

## 04-2 Multidimensional visualization

20 March 2023 17:25



4-2  
Multidime...

# Multidimensional Visualization II

Sungahn Ko

HAiV

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## Disclaimer

- The slides MUST NOT be distributed, posted, or used outside of this class
- Slides in this course courtesy of
  - Dr. Abish Malik (Purdue)
  - Dr. Yun Jang (Sejong Univ.)
  - Dr. Ross Maciejewski (ASU)
  - Dr. Niklas Elmquist (UMD)
  - Dr. David Ebert (Purdue)

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# Outline

- Bertin's visual variables
- Dimensional projection
- Small multiples
- Scatterplot matrices (SPLOMs)
- Chernoff faces
- Dynamic queries
- Parallel Coordinates
- Multidimensional visualization tools
  - Parallel coordinates
  - XmdvTool
  - Polaris/Tableau

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# Data Dimensions

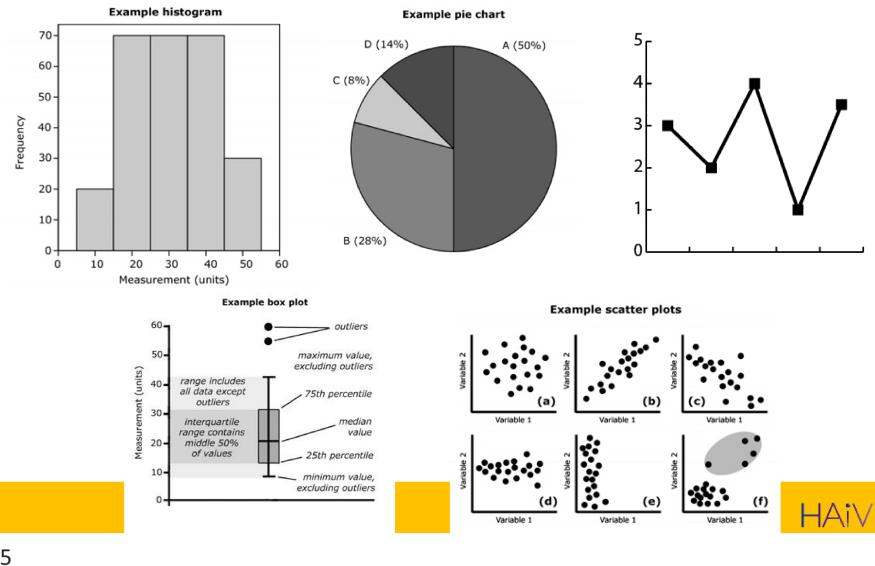
- Common dimensions: 1, 2, 3
  - 1 dimension – univariate
    - Temperature readings
  - 2 dimensions – bivariate
    - Positions on map (lat/long)
  - 3 dimensions – trivariate
    - Positions in space (3D)
- For more than 3 dimensions
  - Hypervariate

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## Visual Representations: Low Dimension Data



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## Hypervariate Data?

- For data with  $>2$  variables, we must project 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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## Table View

- Projecting **hypervariate data** on a spreadsheet
  - Variable → Column
  - Data cases in rows
- Other techniques?

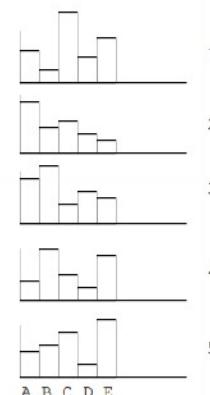
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## Multiple Views

Display for each variable

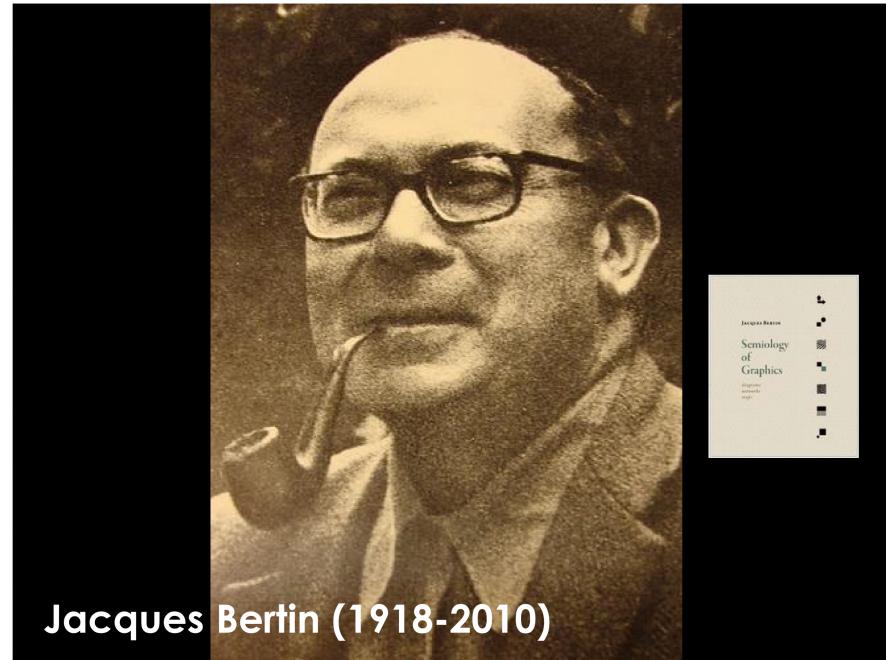
	A	B	C	D	E
1	4	1	8	3	5
2	6	3	4	2	1
3	5	7	2	4	3
4	2	6	3	1	5
5	3	4	5	1	7



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[John Stasko]

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## Visual Variables



IVSTAOAZNULI → ??

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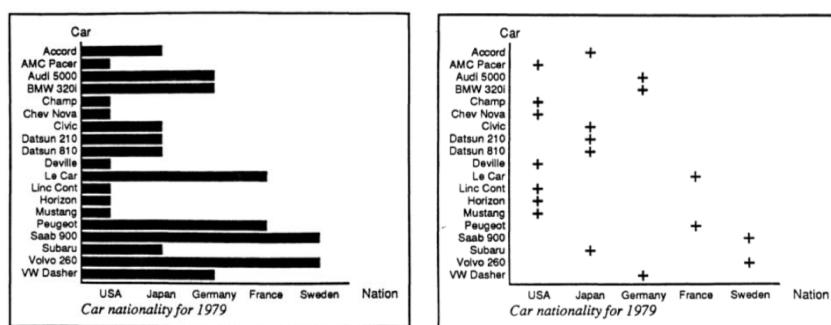
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# Bertin's Visual Variables

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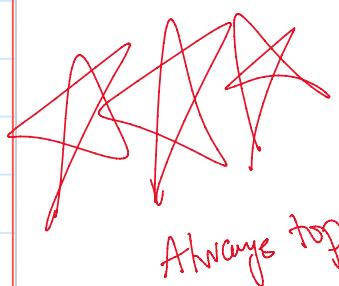
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Which is more effective?



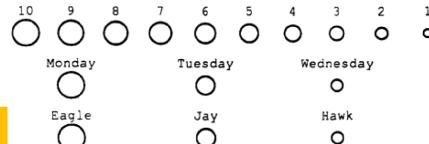
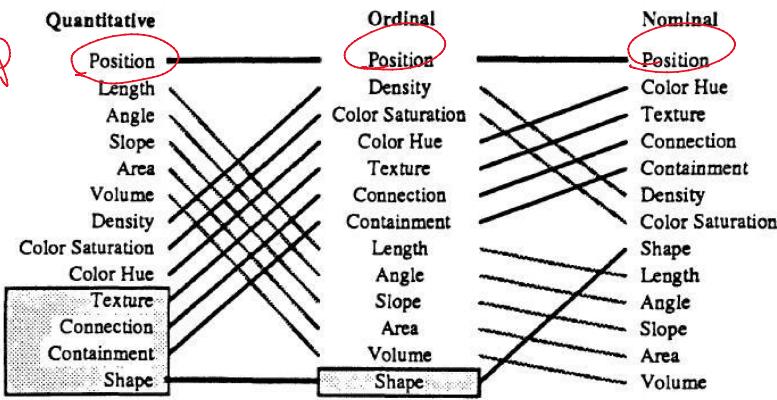
[Mackinlay, 1986]

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## Visual Variables (Jock Mackinlay)

Ranking



[Mackinlay, 1986]

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## Cleveland and McGill (1984)

Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods



William S. Cleveland; Robert McGill

*Journal of the American Statistical Association*, Vol. 79, No. 387. (Sep., 1984), pp. 531-554.

Stable URL:

<http://links.jstor.org/sici?ichi=0162-1459%28198409%2979%3A387%3C531%3AGPTEAA%3E2.0.CO%3B2-Y>

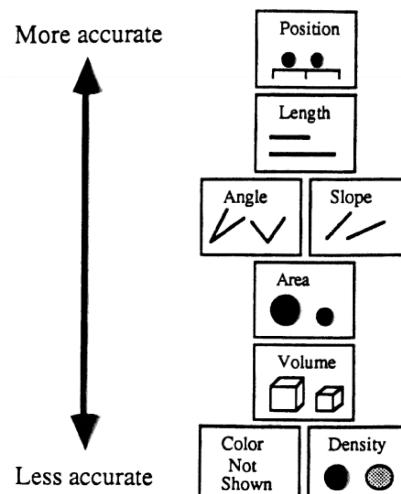
*Journal of the American Statistical Association* is currently published by American Statistical Association.

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*(Understand)*

## Cleveland and McGill (1984)



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## Summary: Visual Variables

- Position
- Length
- Area
- Volume
- Texture
- Color
- Orientation
- Shape
- ~10 dimensions?

	Points	Lines	Areas	Best to show
<i>Shape</i>	● ▲ □	possible, but too weird to show	cartogram	qualitative differences
<i>Size</i>	● ● ●	cartogram	cartogram	quantitative differences
<i>Color Hue</i>	● ● ●	cartogram	cartogram	qualitative differences
<i>Color Value</i>	● ● ●	cartogram	cartogram	quantitative differences
<i>Color Intensity</i>	● ● ●	cartogram	cartogram	qualitative differences
<i>Texture</i>	● ● ●	cartogram	cartogram	qualitative & quantitative differences

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## Recall: US Census Data

- Hundreds of dimensions
- Millions of respondents!
- How can we even begin to visualize hundreds of dimensions if all we have are ~10 visual variables?

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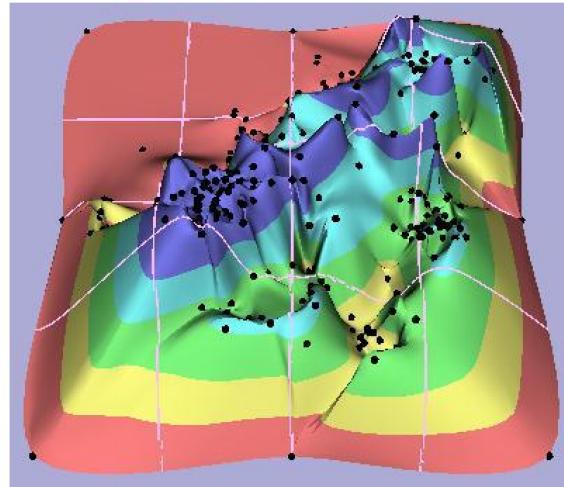
## Visualizing Multidimensional Data

- Must clearly learn to deal with limited visual variables
- Primary ones: space (essentially 2D)
  - 3D for 3D data (scientific visualization)
- **Inspiration:** 3D computer graphics
  - 3D world is projected down to 2D
  - Can we use this idea here?
- **Method:** Dimensional Projection
  - Most basic multidimensional technique
  - Projects n-D data to 2-D data

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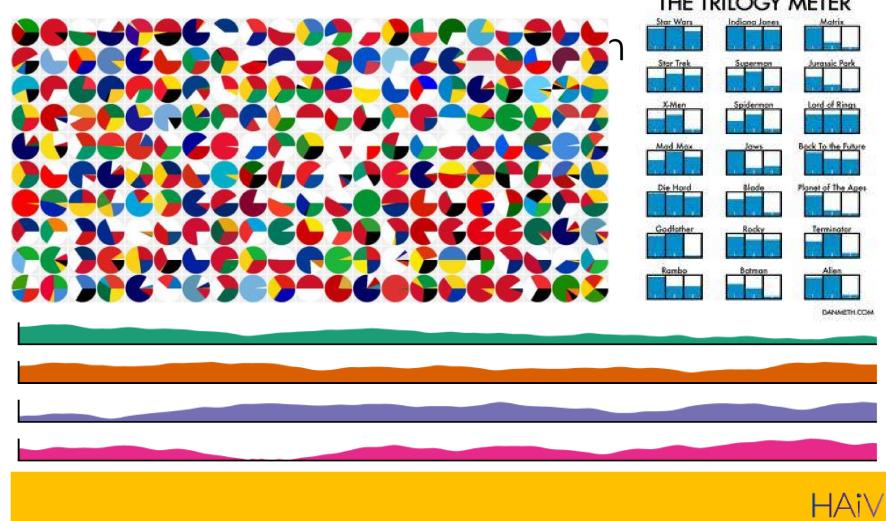
## Dimensional Projection



[Tory, 2007] V

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## Small Multiples

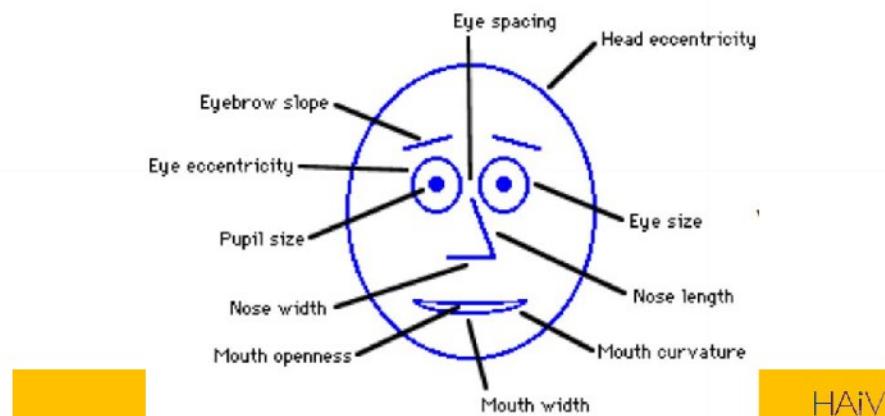


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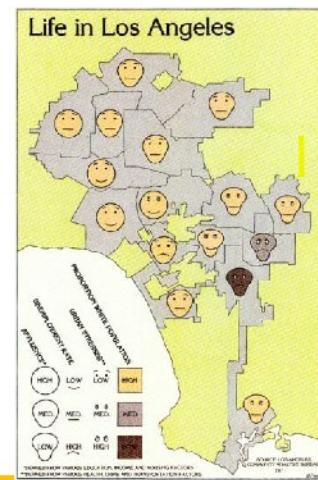
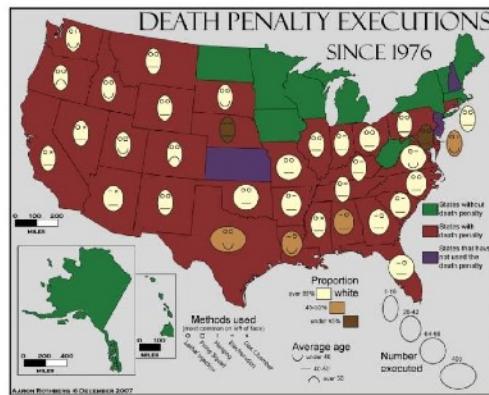
## Chernoff Faces (1973)

- Utilize human face recognition
  - Visualize n-D data (glyphs)



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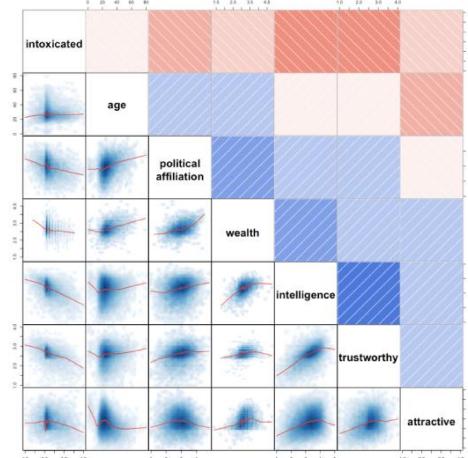
## Chernoff Faces (1973)



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## Scatterplot Matrices

- 2D scatterplots for all combinations of dimensions
- FaceStat data



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## ScatterDice (Elmqvist 2008)

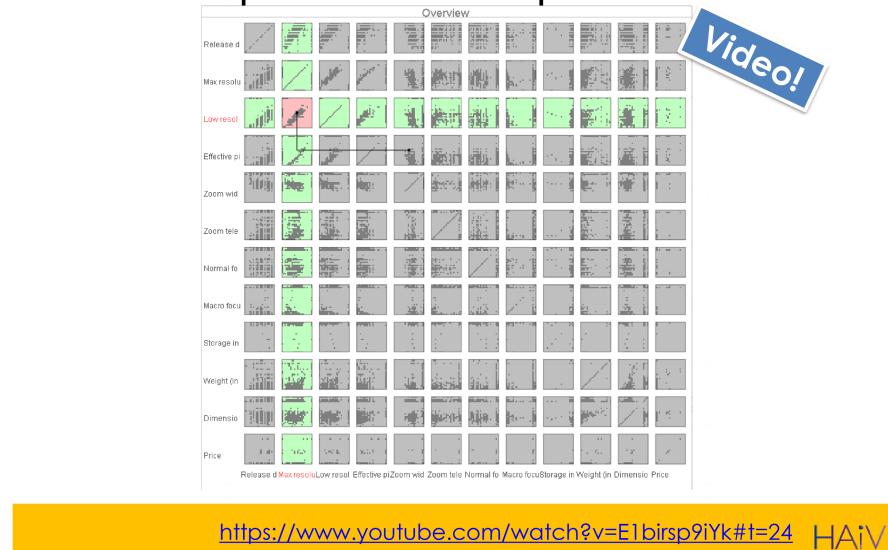
- SPLOMs explored by others, but Emlqvist et al. add a twist:
  - Use matrix as a space for navigation
  - Visual exploration becomes a navigation problem
- **Result:** Visualize complex data through sequence of simple visualizations

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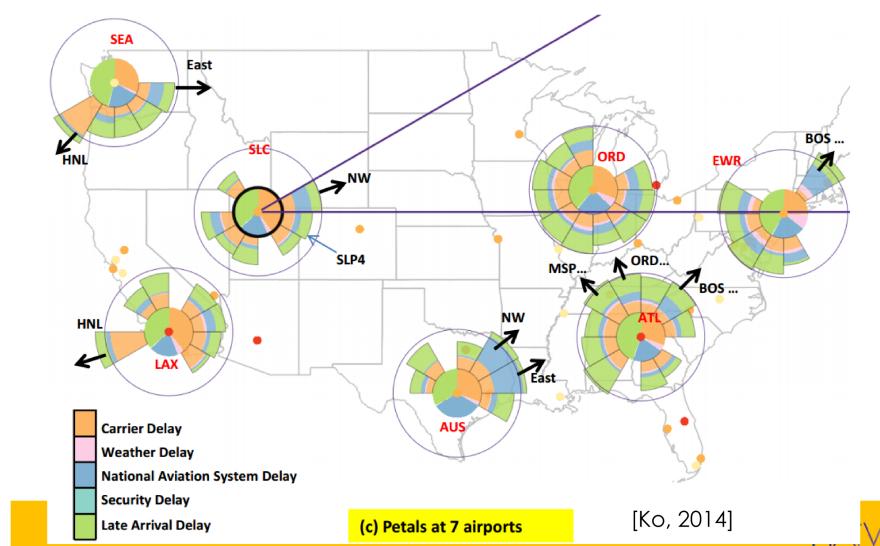
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## Example: Scatterplot Matrix



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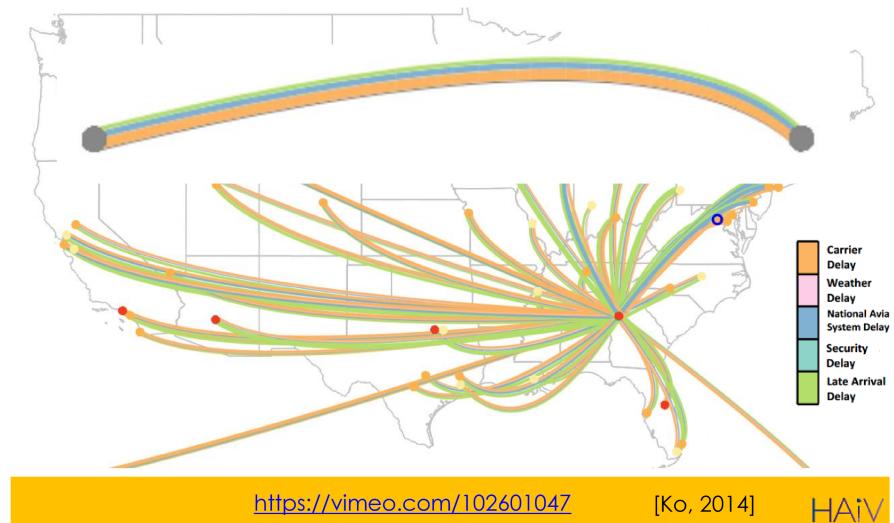
## Petals Visualization for Multivariate Data



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## Threads Visualization



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## Dynamic Queries

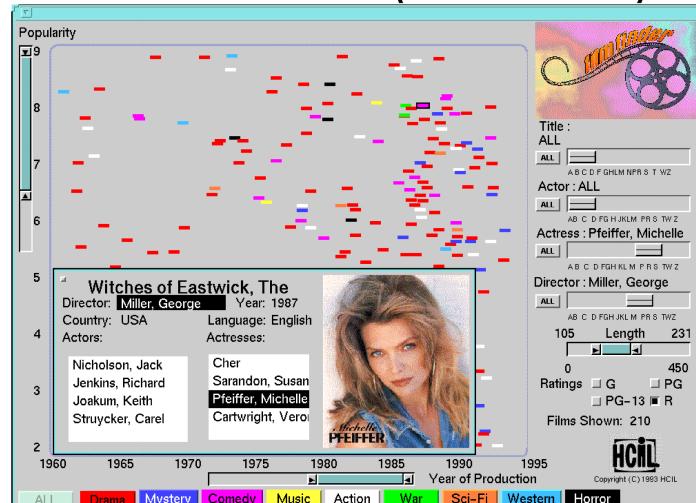
- Ben Shneiderman in 1990s:
  - SQL queries are cumbersome
  - Difficult syntax
  - Conversation, not direct
- Start with sliders, extend them



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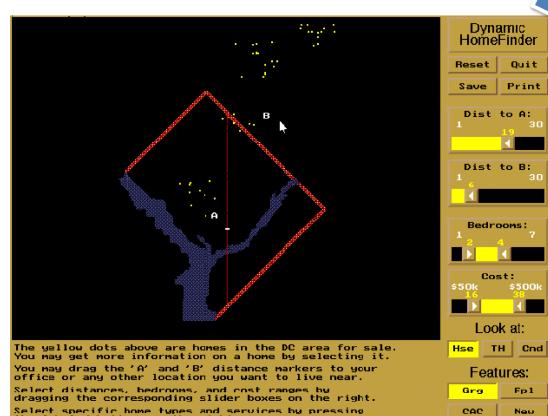
## Film Finder, (CHI 1994)



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## Home Finder (1992 MS-DOS app.)



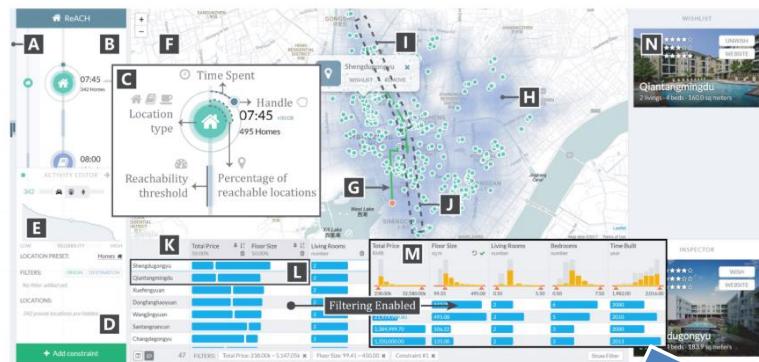
[https://www.youtube.com/watch?time\\_continue=213&v=5X8XY9430fM](https://www.youtube.com/watch?time_continue=213&v=5X8XY9430fM)

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## Home Finder Revisited!



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## Pros & Cons? Parallel Coordinates

- Designed by Alfred Inselberg in 1985

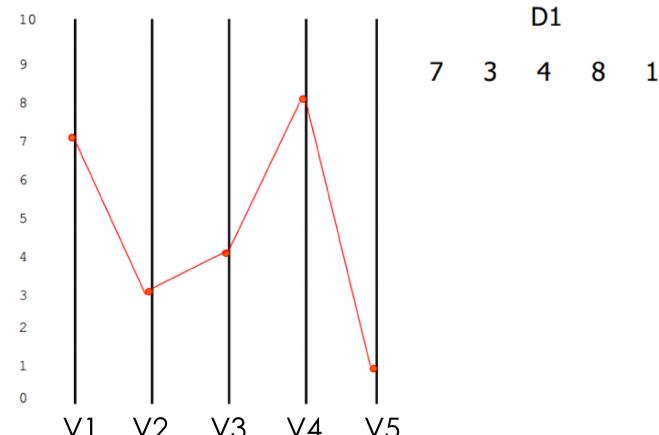
	V1	V2	V3	V4	V5
D1	7	3	4	8	1
D2	2	7	6	3	4
D3	9	8	1	4	2

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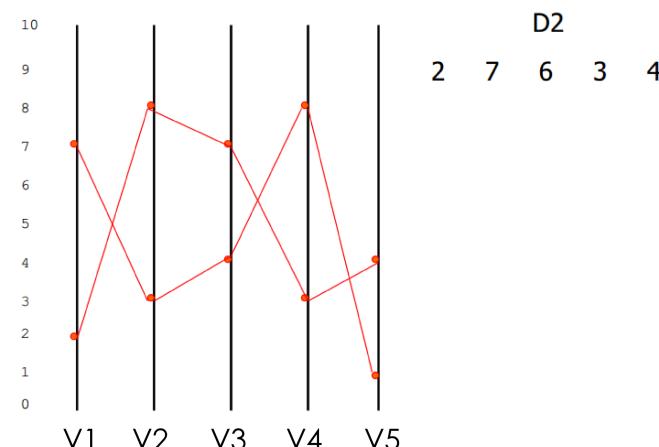
## Parallel Coordinates: Idea



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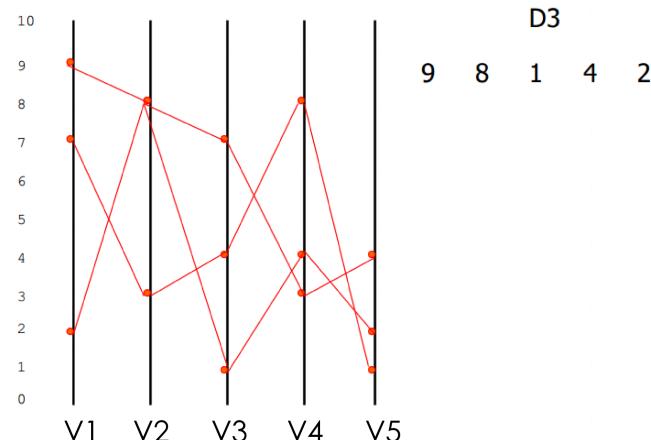
## Parallel Coordinates: Idea



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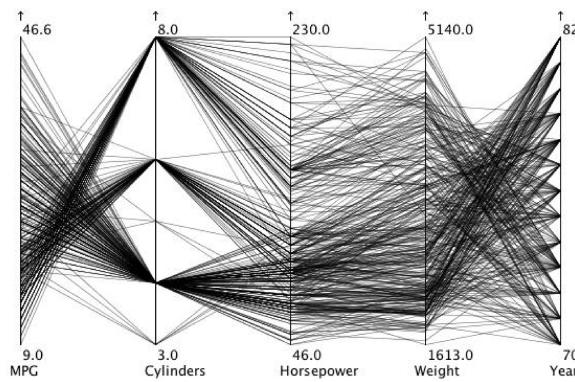
## Parallel Coordinates: Idea



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## Parallel Coordinates

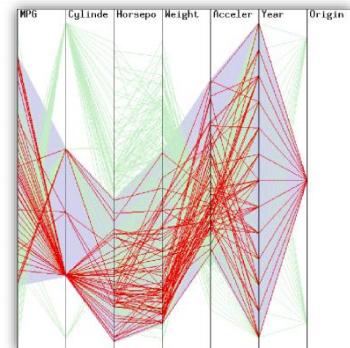


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## XmdvTool

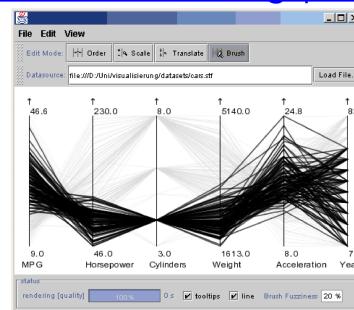
- Developed by Matt Ward (and his team)
  - <http://davis.wpi.edu/xmdv/>
- Freely available infovis tool
  - Multidim visualization
- Parallel coordinates included

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## ParVis

- Freely available parallel coordinate implementation
  - <http://www.mediavirus.org/parvis/>

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## Tableau/Polaris



- Developed as Polaris at Stanford (Pat Hanrahan)
- Commercial product: Tableau
- SQL for visualization!
- Motto: Got Data?
- <http://www.tableausoftware.com/products/desktop>



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# Questions?

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