

Multivariate Visual Representations 1



CS 4460 – Intro. to Information Visualization
Sep. 18, 2017
John Stasko

Learning Objectives



- For the following visualization techniques/systems, be able to describe each and its visual encoding, know what type of data it's best for, know its strengths and limitations, and understand how to apply it
 - Iconic representatons (Chernoff faces), Table Lens, InfoZoom, EZChooser, Mosaic plot, Star plots
- Explain the visual encoding and design issues of Parallel Coordinates, as well as their utility and limitations
- Understand how the different types of variables in a multivariate data set influence the visualization technique that should be chosen to represent the data
- Be able to apply any of these techniques to a data set that is an appropriate match for them

How Many Variables?



- Data sets of dimensions 1, 2, 3 are common
- Number of variables per class
 - 1 - Univariate data
 - 2 - Bivariate data
 - 3 - Trivariate data
 - >3 – Hyper/Multivariate data **Focus This Week**

Earlier



- We examined a number of tried-and-true techniques/visualizations for presenting multivariate (typically ≤ 3) data sets
 - Bar graph, line graph, pie chart, scatterplot, box plot, trellis display, crosstab, radar graph, heatmap
- Hinted at how to go above 3 dimensions

Hypervariate Data



- How about 4 to 20 or so variables (for instance)?
 - Lower-dimensional hypervariate data
 - Many data sets fall into this category

How would you handle that?

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One Approach



- Stay with standard views, but use lots and lots of them



Voyager

Video

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Wongsuphasawat et al.
TVCG (InfoVis) '16

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More Dimensions



- Fundamentally, we have 2 geometric (position) display dimensions
- For data sets with >2 variables, we must project data down to 2D
- Come up with visual mapping that locates each dimension into 2D plane

- Computer graphics: 3D- \rightarrow 2D projections

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Wait a Second



- A spreadsheet already does that
 - Each variable is positioned into a column
 - Data cases in rows
 - This is a projection (mapping)

- What about some other techniques?
 - Already seen a couple

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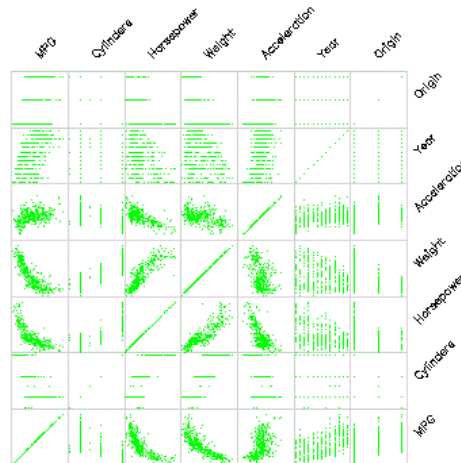
8

Scatterplot Matrix



Represent each possible pair of variables in their own 2-D scatterplot

If pairwise correlation is key



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Key Principle (today)



- Handle all data sets generically
 - Examine techniques not specific to some data or domain
 - Technique can generally handle all data sets

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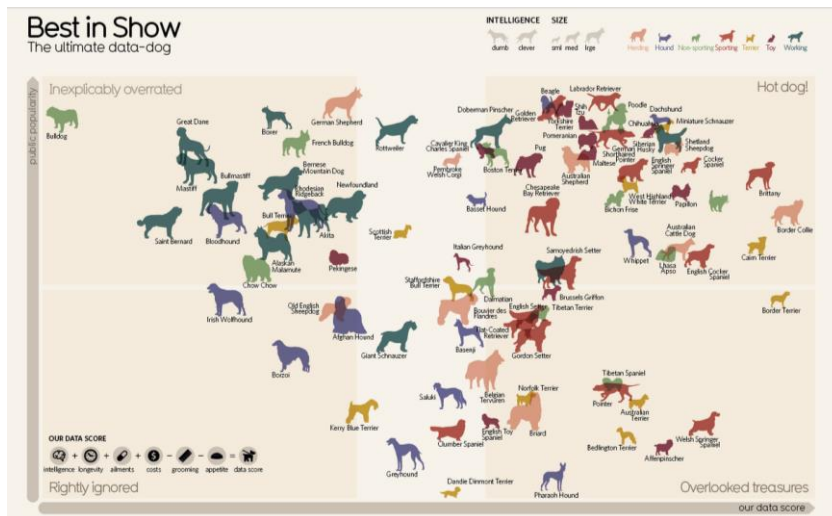
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Iconic Representations



- Glyph (graphical object) represents a data case
- Visual properties of glyph represent different variables

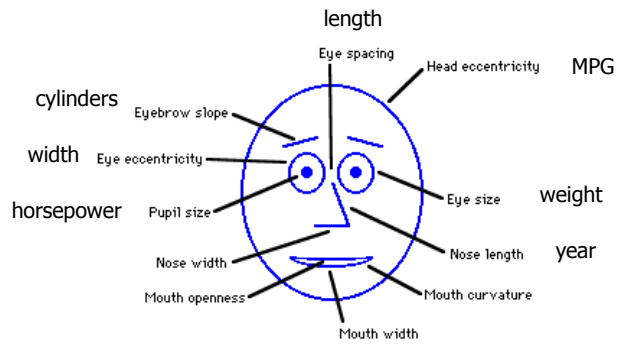
Remember?



Chernoff Faces



Encode different variables' values in characteristics of human face

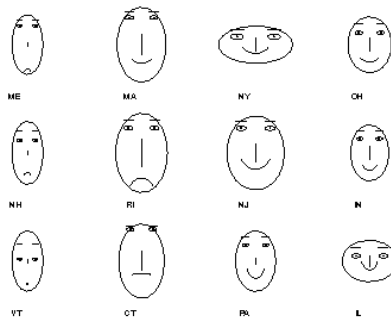


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Examples



Cute applet: <http://www.cs.uchicago.edu/~wiseman/chernoff/>

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Table Lens



- Spreadsheet is certainly one hypervariate data presentation
- Idea: Make the text more visual and symbolic
- Just leverage basic bar chart idea

Rao & Card
CHI '94

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Visual Mapping



	A	B	C	D	E	F
1	Sales rep	Quota	Variance to quota	% of quota	Forecast	Actual bookings
2	Albright, Gary	200,000	-16,062		92	205,000
3	Brown, Sheryll	150,000	84,983		157	260,000
4	Cartwright, Bonnie	100,000	-56,125		44	50,000
5	Caruthers, Michael	300,000	-25,125		92	324,000
6	Garibaldi, John	250,000	143,774		158	410,000
7	Girard, Jean	75,000	-48,117		36	50,000
8	Jones, Suzanne	140,000	-5,204		96	149,000
9	Larson, Terri	350,000	238,388		168	600,000
10	LeShan, George	200,000	-75,126		62	132,000
11	Levenson, Bernard	175,000	-9,267		95	193,000
12	Mulligan, Robert	225,000	34,383		115	275,000
13	Tetracelli, Sheila	50,000	-1,263		97	50,000
14	Wotisek, Gillian	190,000	-3,648		98	210,000
15						

Change quantitative values to bars



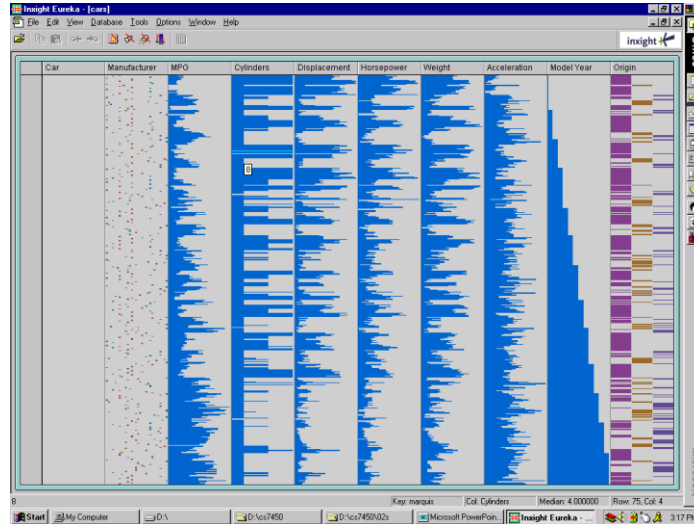
How did they handle nominal data?

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Instantiation



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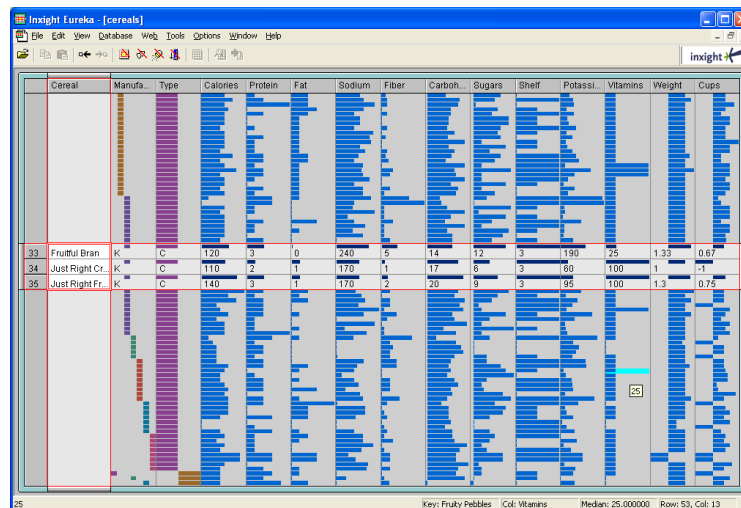
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Details

Video



Focus on item(s) while showing the context



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Alternative



What if you
Flipped rows and columns
Sorted each row

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Result



InfoZoom

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	T	V	Z
Name	All items, models included, are Copyright © 2004 by Apple Computer, Inc. All rights reserved. Apple, the Apple logo, and Mac OS are trademarks of Apple Computer, Inc., registered in the U.S. and other countries. Other names may be the trademarks of their respective owners.																				
Capacity	8 GB (configurable) 16 GB (configurable) 32 GB (configurable) 64 GB (configurable)																				
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	T	V	Z
Mechanism	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic
Product Name	iPhone 2G	iPhone 3G	iPhone 3GS	iPhone 4	iPhone 4S	iPhone 5	iPhone 5c	iPhone 5s	iPhone SE	iPhone 6	iPhone 6 Plus	iPhone 6s	iPhone 6s Plus	iPhone SE (2nd generation)	iPhone 7	iPhone 7 Plus	iPhone 8	iPhone 8 Plus	iPhone X	iPhone 11	iPhone 11 Pro
Price	199	299	399	499	599	699	799	899	999	1099	1199	1299	1399	1499	1599	1699	1799	1899	1999	2099	2199
Release Date	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Dimensions	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
Weight	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
Color	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black

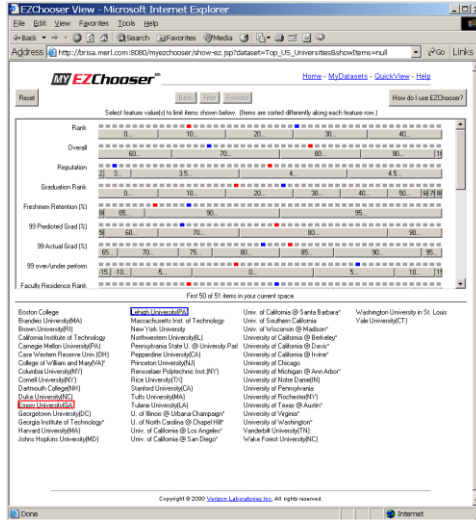
Commercial product
Demo/video

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Similar Idea



EZChooser

Video

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Alternate UI



- Can slide the values in a row horizontally
- A particular data case then can be lined up in one column, but the rows are pushed unequally left and right

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Attributes as Sliding Rods



Choose Back Filter Forward 5 of 32 items selected

Rows Table

Manufacturer:	Kodak
	Fuji HP Kodak
Macro:	false
	false
Offer Price (\$):	599.95
LCD Display:	true
	false true

DC220 MEGAPIXEL DIGITAL CAMERA

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Limitations?



- Number of cases (horizontal space)
- Nominal & textual attributes don't work quite as well

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An Application



- What if you cared about ranking items?
 - Think of the attributes per item as contributing to some score or value for it
- Apply the Table Lens representation we saw earlier

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LineUp

Video



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Gratz et al
TVCG (InfoVis) '13

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Categorical data?



- How about multivariate categorical data?
- Students
 - Gender: Female, male
 - Eye color: Brown, blue, green, hazel
 - Hair color: Black, red, brown, blonde, gray
 - Home country: USA, China, Italy, India, ...

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Mosaic Plot

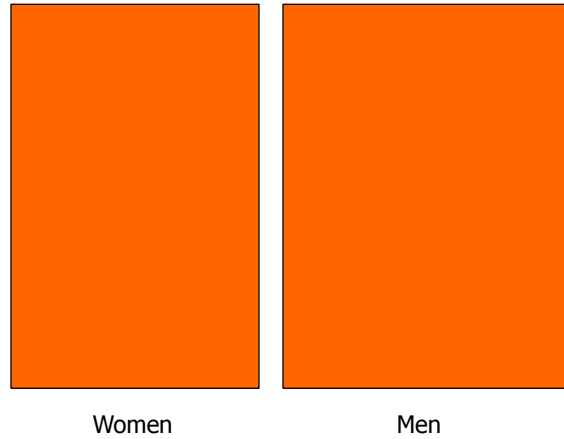


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Mosaic Plot

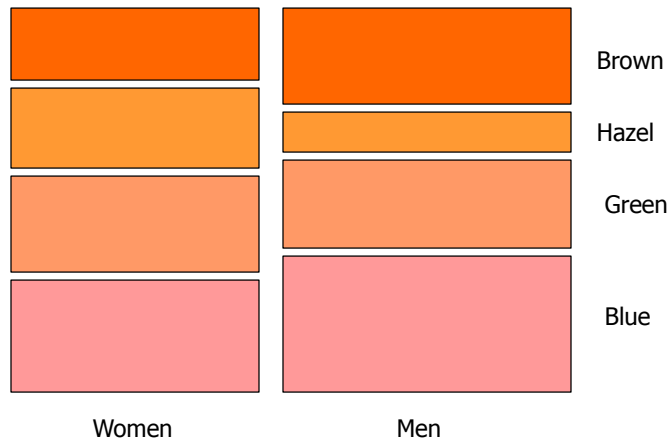


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Mosaic Plot

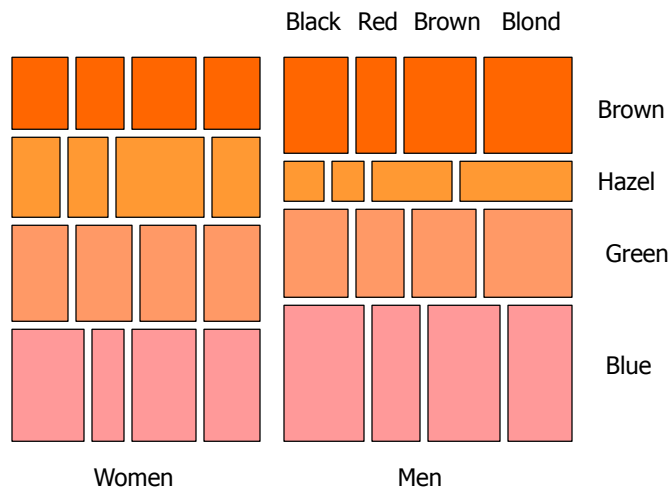


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Mosaic Plot



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Fundamental Limitation



- Run out of rows/columns for lots of data cases
- How about an alternative generic representation?

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Parallel Coordinates



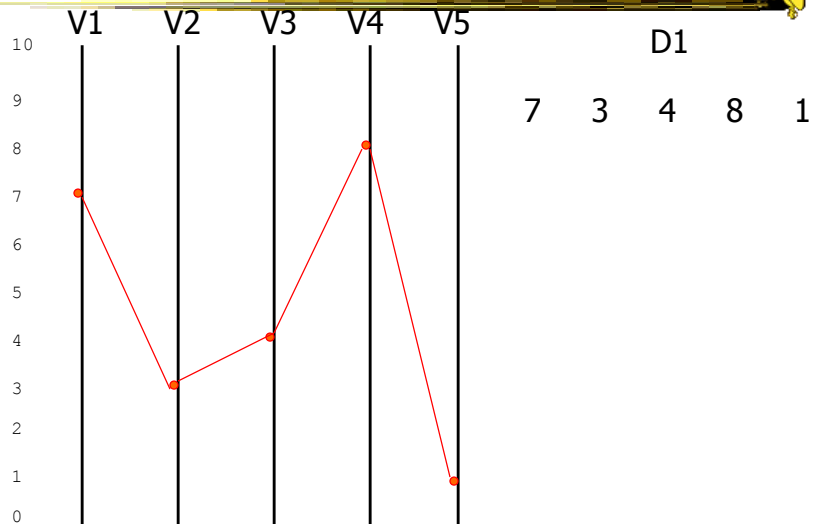
		variables				
		V1	V2	V3	V4	V5
	D1	7	3	4	8	1
data cases	D2	2	7	6	3	4
	D3	9	8	1	4	2

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Parallel Coordinates

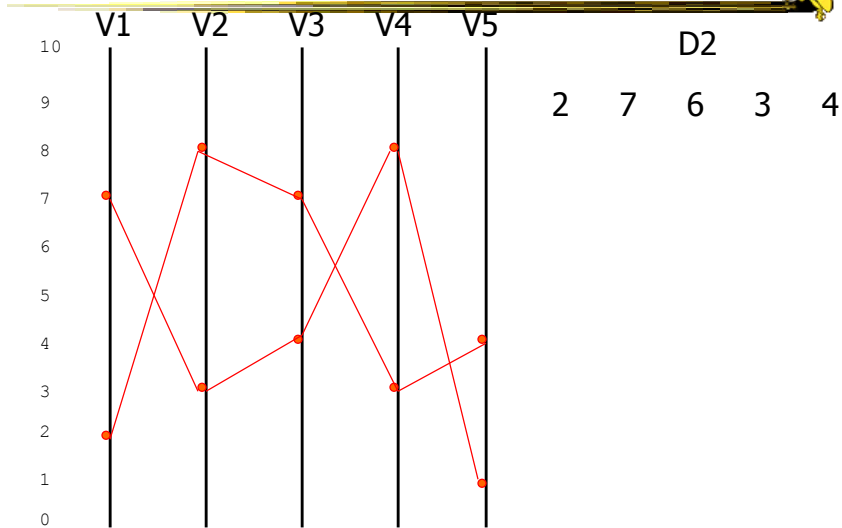


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Parallel Coordinates

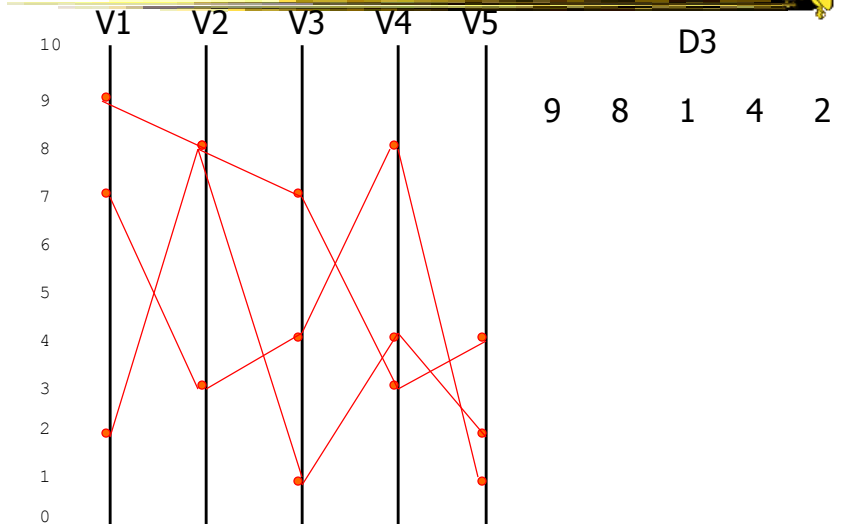


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Parallel Coordinates

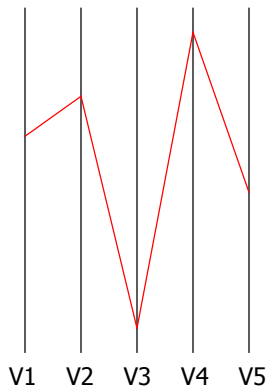


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Parallel Coordinates



Encode variables along a horizontal row

Vertical line specifies different values that variable can take

Data point represented as a polyline

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Questions



What do two correlated variables look like?

What do two inversely correlated variables look like?

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Issue



- Different variables can have values taking on quite different ranges
- Must normalize all down (e.g., 0->1)

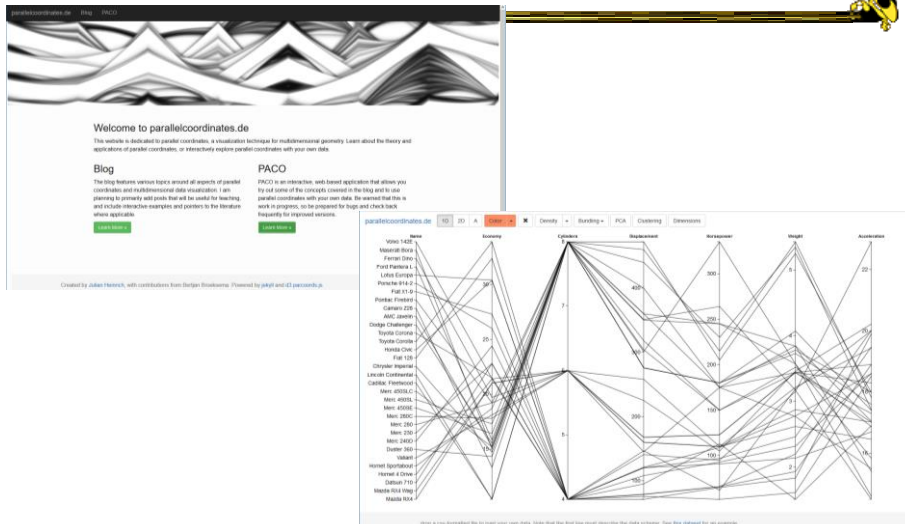
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To Learn More

Great site that's all about parallel coords



<http://www.paralleloordinates.de>

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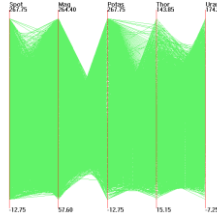
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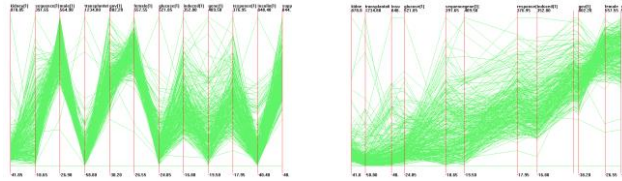
Challenges



- Too much data



- Order of dimensions really matters



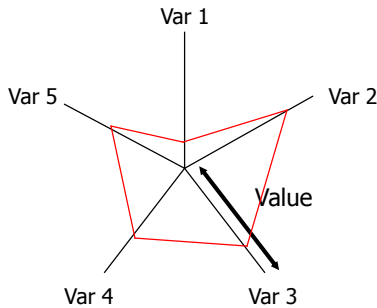
Yang et al
InfoVis '03

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Star Plots (Radar Chart)



Space out the n variables at equal angles around a circle

Each "spoke" encodes a variable's value

Alternative Rep.

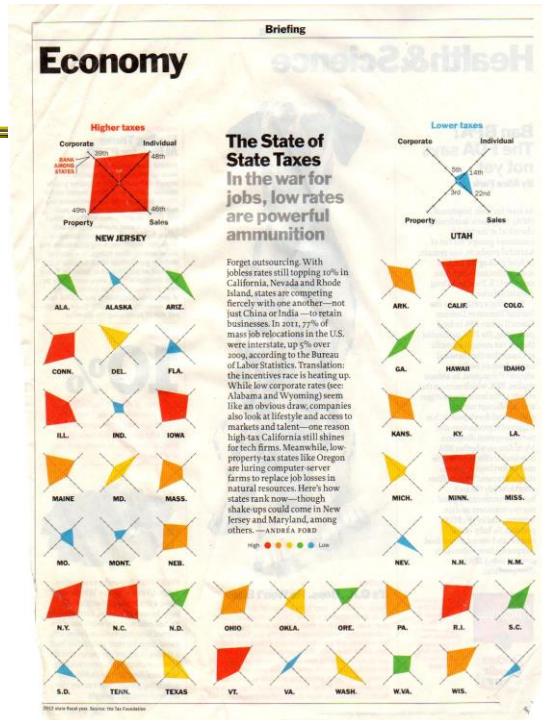
Data point is now a "shape"

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Example



Time
April 16, 2012

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Generalizing the Principles



- General & flexible framework for axis-based visualizations
 - Scatterplots, par coords, etc.
- User can position, orient, and stretch axes
- Axes can be linked

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Claessen & van Wijk
TVCG (InfoVis) '11

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FLINA View

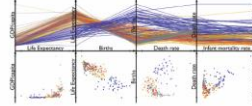
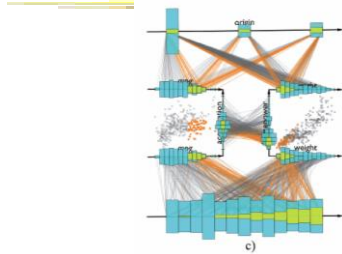


Fig. 6. Demographic data for different countries. Asia: brown; Africa: blue; North America: red; South America: green; Oceania: orange; Europe: gray.

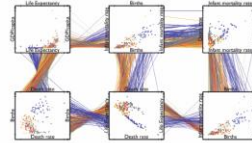
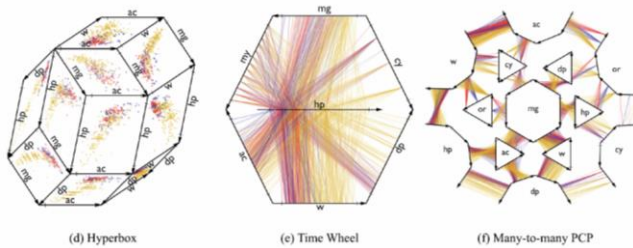


Fig. 7. Alternative lay-out for demographic data



Video

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Learning Objectives

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HW 3



- Due Friday
- Questions?

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Upcoming



- Multivariate Visual Representations 2
 - Prep: Dust & Magnet video
- Lab 2: SVG

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