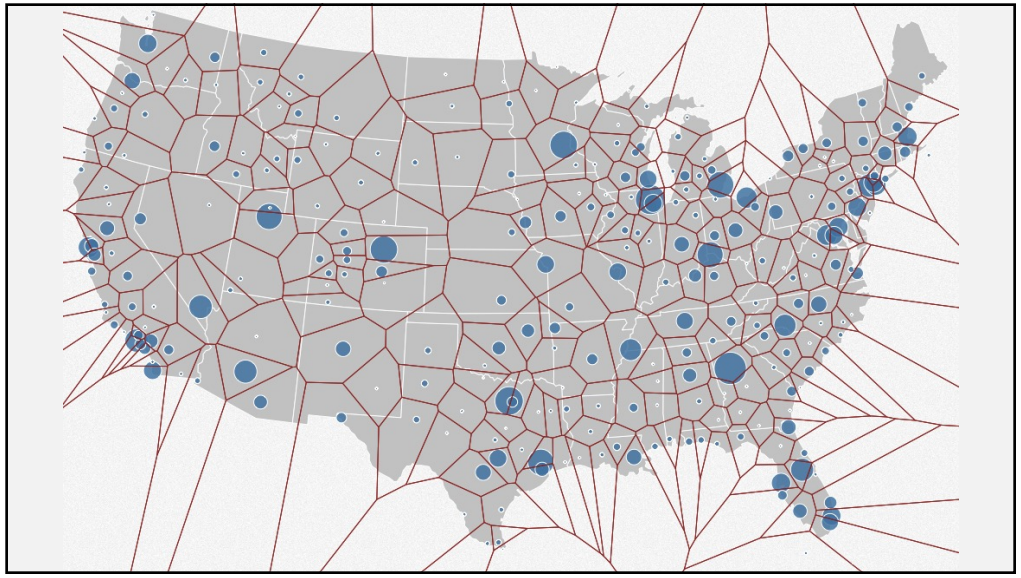


48

BASIC SELECTION METHODS

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

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

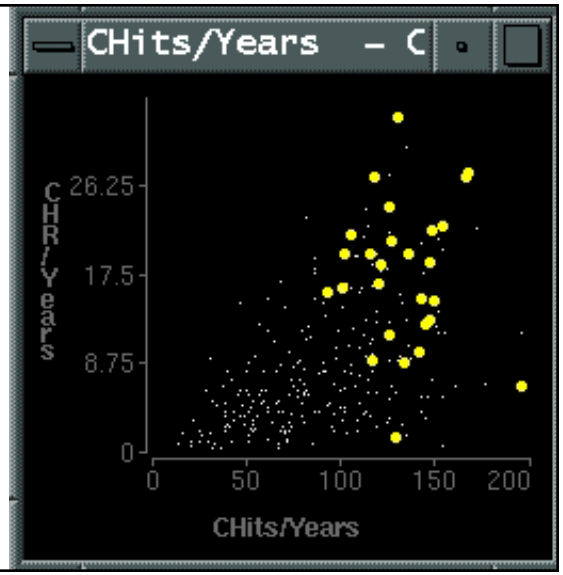
49

BRUSHING AND LINKING

50

BRUSHING

Direct attention to a subset of the data [Wills 95]



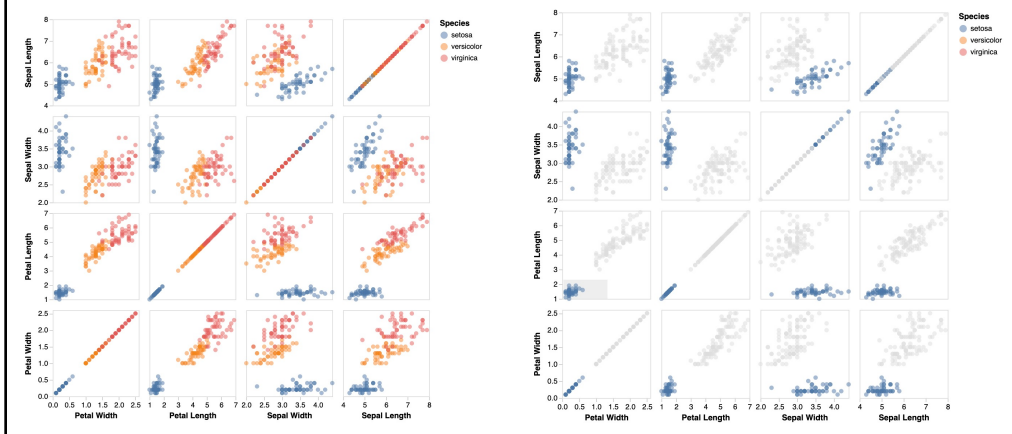
51

BRUSHING & LINKING

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

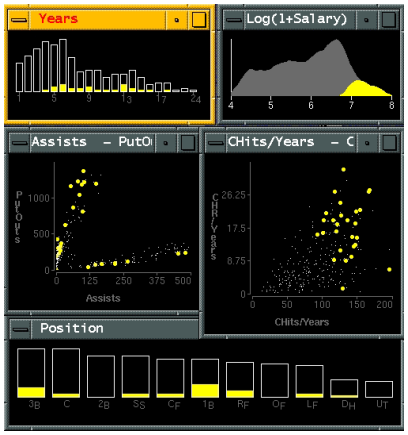
The component views must be *linked*
by *tuple* (matching same data point across views), or
by *query* (matching range or values of fiekds)

52



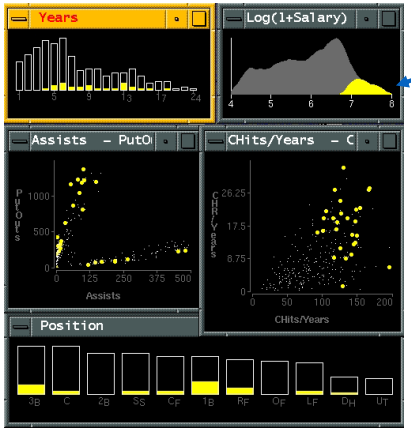
54

BASEBALL STATISTICS [Wills 1995]



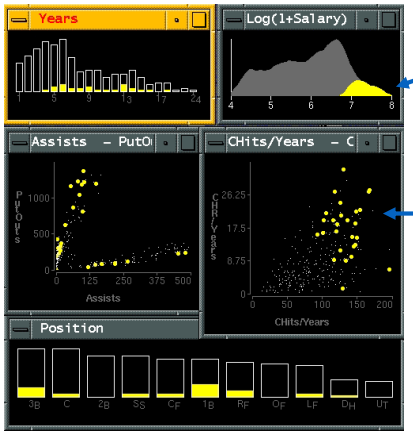
55

BASEBALL STATISTICS [Wills 1995]



56

BASEBALL STATISTICS [Wills 1995]



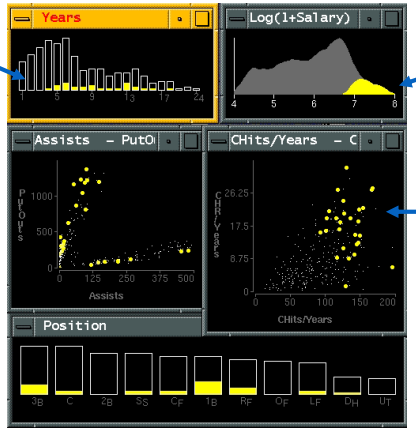
select high salaries

avg career HRs vs avg career hits (batting ability)

57

BASEBALL STATISTICS [Wills 1995]

how long in majors

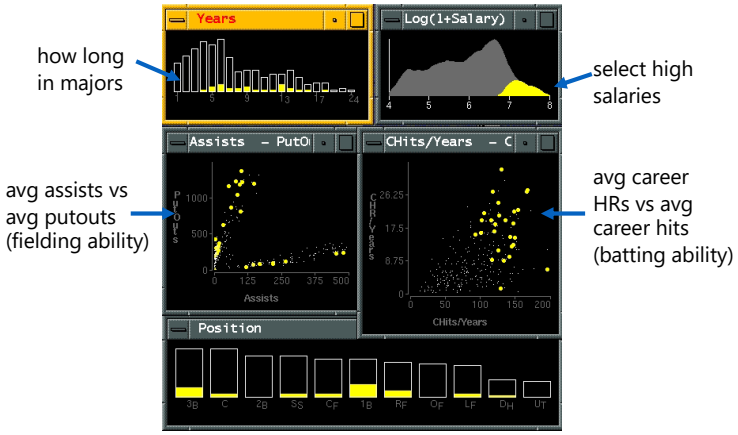


select high salaries

avg career HRs vs avg career hits (batting ability)

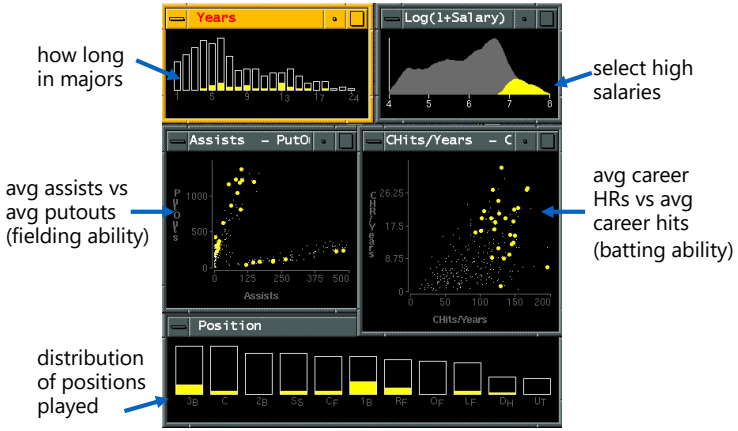
58

BASEBALL STATISTICS [Wills 1995]



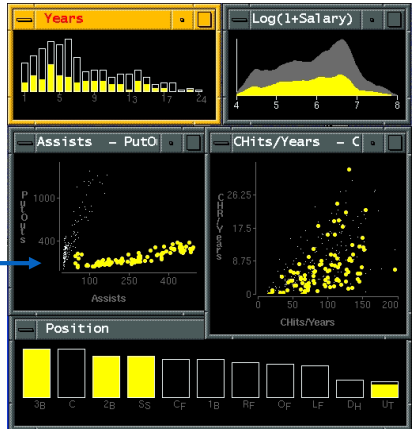
59

BASEBALL STATISTICS [Wills 1995]



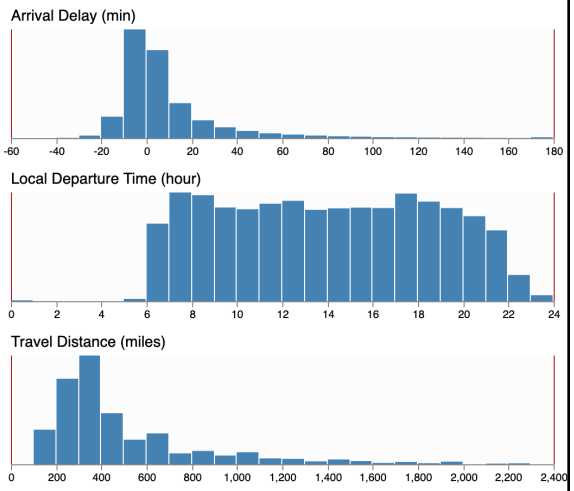
60

BASEBALL STATISTICS [Wills 1995]



61

CROSS-FILTERING



62

DYNAMIC QUERIES

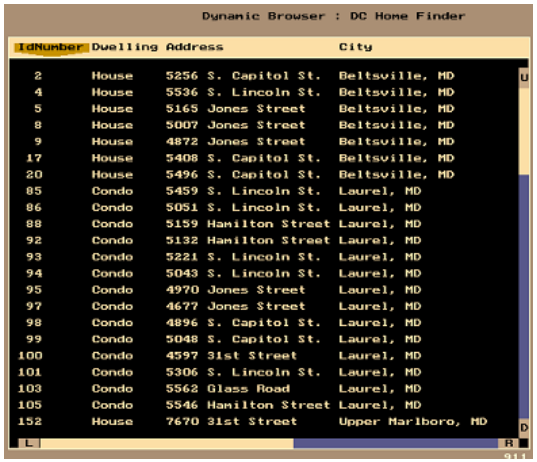
63

QUERY & RESULTS

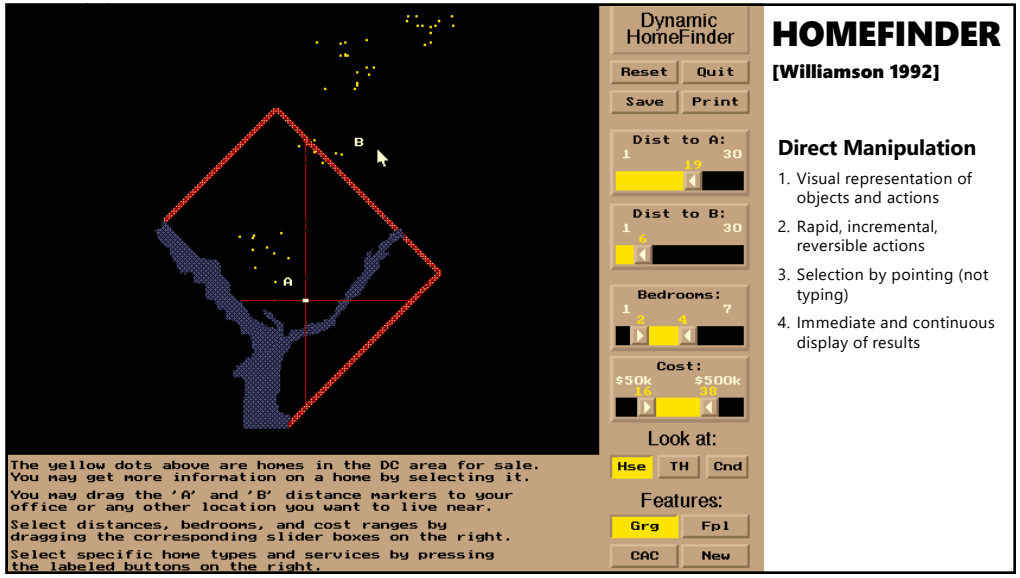
SELECT house FROM palo alto
WHERE price < 1,000,000 AND bedrooms > 2
ORDER BY price

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



64



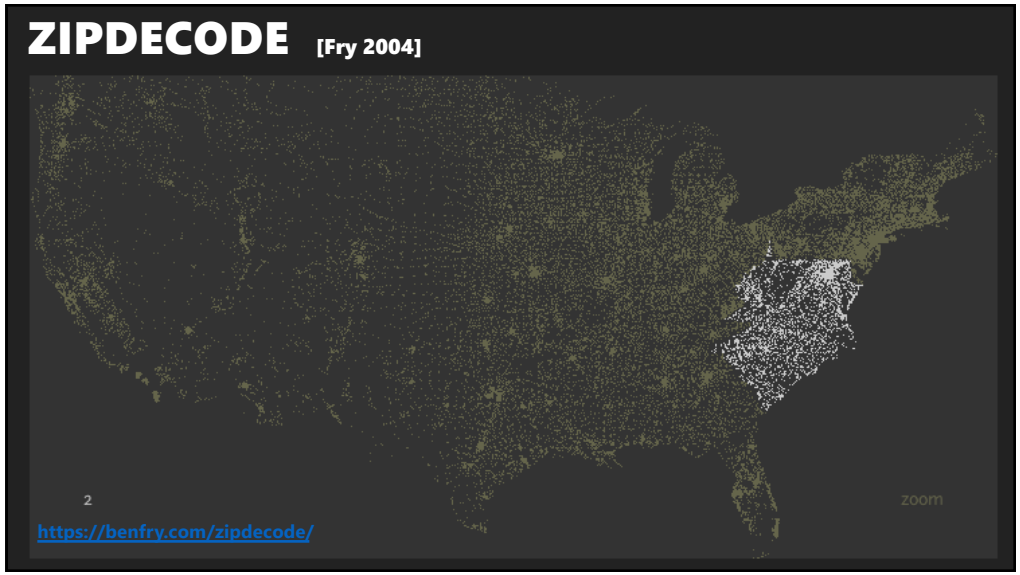
HOMEFINDER

[Williamson 1992]

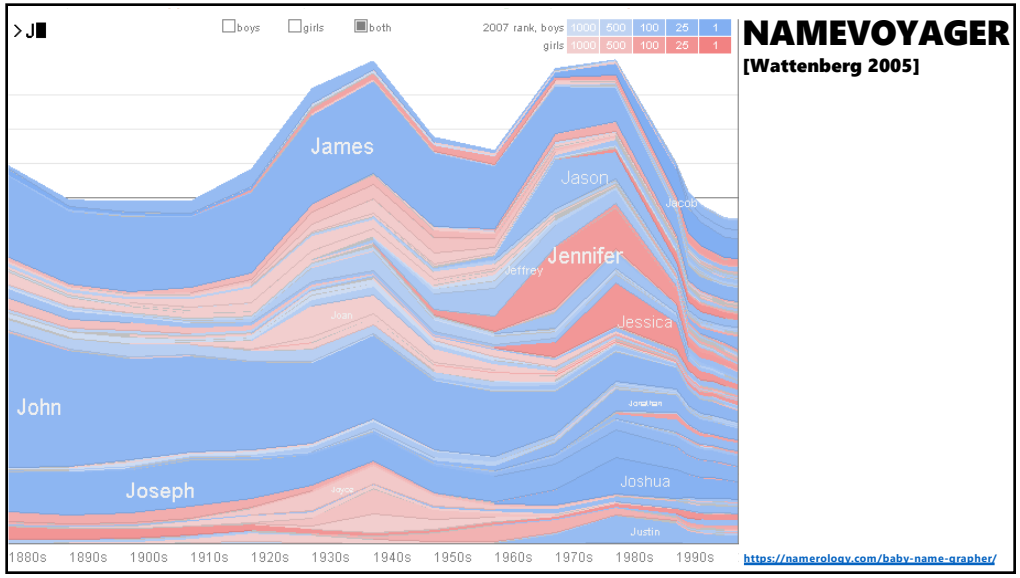
Direct Manipulation

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

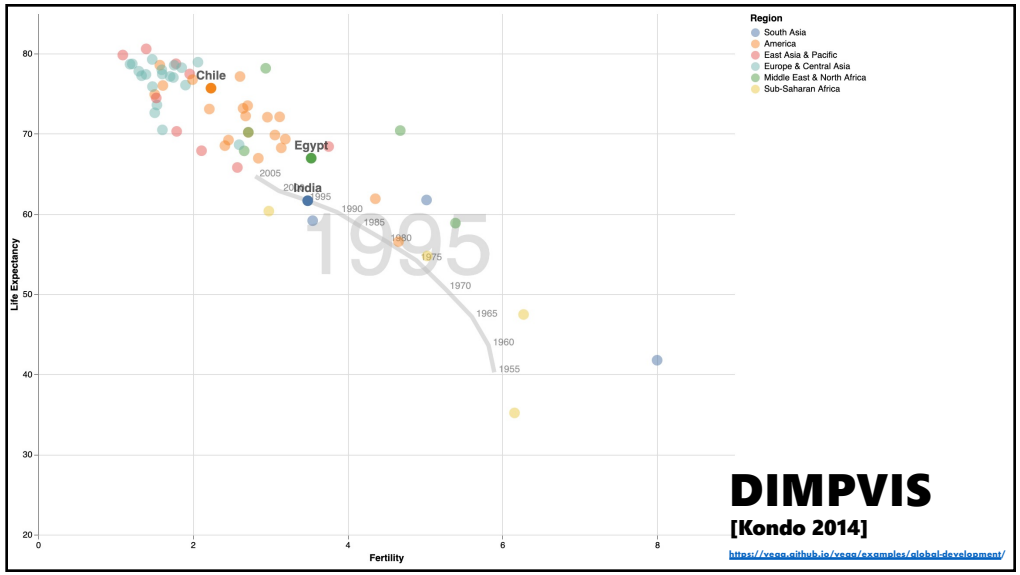
65



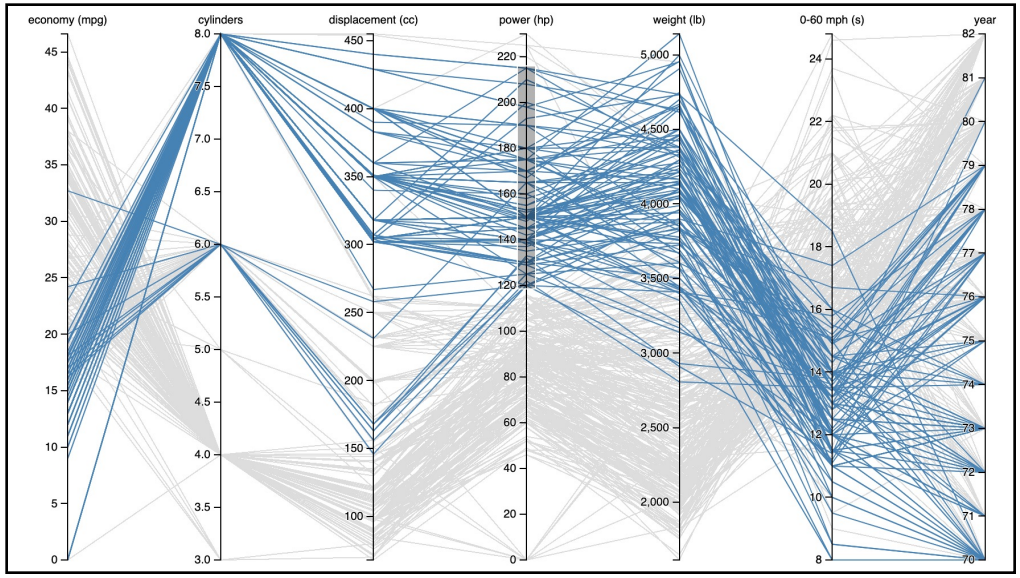
72


boys
girls
both
2007 rank, boys 1000 500 100 25 1
girls 1000 500 100 25 1
James
Jason
Jacob
Jennifer
Jeffrey
Joan
Jessica
John
Jonathan
Joseph
Joyce
Joshua
Justin
1880s 1890s 1900s 1910s 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s
NAMEVOYAGER
[Wattenberg 2005]
https://namerology.com/baby-name-grapher/

73

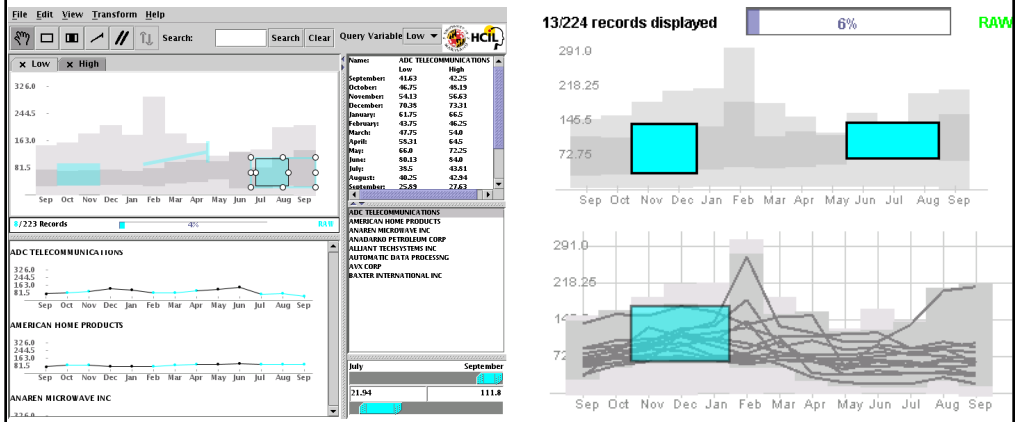

Region
South Asia
America
East Asia & Pacific
Europe & Central Asia
Middle East & North Africa
Sub-Saharan Africa
Chile
Egypt
India
2005
1995
1990
1985
1980
1975
1970
1965
1960
1955
1995
Life Expectancy
Fertility
20
30
40
50
60
70
80
0
2
4
6
8
DIMPVIS
[Kondo 2014]
https://vega.github.io/vega/examples/global-development/

74



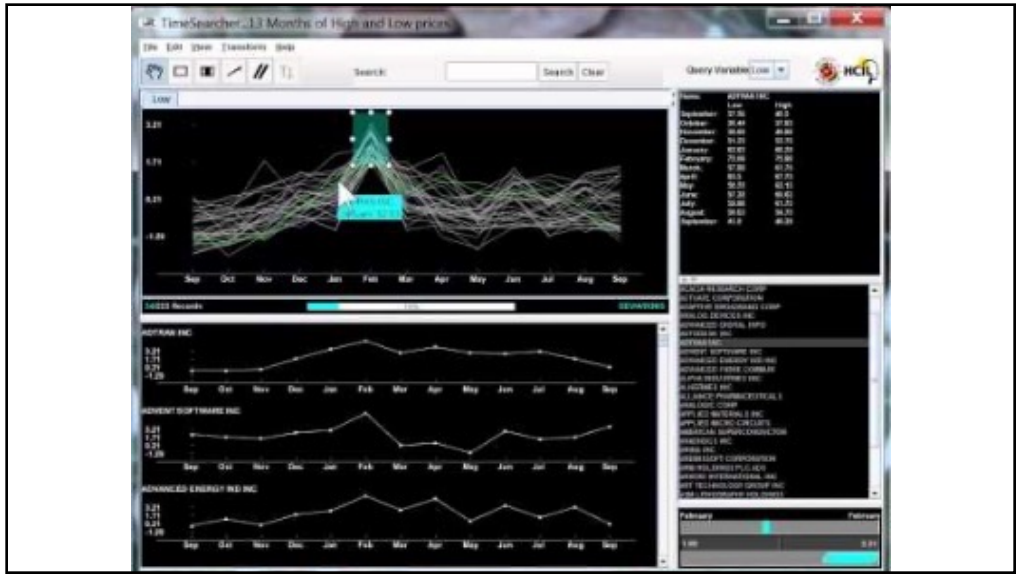
75

TIMESEARCHER [Hocheiser 2002]



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

76


TimeSearcher: 13 Months of High and Low prices
Search
Clear
Low
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

77