CS 147: Computer Systems Performance Analysis

Mistakes in Graphical Presentation

2015-06-15

CS147

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Computer Systems Performance Analysis
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Overview

- Common Mistakes in Graphics
  - Excess Information
  - Multiple Scales
  - Symbols for Text
  - Poor Scales
  - Bad Line Usage
- Pictorial Games
  - Non-Zero Origins
  - Double Whammy
  - No Confidence Intervals
  - Height Scaling
  - Histogram Problems
- Graphical Integrity
- Special-Purpose Charts
- A Few Examples

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- Sneaky trick to meet length limits
- Rules of thumb:
  - 6 curves on line chart
  - 10 bars on bar chart
  - 8 slices on pie chart
    - (But note that Tufte *hates* pie charts)
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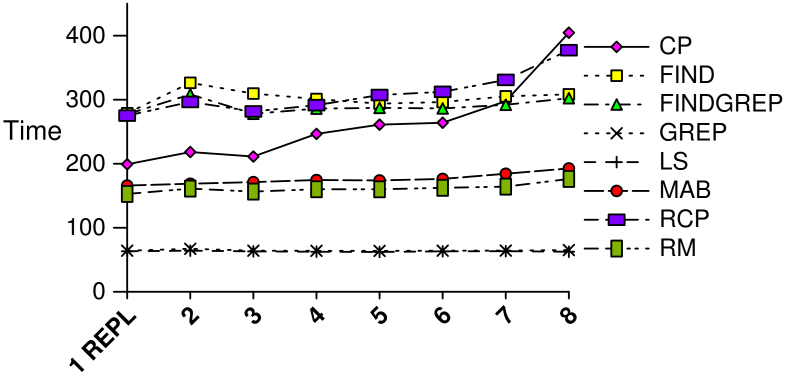
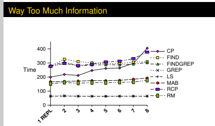
Way Too Much Information

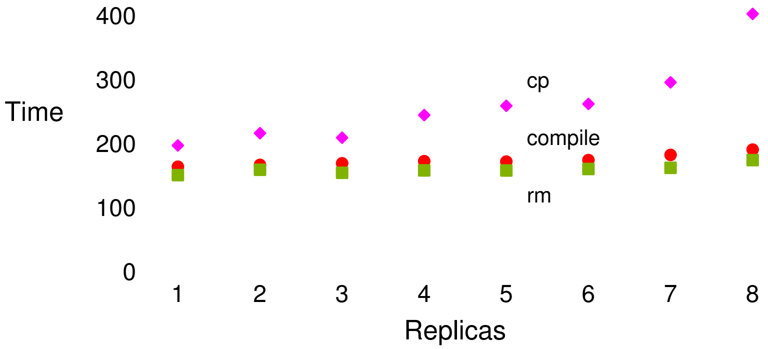




What's important on that chart?

- Times for cp and rcp rise with number of replicas
- Most other benchmarks are near constant
- Exactly constant for rm

The Right Amount of Information



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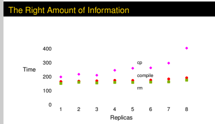

Multiple Scales

- Another way to meet length limits
- Basically, two graphs overlaid on each other
- Confuses reader (which line goes with which scale?)
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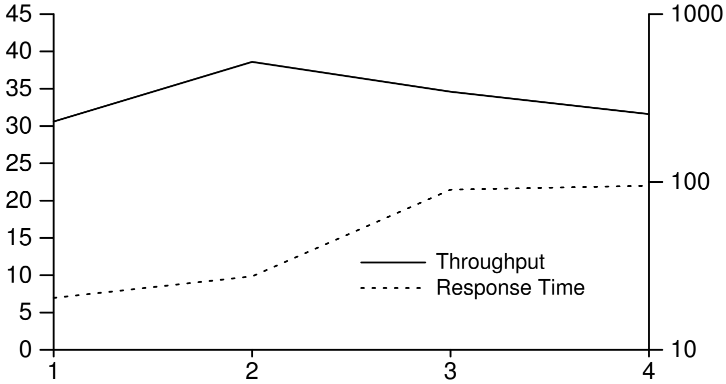
Some Especially Bad Multiple Scales



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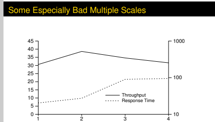

Using Symbols in Place of Text

- Graphics should be self-explanatory
  - Remember that the graphs often draw the reader in
- So use explanatory text, not symbols
- This means no Greek letters!
  - Unless your conference is in Athens...

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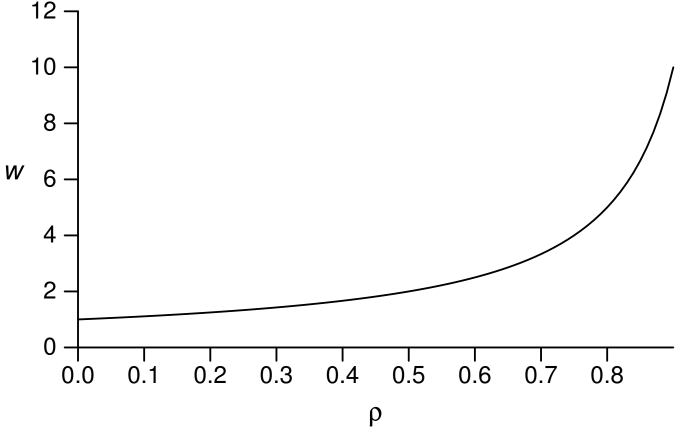
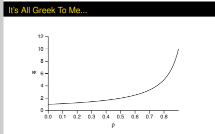
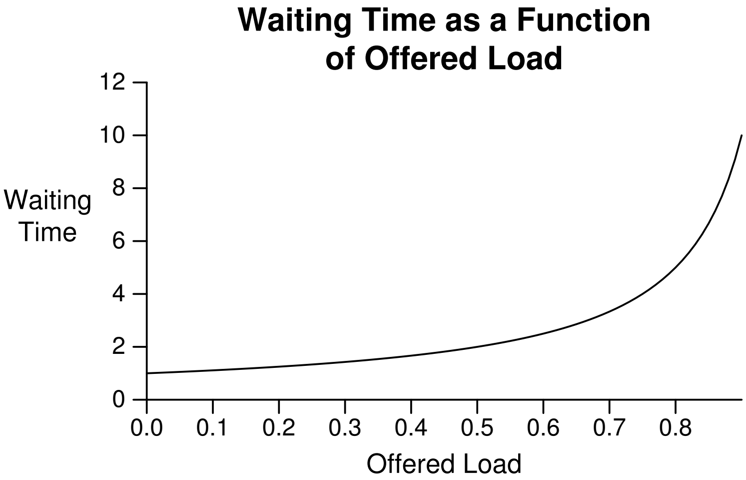
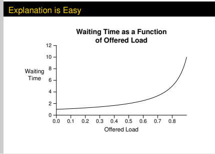
It’s All Greek To Me...





Explanation is Easy





Poor Scales

- Fiddle with axis ranges (and logarithms) to get your message across
  - But don't lie or cheat
- Sometimes trimming off high ends makes things clearer
  - Brings out low-end detail

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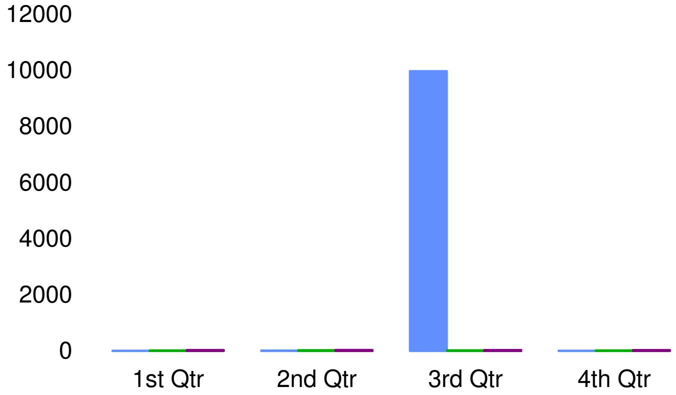
A Poor Axis Range



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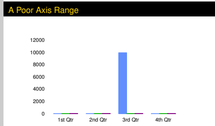
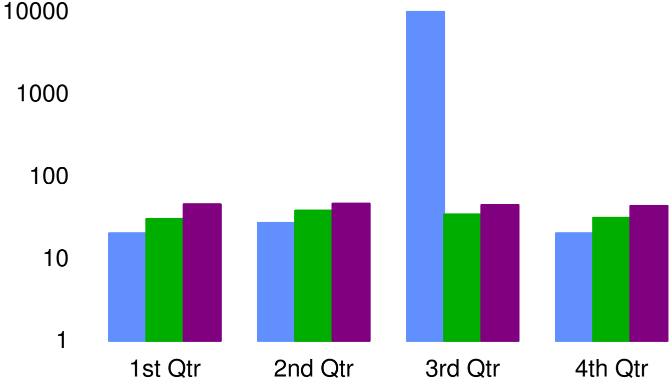


A Logarithmic Range



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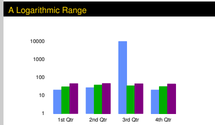
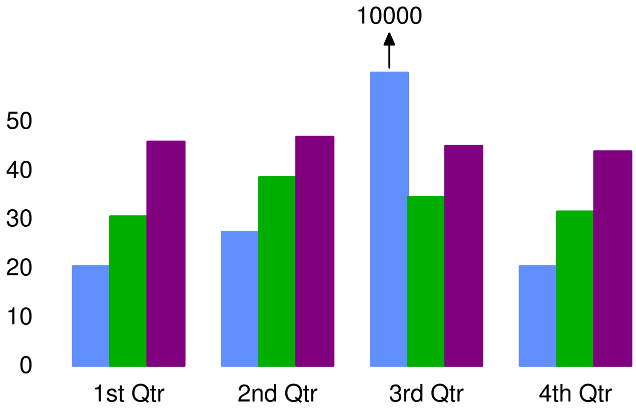


A Truncated Range



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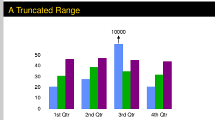

Using Lines Incorrectly

- Don’t connect points unless interpolation is meaningful
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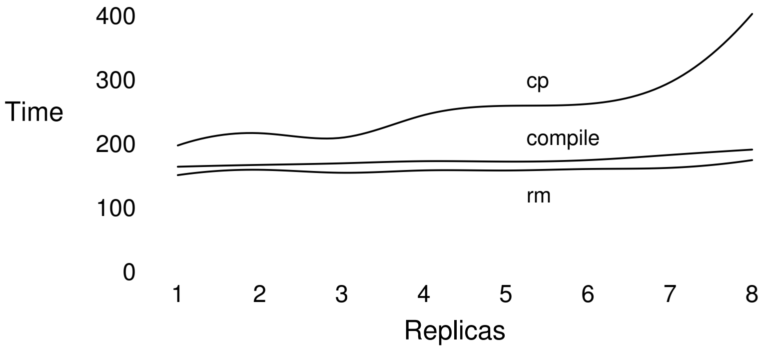
Incorrect Line Usage



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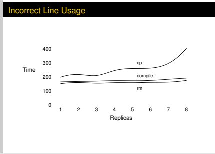

Non-Zero Origins and Broken Scales

- People expect (0,0) origins
  - Subconsciously
- So non-zero origins are great way to lie
- More common than not in popular press
- Also very common to cheat by omitting part of scale
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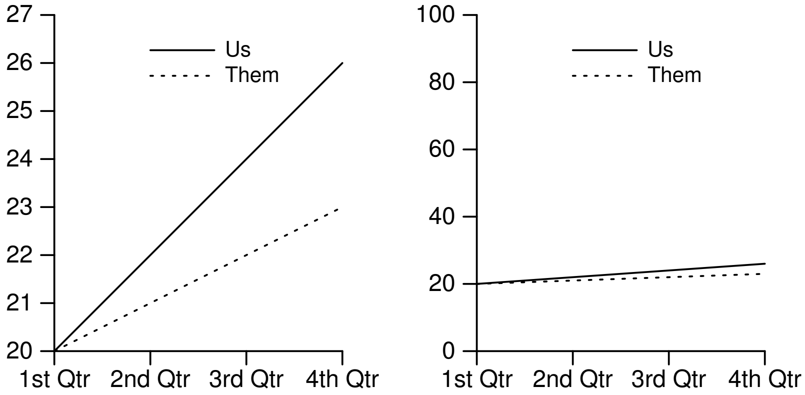

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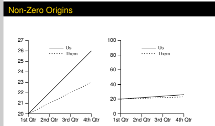
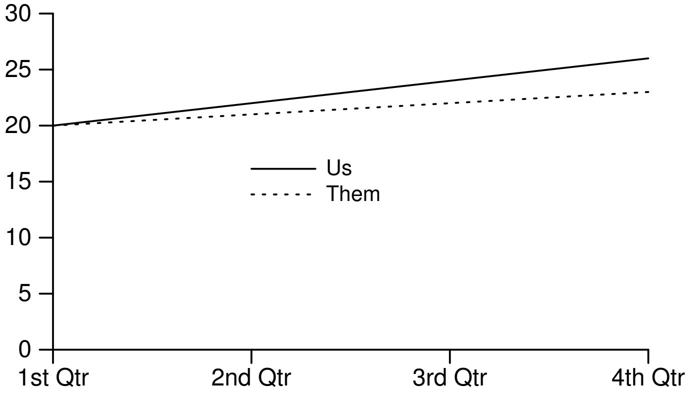


The Three-Quarters Rule

Highest point should be 3/4 of scale or more



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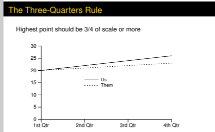
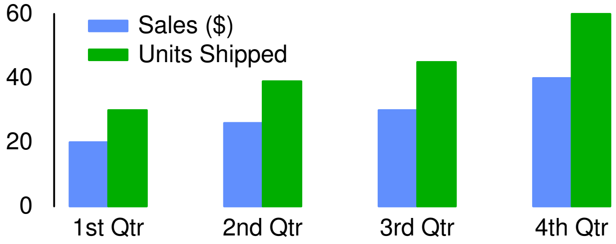


Double-Whammy Graphs

- Put two related measures on same graph
  - One is (almost) function of other
- Hits reader twice with same information
  - And thus overstates impact



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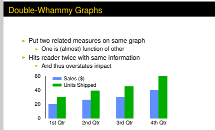

Omitting Confidence Intervals

- Statistical data is inherently fuzzy
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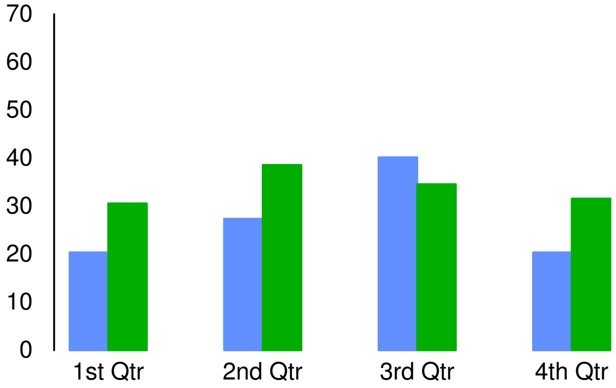
Graph Without Confidence Intervals



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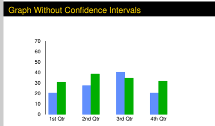

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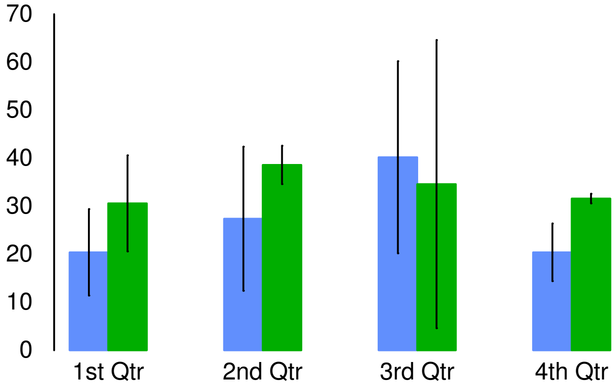

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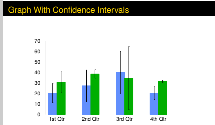
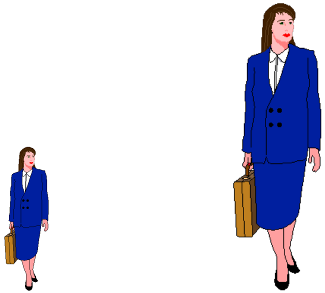

Graph With Confidence Intervals

Scaling by Height Instead of Area

Clip art is popular with illustrators:

Women in the Workforce



1960 1980

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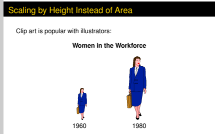

The Trouble with Height Scaling

- Previous graph had heights of 2:1
- But people perceive areas, not heights
  - So areas should be what's proportional to data
- Tufte defines *lie factor:* size of effect in graphic divided by size of effect in data
  - Not limited to area scaling
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Scaling by Area

Same graph with 2:1 area:

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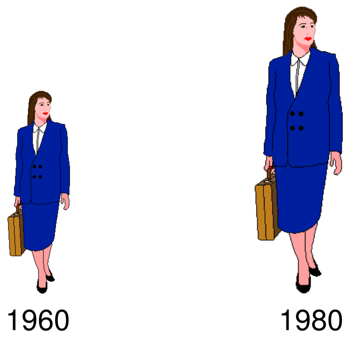

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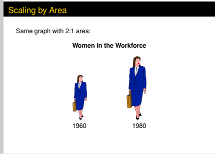
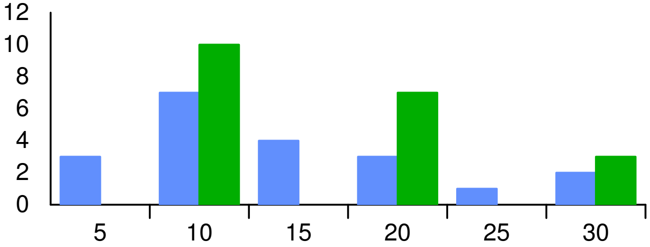
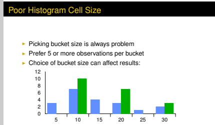


Poor Histogram Cell Size

- Picking bucket size is always problem
- Prefer 5 or more observations per bucket
- Choice of bucket size can affect results:





Note that green bars are steadily decreasing, but blue bars rise, fall, and rise again.

It’s not clear which is correct (given small counts in the smaller buckets).

Principles of Graphics Integrity (Tufte)

- Proportional representation of numbers
- Clear, detailed, thorough labeling
- Show data variation, not design variation
- Use deflated money units
- Don't have more dimensions than data has
- Don't quote data out of context

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  - Even in computer science
  - E.g., price/performance over time
  - Or expected future cost of a disk
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Don’t Have More Dimensions Than Data Has

- This gets back to the Lie Factor
- 1-D data (e.g., money) should occupy one dimension on the graph: not 
- Clip art is prohibited by this rule
  - But if you have to, use an area measure

$1.00

$2.00

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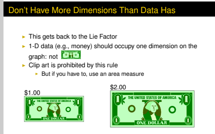
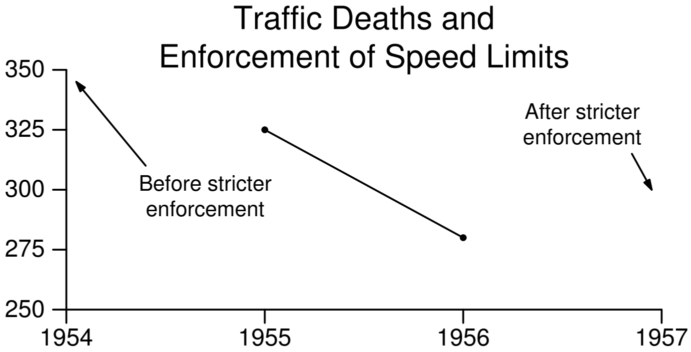
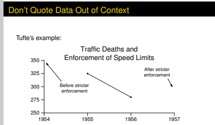


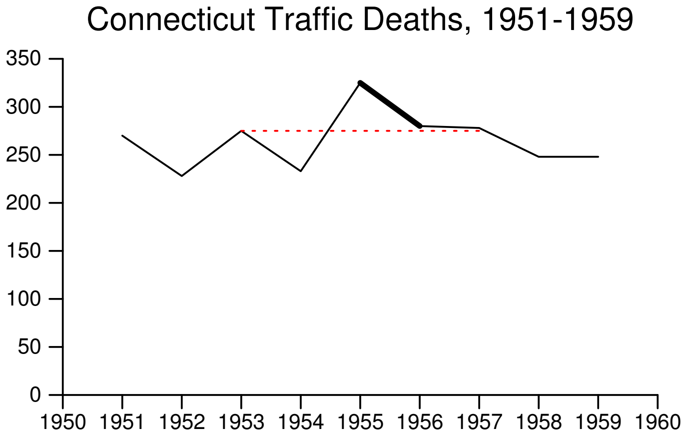
Don’t Quote Data Out of Context

Tufte’s example:





The Same Data in Context



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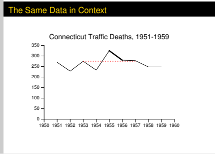

Special-Purpose Charts

- Tukey's box plot
- Histograms
- Scatter plots
- Gantt charts
- Kiviat graphs

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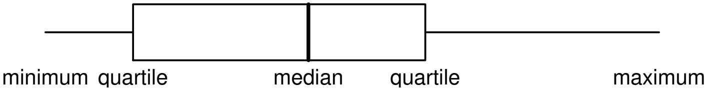
Tukey’s Box Plot

- Shows range, median, quartiles all in one:



- Tufte can’t resist improvements:

or

or even

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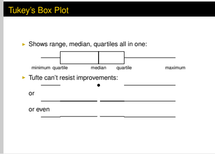
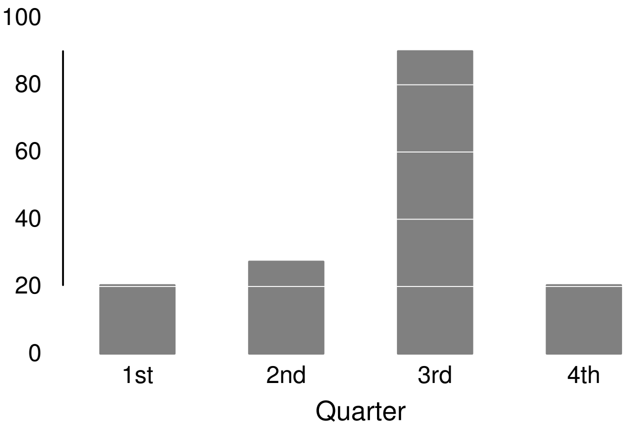


Histograms

Tufte improves everything about them:



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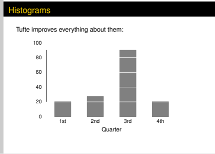
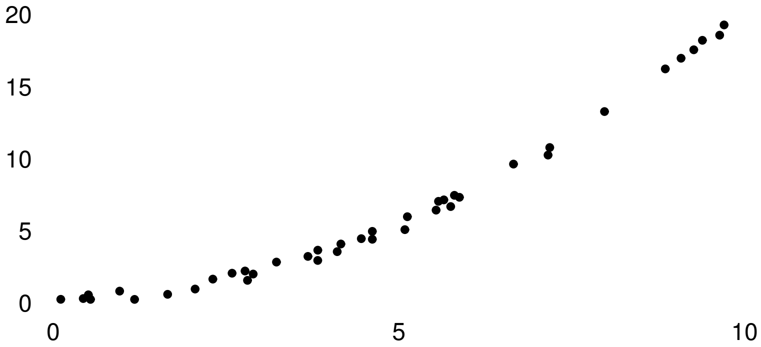


Scatter Plots

- Useful in statistical analysis
- Also excellent for huge quantities of data
  - Can show patterns otherwise invisible



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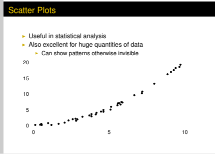
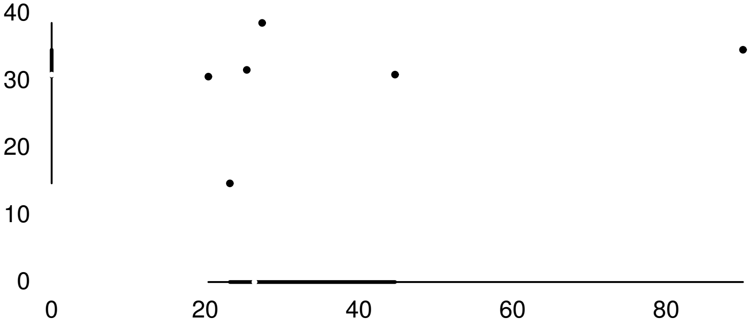


Better Scatter Plots

- Again, Tufte improves the standard
  - But it can be a pain with automated tools
- Can use modified Tukey box plot for axes:



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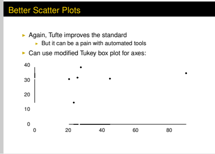
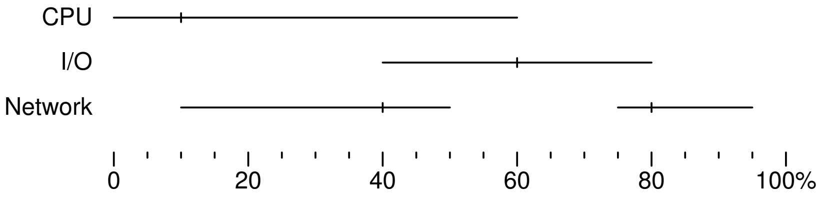
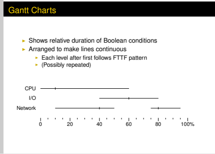


Gantt Charts

- Shows relative duration of Boolean conditions
- Arranged to make lines continuous
  - Each level after first follows FTTF pattern
  - (Possibly repeated)

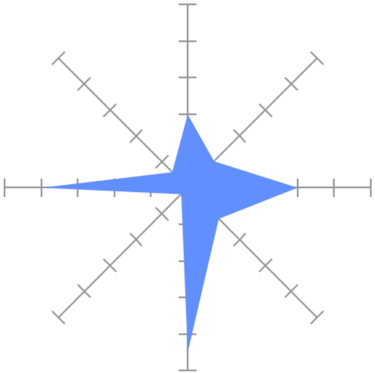




Gantt charts are any chart with horizontal lines showing spans on the X axis.
Also useful for scheduling; shows simultaneous tasks.
Lines are divided in mid-true; any vertical line shows one unique combo of conditions.
Length of line with particular condition shows percentage of time system spends in that state.

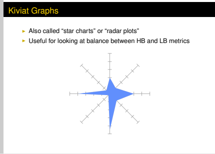
Kiviat Graphs

- Also called “star charts” or “radar plots”
- Useful for looking at balance between HB and LB metrics

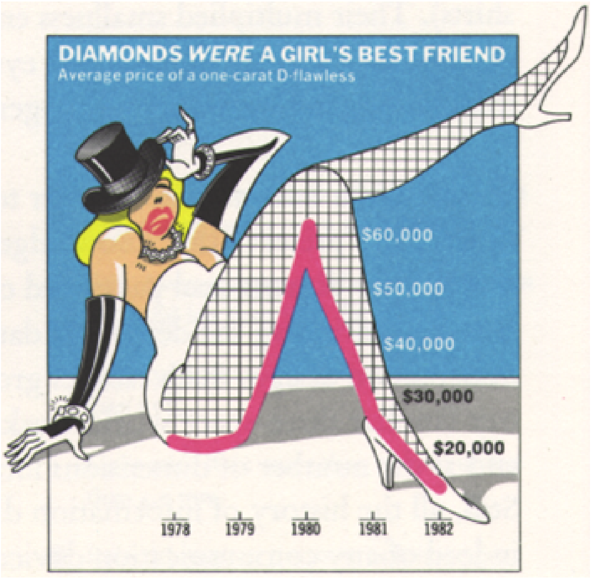


2015-06-15

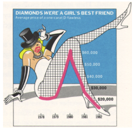
CS147
└Special-Purpose Charts
└Kiviat Graphs



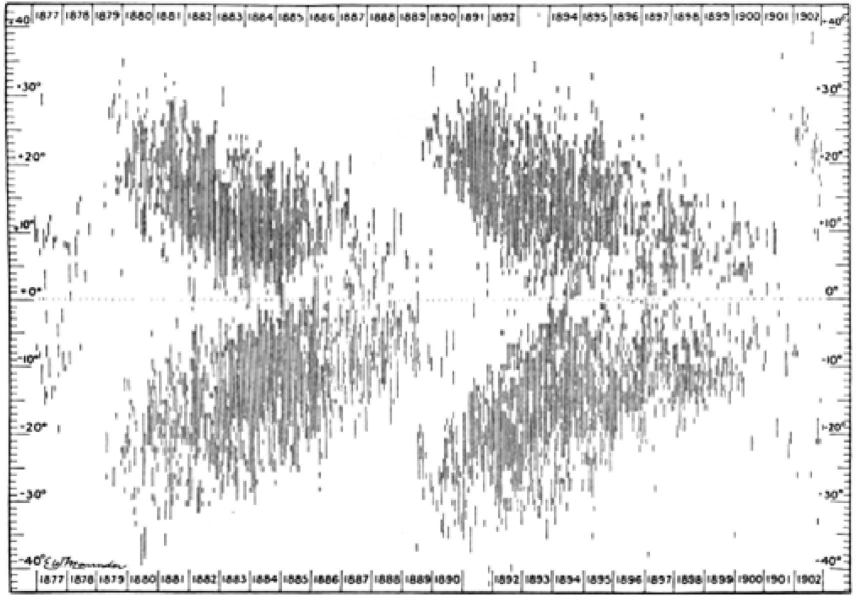
A Very Bad Graph

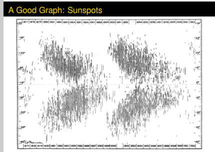


A Very Bad Graph



A Good Graph: Sunspots



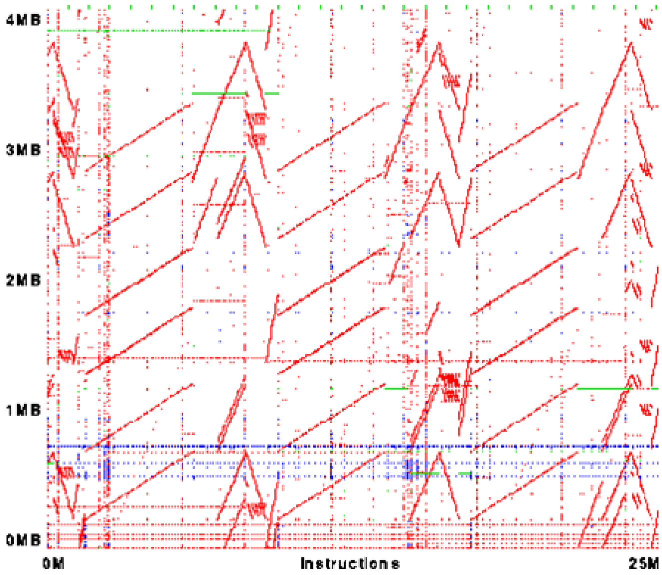


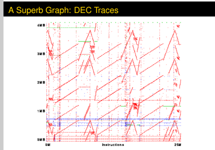
Vertical scale is latitude of sunspot; length of bar is extent of latitude width of sunspot (longitude width is not in the graph). The 11-year cycle is easily visible.

The horizontal scale is empty in a few places where sunspot data extends into it.

This graph was drawn in 1904 by Edward Walter Maunder (1851-1928). It is commonly called a “butterfly diagram” for obvious reasons.

A Superb Graph: DEC Traces





X axis is time (instructions executed). Y axis is memory address referenced, modulo 4 MB. Red lines are data accesses, blue instructions. Green is perhaps stack? Note how parallel access to arrays is easy to see, as well as occasional faster access and reverse-order access.