Visualization
and
Data Mining

Outline

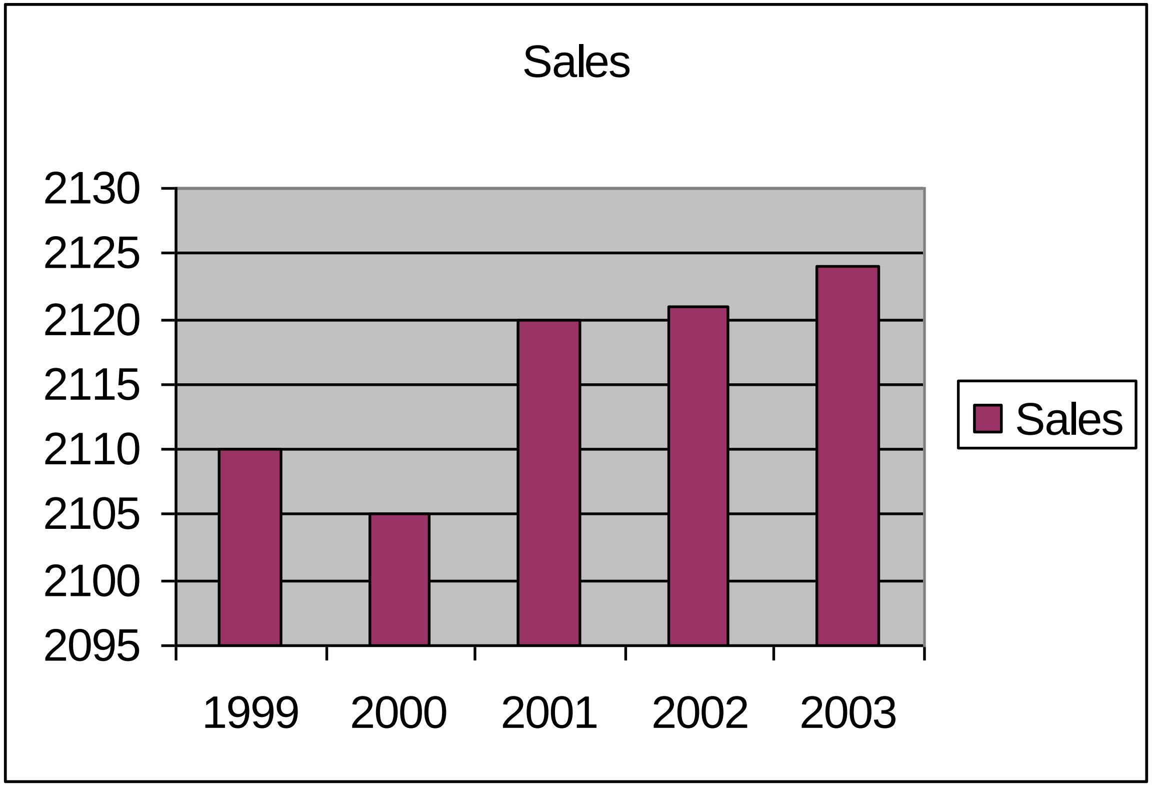
- Graphical excellence and lie factor
- Representing data in 1-D, 2-D, and 3-D
- Representing data in 4+ dimensions
  - Parallel coordinates
  - Scatterplots
  - Stick figures

Visualization Role

- Support interactive exploration
- Help in result presentation
- Disadvantage: requires human eyes
- Can be misleading

Bad Visualization: Spreadsheet

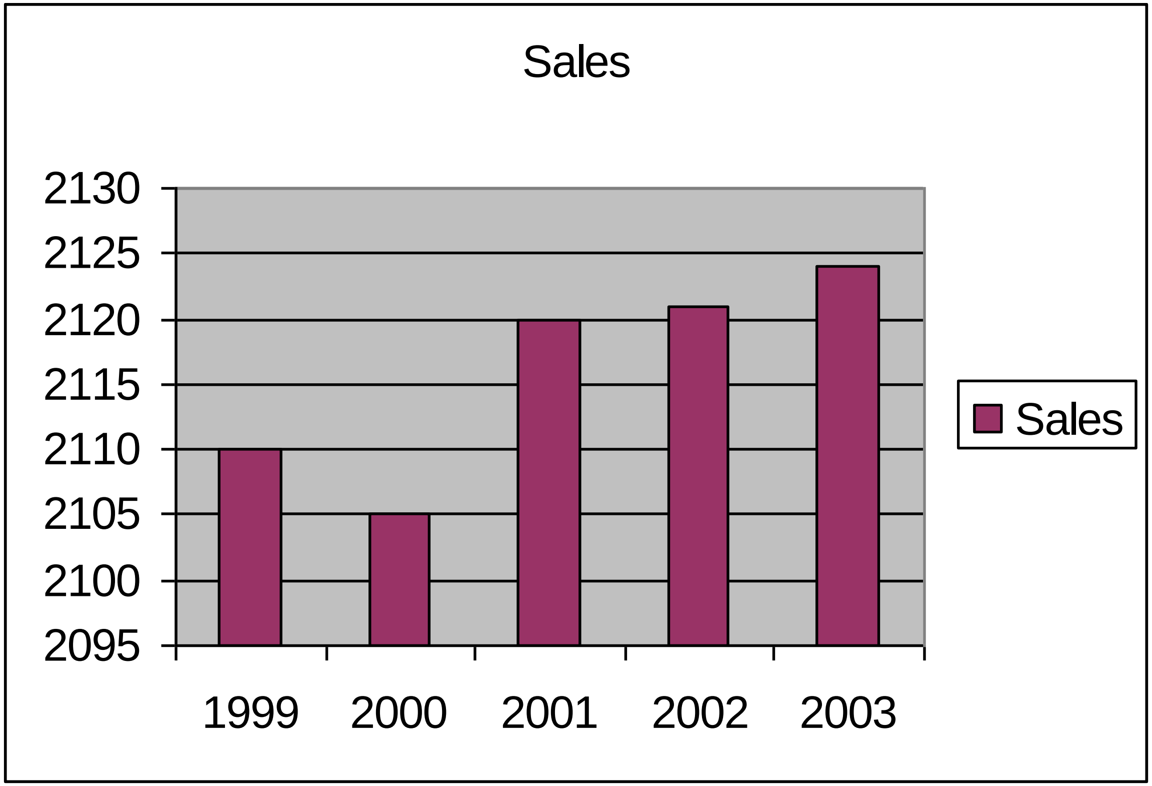
Year	Sales
1999	2,110
2000	2,105
2001	2,120
2002	2,121
2003	2,124



What is wrong with this graph?

Bad Visualization:
Spreadsheet with misleading Y –axis

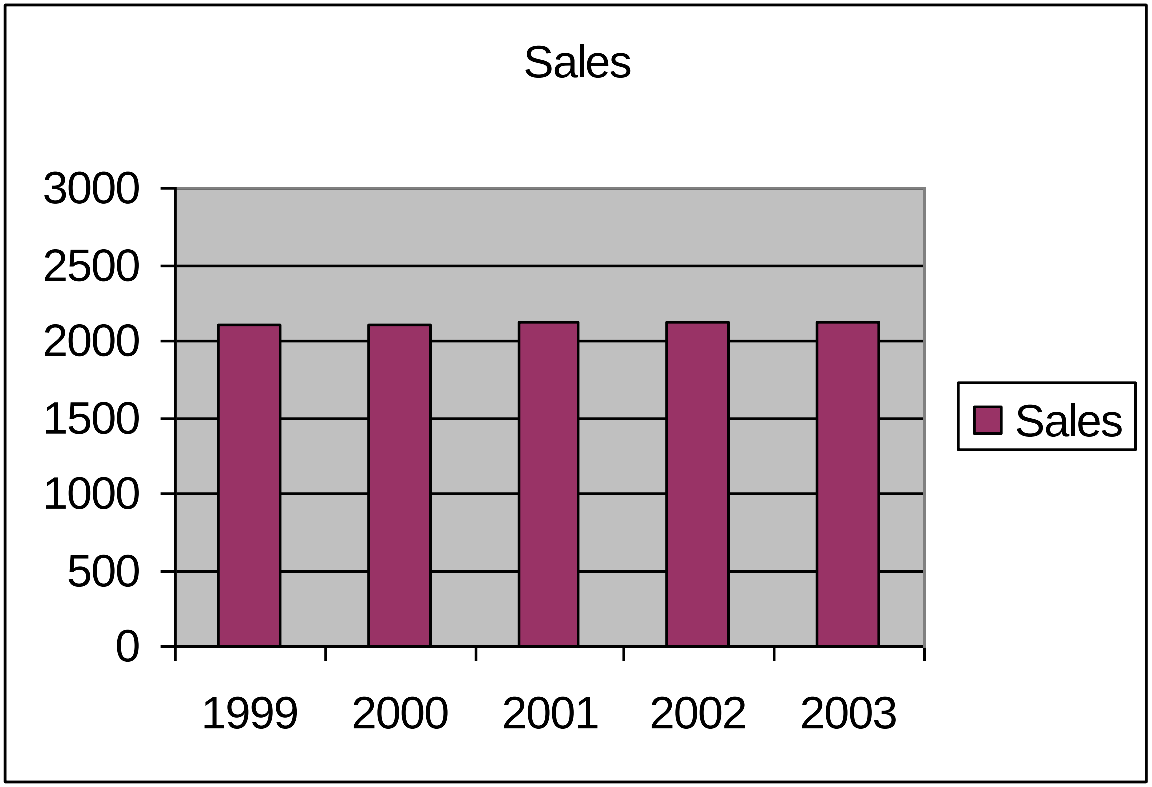
Year	Sales
1999	2,110
2000	2,105
2001	2,120
2002	2,121
2003	2,124



Y-Axis scale gives **WRONG** impression of big change

Better Visualization

Year	Sales
1999	2,110
2000	2,105
2001	2,120
2002	2,121
2003	2,124



Axis from 0 to 2000 scale gives correct impression of small change

Lie Factor

$$Lie\ Factor = \frac{size\ of\ \ effect\ shown\ in\ graphic}{size\ of\ \ effect\ in\ data} =$$

$$= \frac{\dfrac{(20-10)}{10}}{\dfrac{(2120-2105)}{2105}} = \frac{0.5}{0.007125} = 70.18$$

Tufte requirement: $0.95 < \text{Lie Factor} < 1.05$

(E.R. Tufte, “The Visual Display of Quantitative Information”, 2nd edition)

Tufte's Principles of Graphical Excellence

- Give the viewer
  - the greatest number of ideas
  - in the shortest time
  - with the least ink in the smallest space.

- Tell the truth about the data!

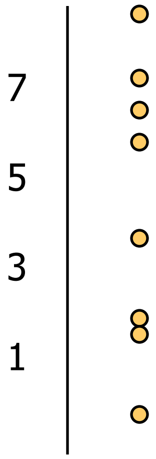
(E.R. Tufte, "The Visual Display of Quantitative Information", 2nd edition)

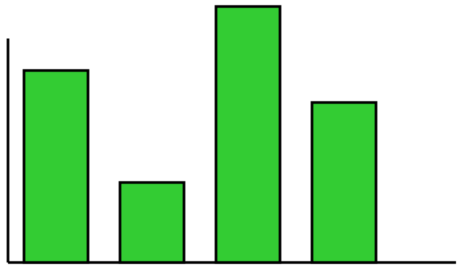
Visualization Methods

- Visualizing in 1-D, 2-D and 3-D
  - well-known visualization methods
- Visualizing more dimensions
  - Parallel Coordinates
  - Other ideas

1-D (Univariate) Data

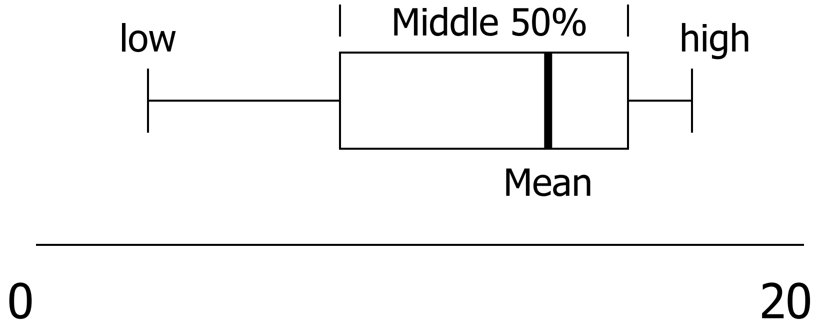
- Representations





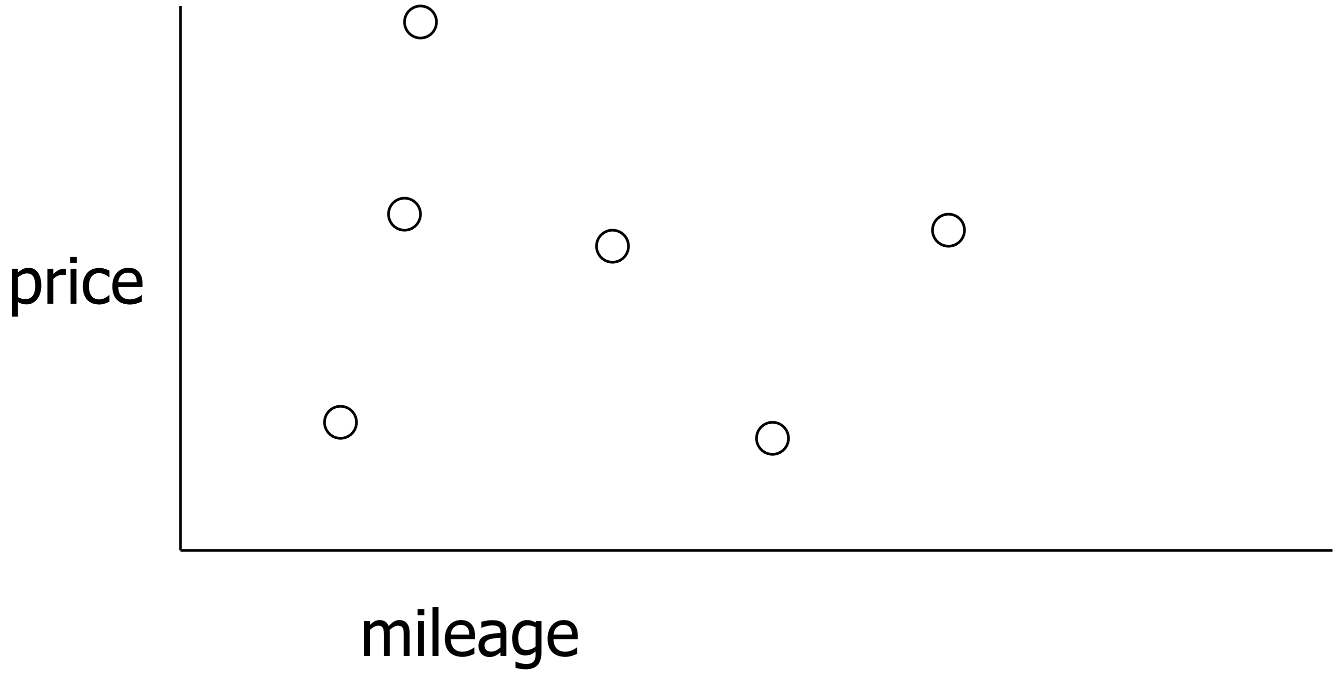
Histogram

Tukey box plot

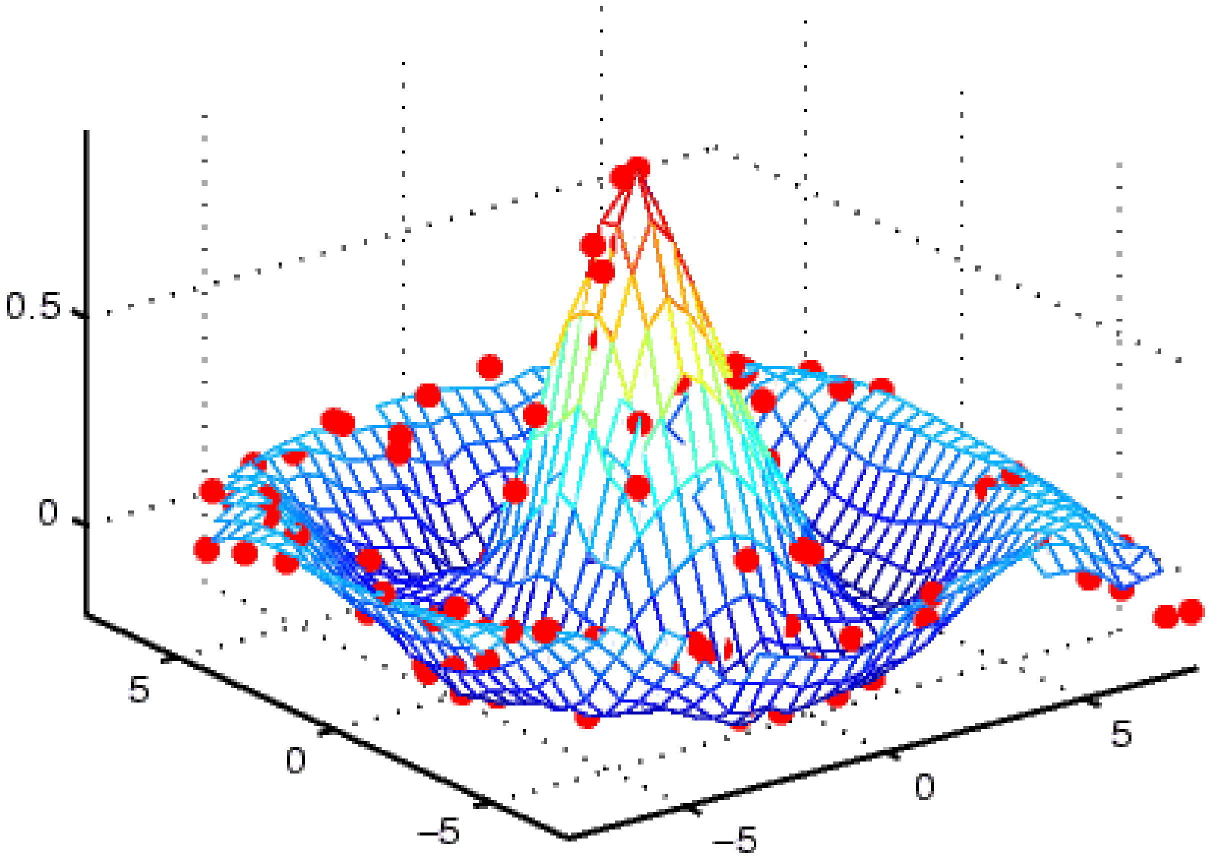


2-D (Bivariate) Data

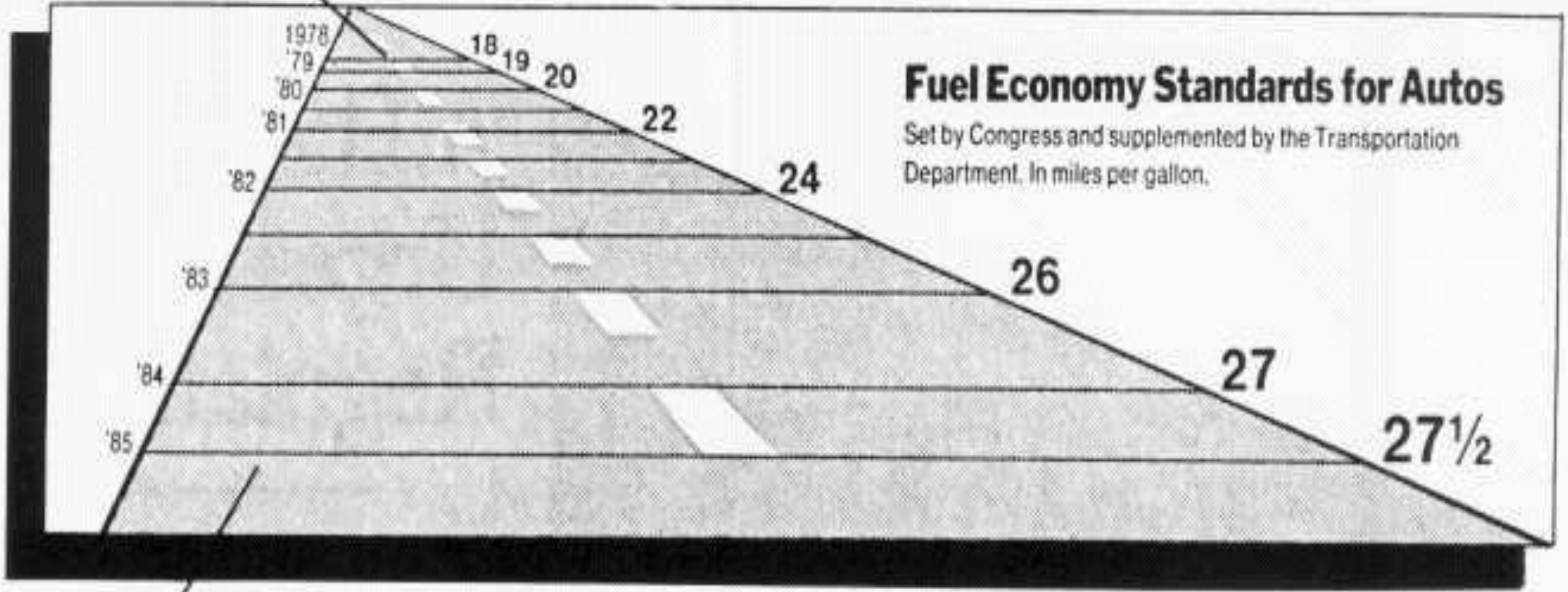
- Scatter plot, …



3-D Data (projection)



This line, representing 18 miles per gallon in 1978, is 0.6 inches long.



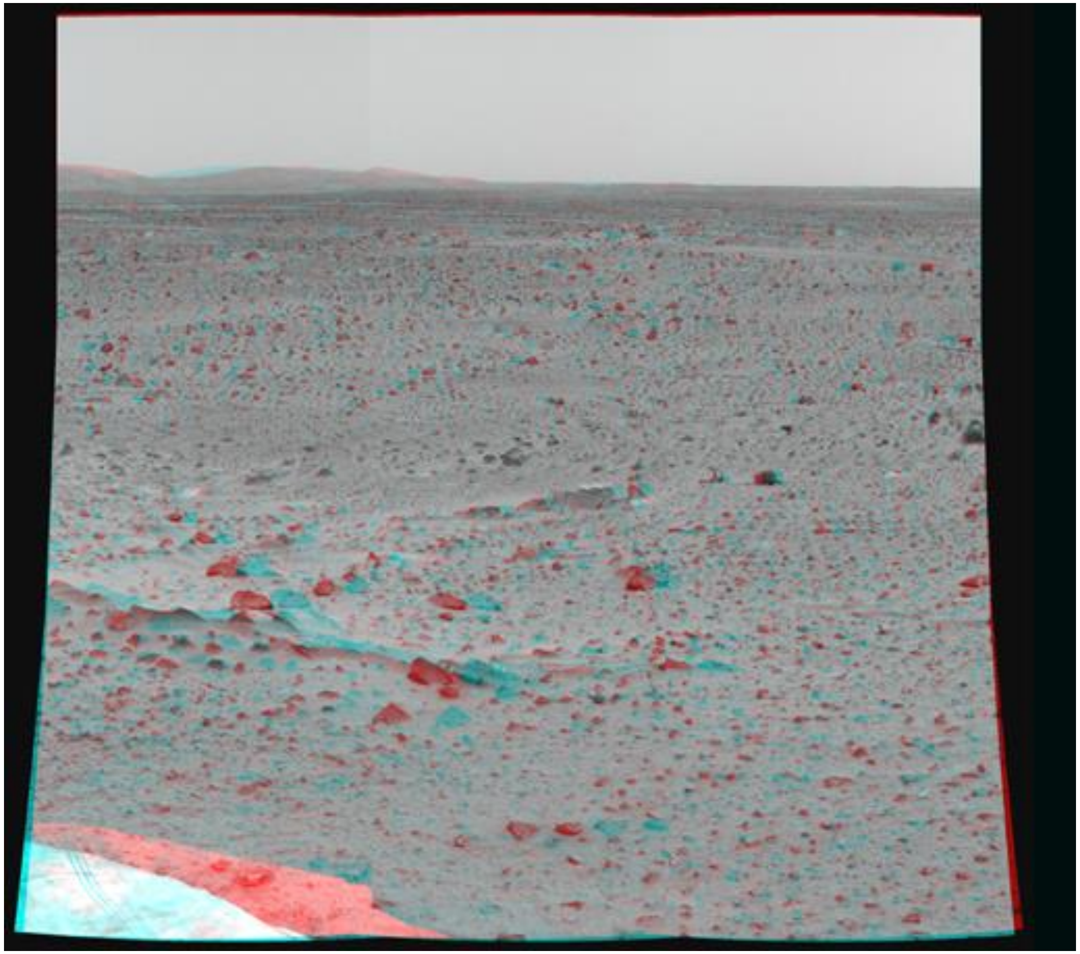
This line, representing 27.5 miles per gallon in 1985, is 5.3 inches long.

Lie Factor=14.8

New York Times, August 9, 1978, p. D-2.

(E.R. Tufte, "The Visual Display of Quantitative Information", 2nd edition)

3-D image
(requires 3-D blue and red glasses)



Taken by Mars Rover Spirit, Jan 2004

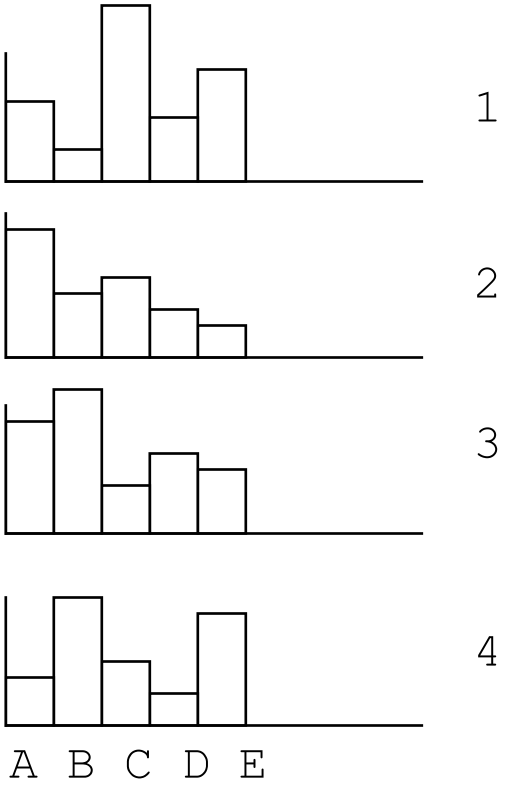
Visualizing in 4+ Dimensions

- Scatterplots
- Parallel Coordinates
- Chernoff faces
- Stick Figures
- …

Multiple Views

Give each variable its own display

	A	B	C	D	E
1	4	1	8	3	5
2	6	3	4	2	1
3	5	7	2	4	3
4	2	6	3	1	5



Problem: does not show correlations

Scatterplot Matrix

Represent each possible pair of variables in their own 2-D scatterplot (car data)

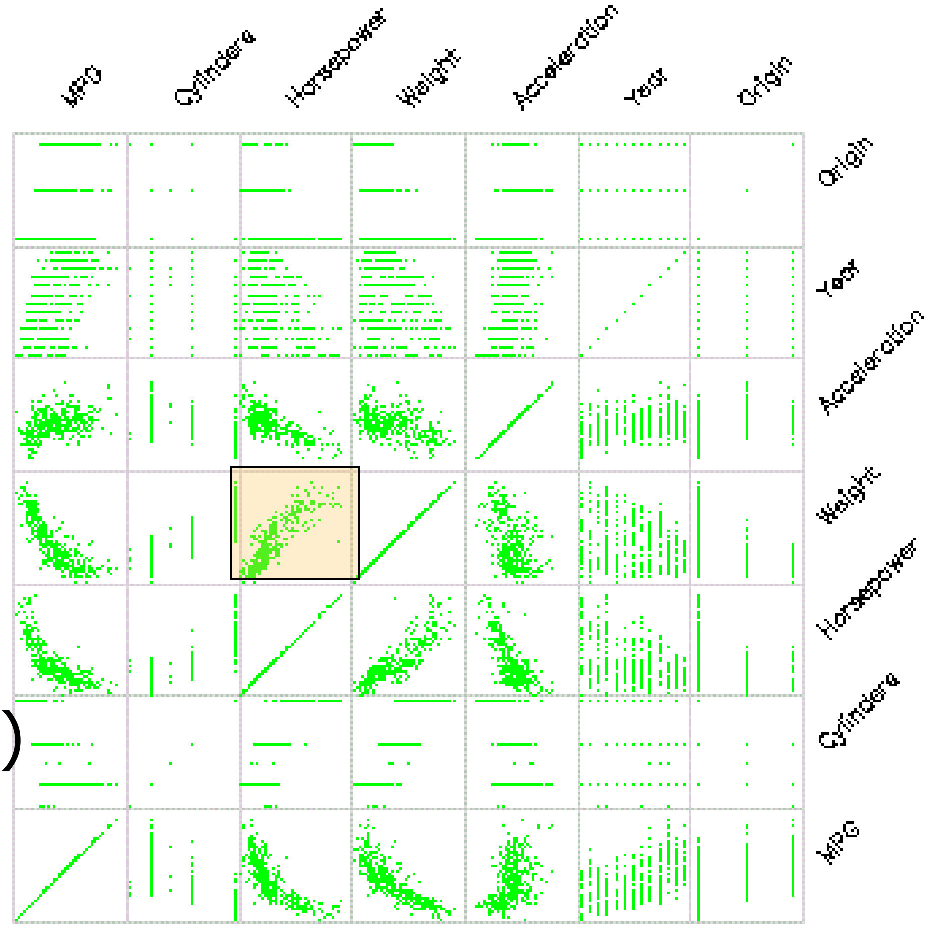
Q: Useful for what?

A: linear correlations

(e.g. horsepower & weight)

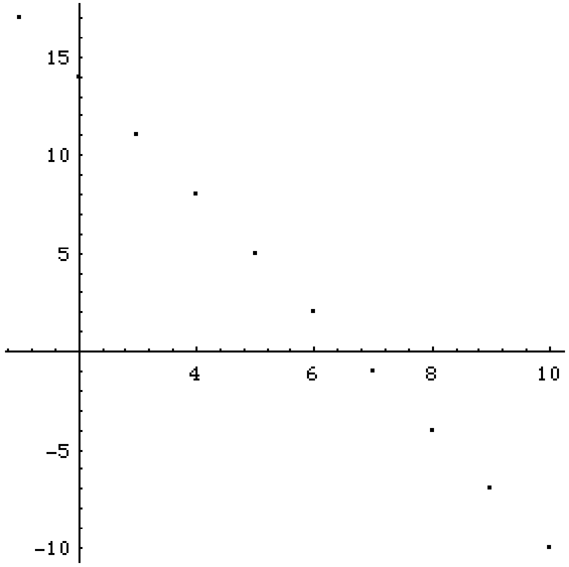
Q: Misses what?

A: multivariate effects

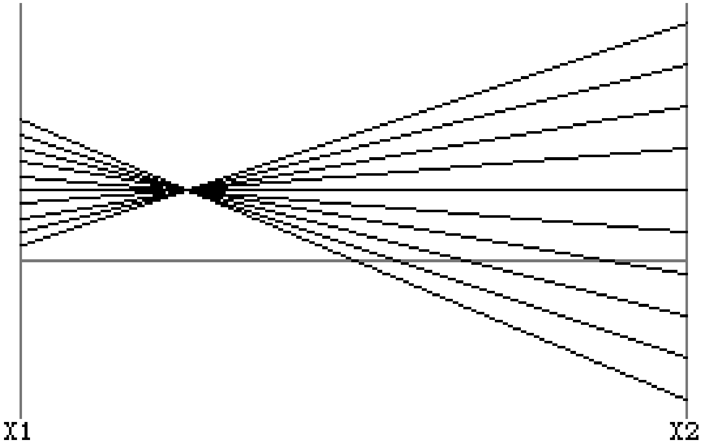


Parallel Coordinates

- Encode variables along a horizontal row
- Vertical line specifies values



Dataset in a Cartesian coordinates



Same dataset in parallel coordinates

Invented by
Alfred Inselberg
while at IBM, 1985

Example: Visualizing Iris Data

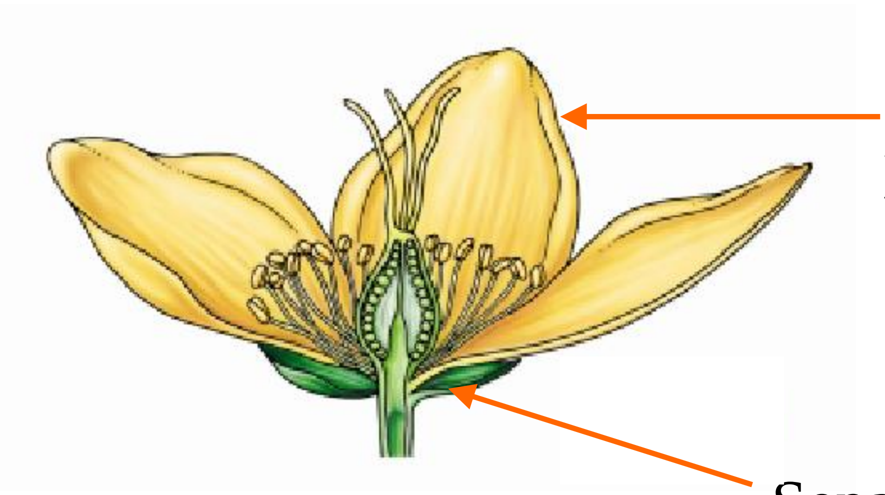
Iris setosa

sepal length	sepal width	petal length	petal width
5.1	3.5	1.4	0.2
4.9	3	1.4	0.2
…	…	…	…
5.9	3	5.1	1.8

Iris versicolor

Iris virginica

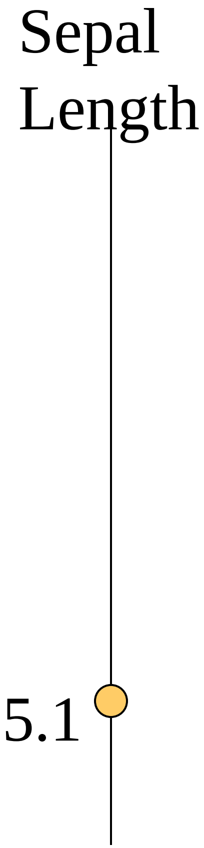
Flower Parts



Petal, a non-reproductive part of the flower

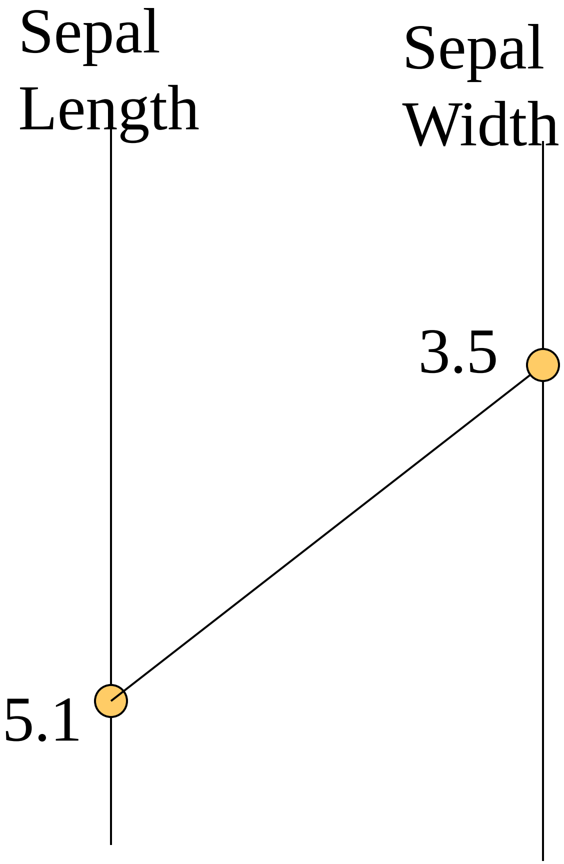
Sepal, a non-reproductive part of the flower

Parallel Coordinates



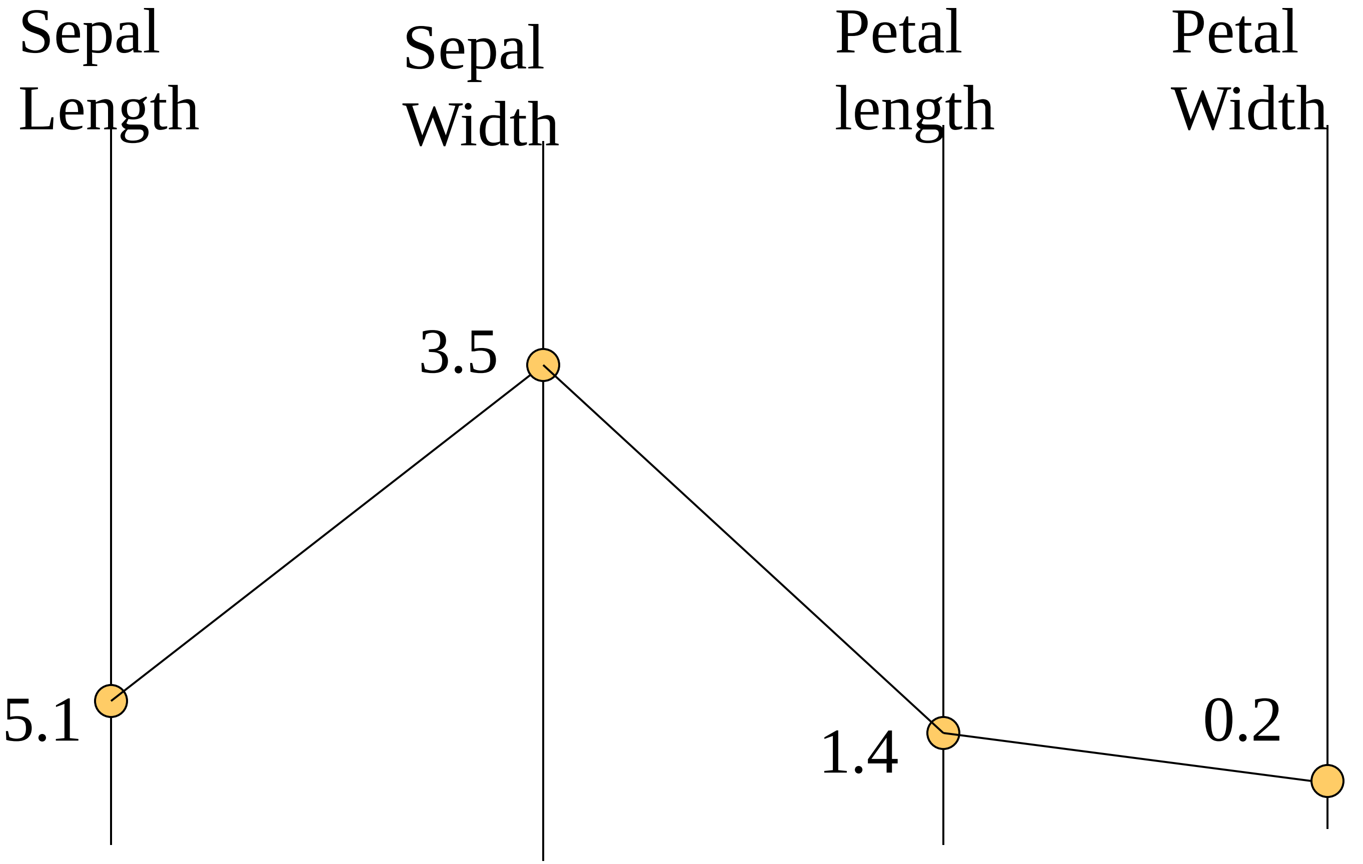
sepal length	sepal width	petal length	petal width
5.1	3.5	1.4	0.2

Parallel Coordinates: 2 D



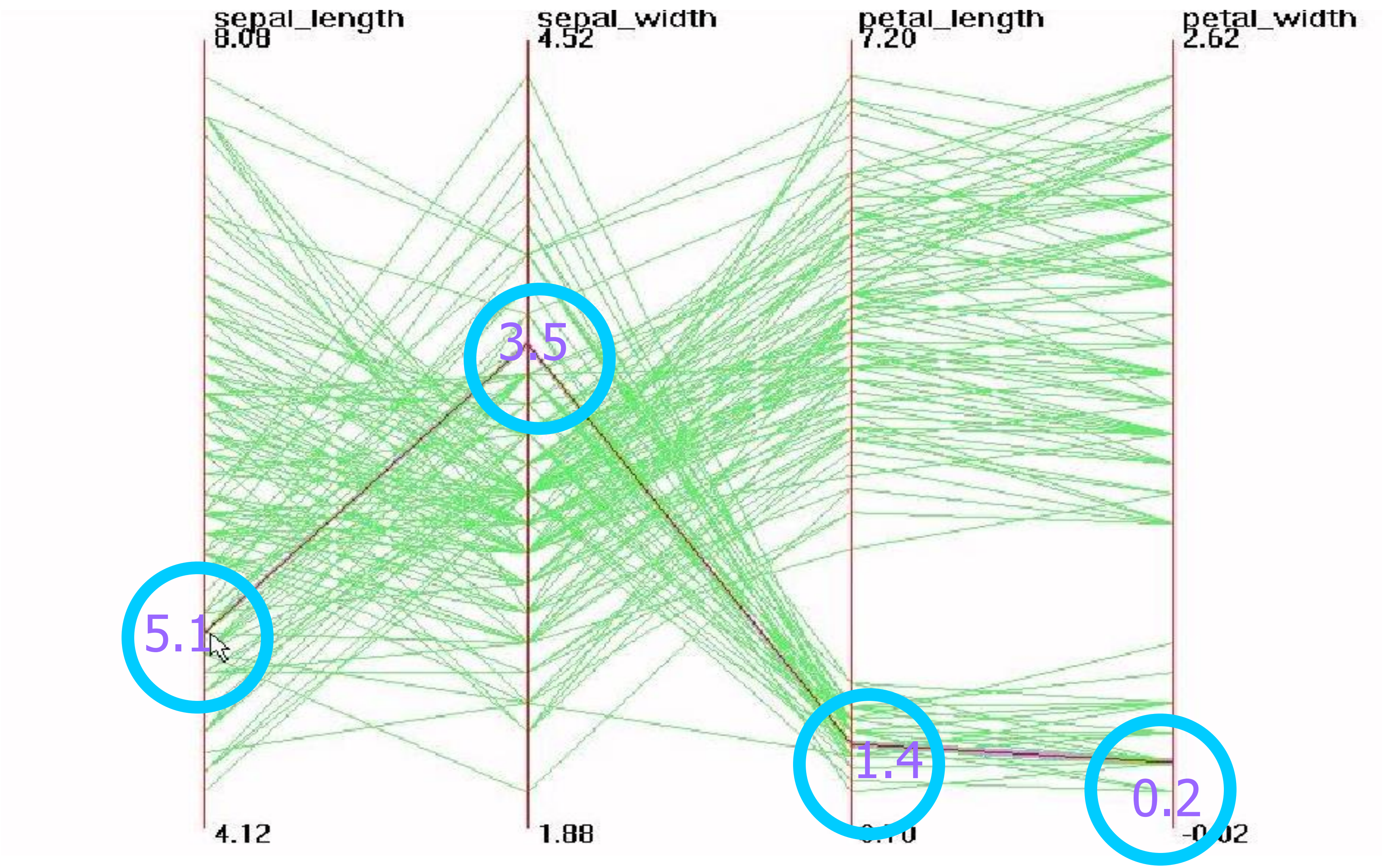
sepal length	sepal width	petal length	petal width
5.1	3.5	1.4	0.2

Parallel Coordinates: 4 D



sepal length	sepal width	petal length	petal width
5.1	3.5	1.4	0.2

Parallel Visualization of Iris data



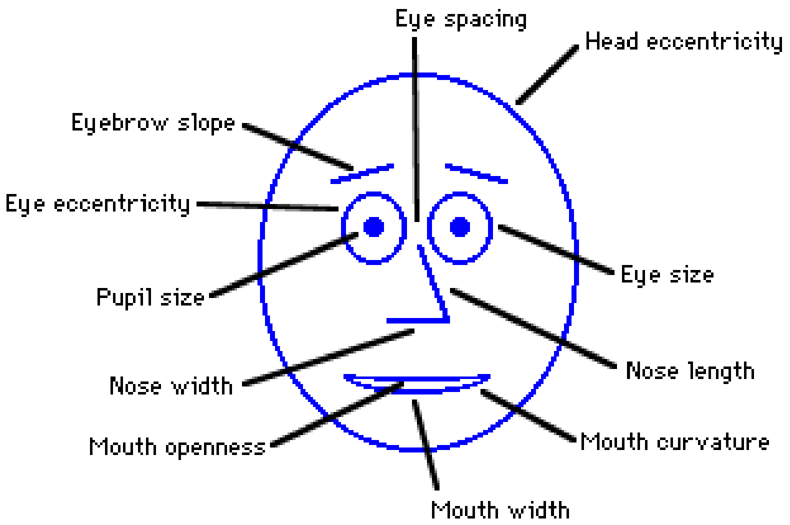
Parallel Visualization Summary

- Each data point is a line
- Similar points correspond to similar lines
- Lines crossing over correspond to negatively correlated attributes
- Interactive exploration and clustering

- Problems: order of axes, limit to ~20 dimensions

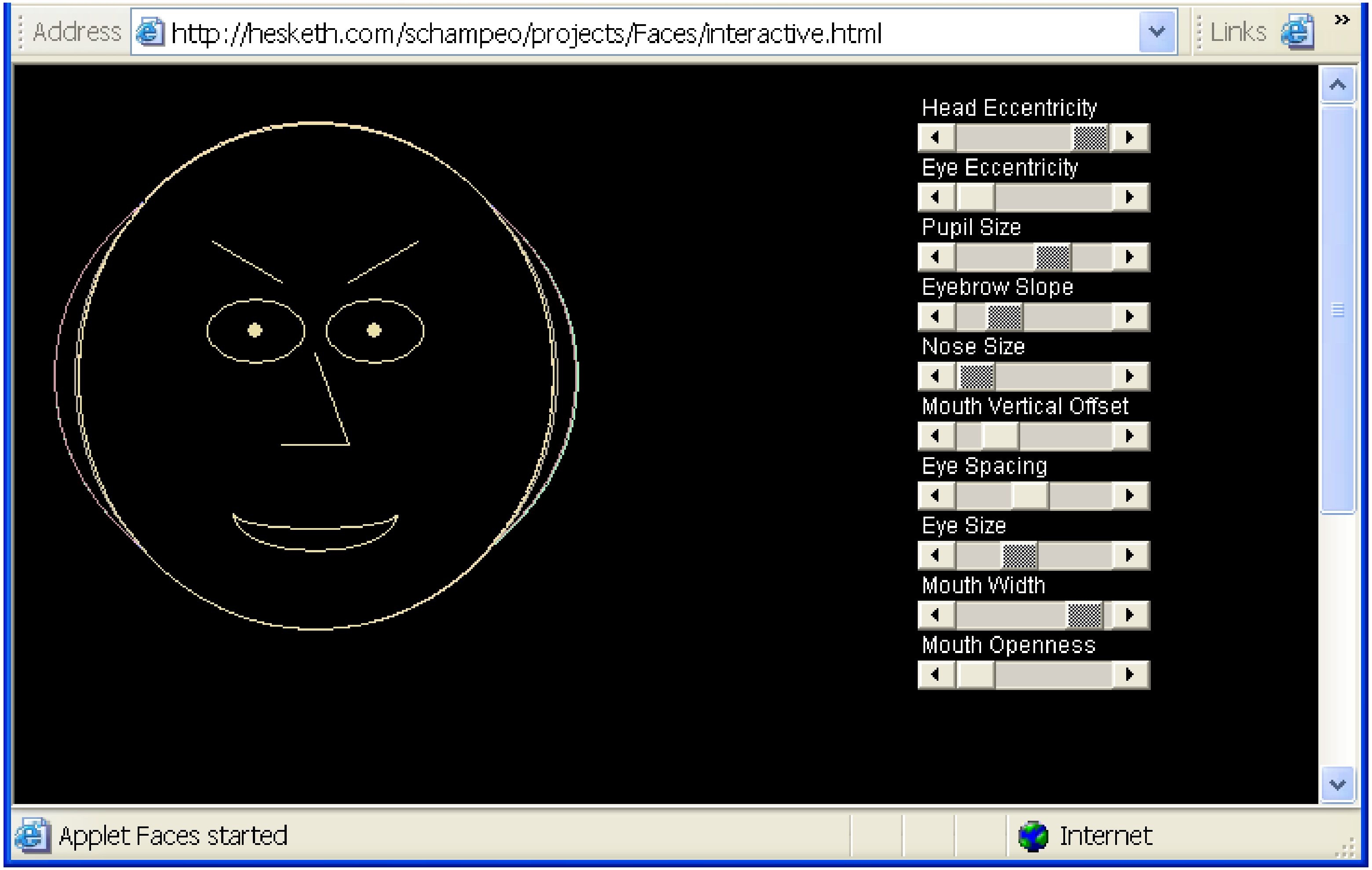
Chernoff Faces

Encode different variables' values in characteristics of human face



Cute applets: http://www.cs.uchicago.edu/~wiseman/chernoff/
http://hesketh.com/schampeo/projects/Faces/chernoff.html

Interactive Face

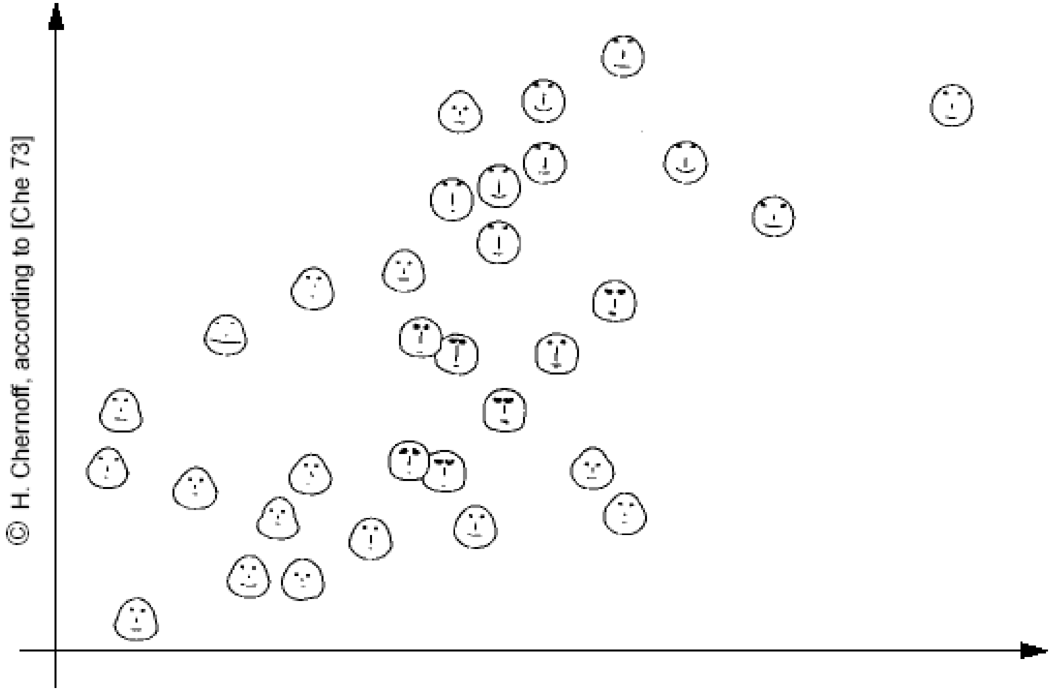


Address http://hesketh.com/schampeo/projects/Faces/interactive.html

Applet Faces started

Chernoff faces, example

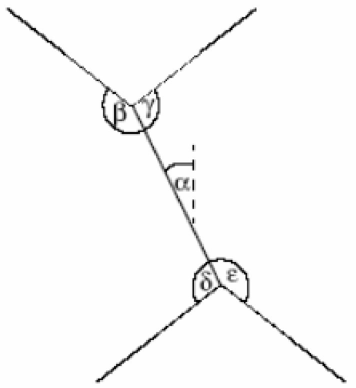
Chernoff-Faces [Che 73, Tuf 83]



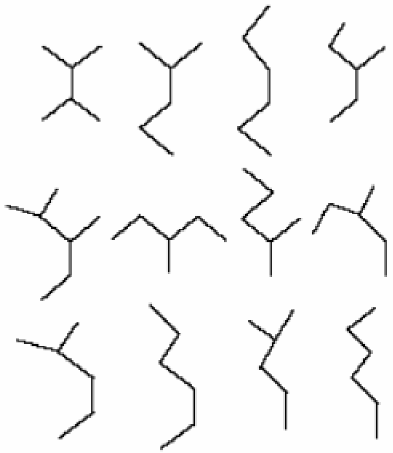
© H. Chernoff, according to [Che 73]

Stick Figures

- Two variables are mapped to X, Y axes
- Other variables are mapped to limb lengths and angles
- Texture patterns can show data characteristics

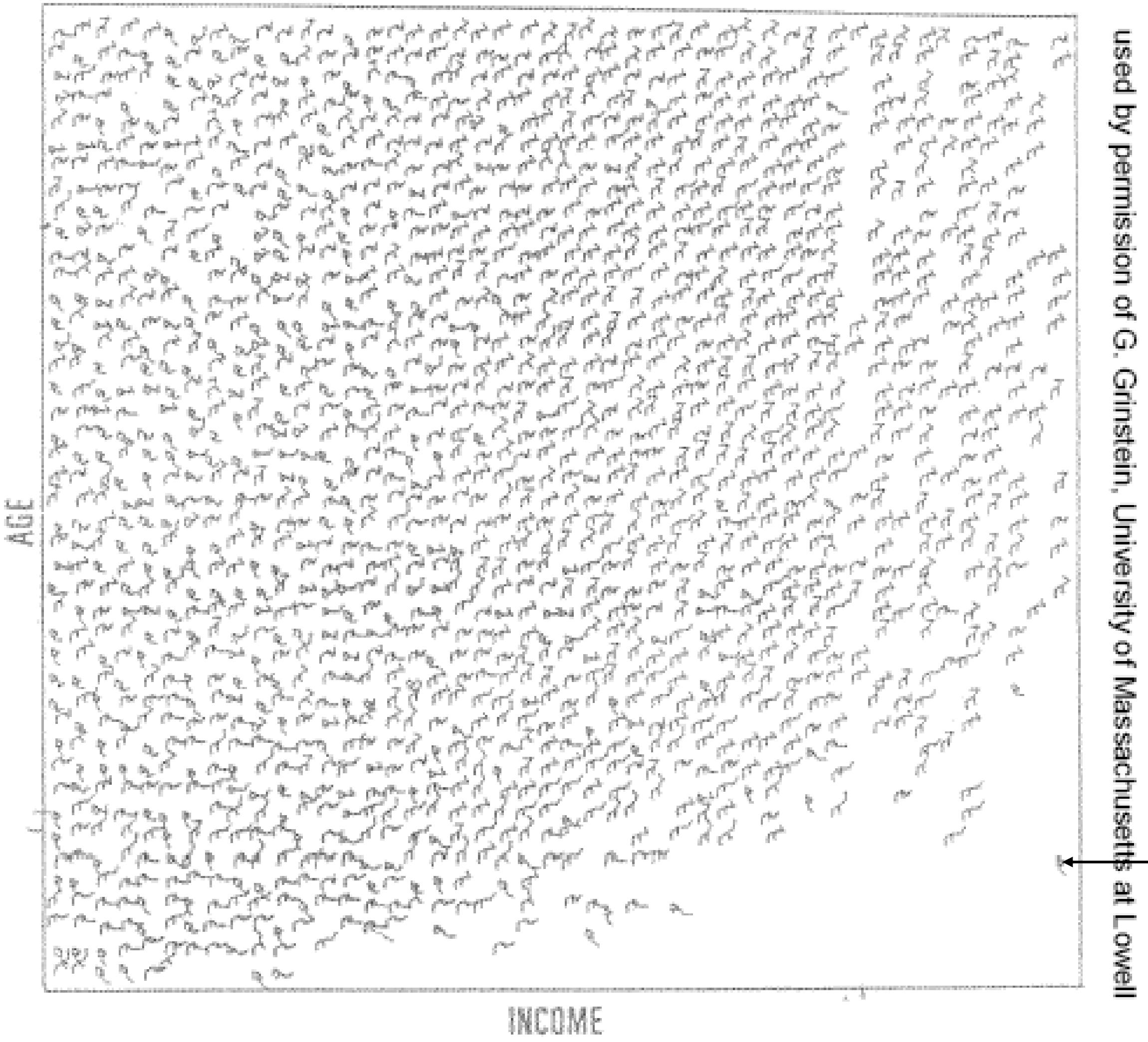


Stick Figure Icon



A Family of Stick Figures

Stick figures, example



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census data showing age, income, sex, education, etc.

Closed figures correspond to women and we can see more of them on the left.

Note also a young woman with high income

Visualization software

Free and Open-source

- R + ggplot2
- Python + vizualization libraries
- Orange

- Many more – see:
  www.KDnuggets.com/software/visualization.html

Visualization Summary

- Many methods
- Visualization is possible in more than 3-D
- Aim for graphical excellence
- Tell the truth about the data