Information Visualization

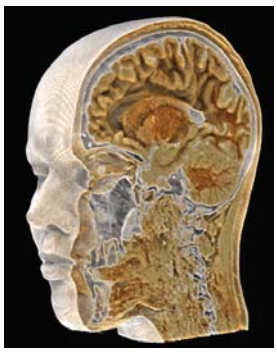
Matt Cooper

Visualization?

- **New Oxford Dictionary of English, 1999**
- **visualize** - ***verb*** **[with *obj.*]**
  1. **form a mental image of; imagine: *it is not easy to visualize the future.***
  2. **make (something) visible to the eye: *the DNA as visualized by staining with ethidium bromide.***

Ceci n'est pas une visualization!

- This is not a visualization!
- This is a picture!
  - A very useful picture!
- The visualization is all in your mind.

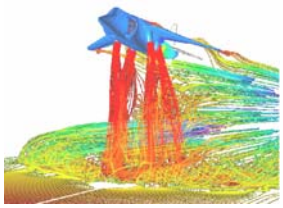


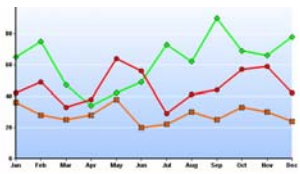
Information Visualization?

- Techniques to enable the visualization of Information
- So what is Scientific Visualization?
  - Scientific data doesn't contain information?!?!?!
- What's the difference?
  - The application areas are different?
  - The data is different?
  - The needs of the users are different?

So why two disciplines?

- Information Visualization exists as a discipline due to a superiority complex.
  - "My pictures are nicer than your pictures"





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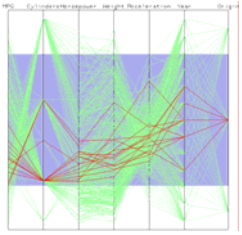

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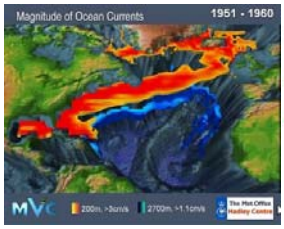

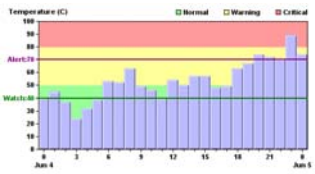

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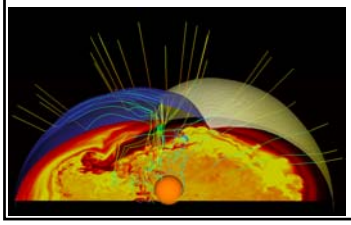

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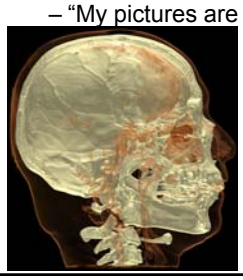
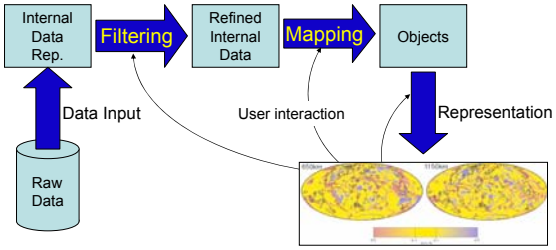


Two disciplines

- So, we end up with two "distinct" disciplines in the same area.
  - Doing the same thing
  - Focussing in different ways
- How are they really separated?
  - The application areas are usually different
  - The needs of the users are usually different
  - The data is different

The Visualization Pipeline



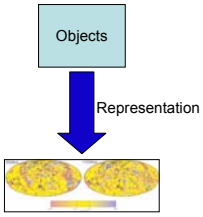
The Viz pipeline: Filtering

- Selecting data to seek specific relations
- Reducing data to manageable sizes
- Modifying the internal structure

The Viz pipeline: Mapping

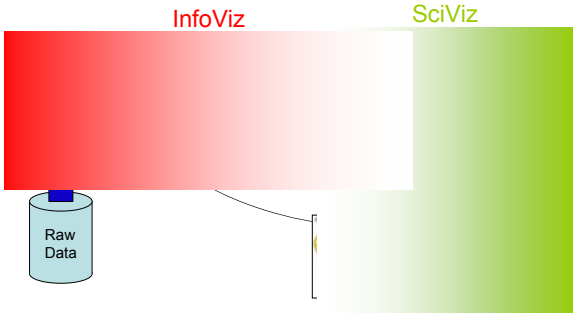
- This is the most complex phase
- Involves the definition of relationship representations
- Driven by models of human perception…

The Viz pipeline: Display



- Rendering of (simple) shapes.
- Simple for ease of interpretation.
- And ease of interaction
  - Important for exploring

So who gets clever where?



The (re-)merging of the disciplines

- SciViz is rapidly heading into InfoViz territory:
  - Sophisticated data analysis and pattern identification
  - Complex data representations
  - Sophisticated interaction
- Infoviz taking up methods from SciViz:
  - Volumetric rendering (translucent blocks of data)
  - Surfacing of data structures (clusters)
  - Tensor representations (high-dimensional data)

Why the different approaches?

- SciViz data is:
  - Small
  - Well understood
    - The data values are low dimensional
    - The geometry is often regular and always known
  - Clean (or at least predictably dirty)
  - Filled with well understood relationships
    - Simulated or measured data
    - Created or gathered for a purpose

Why the different approaches?

- InfoViz data is:
  - Big (hundreds of gigabytes is common)
  - May not be well understood
    - Data items have tens or hundreds of dimensions
    - The ‘geometry’ is usually next to non-existant.
  - Often very dirty (and unpredictably so)
  - Filled with (apparent) relationships
    - Correlations and anticorrelations
    - Patterns which exist only in certain regions in the data

A Comparative example: Heart disease

- SciViz problem: Is this patient sick?
  - Examine (scan) hearts of sick and well patients
  - Examine their hearts by visualizing features of the data:
    - muscle, fluid, blood flow, fatty tissue…
  - Determine what features correlate with heart disease
- Test new patient for those features

A Comparative example: Heart disease

- InfoViz problem: Who's going to get sick?
  - Collect detailed multi-generation histories of similar-seeming patients who are/aren't sick
    - Think of the endless possible measurements!
  - Explore that data looking for patterns of factors which correlate with sickness and not wellness
  - Create a model of behaviour(s) which produce a relatively high risk
- Tell media – who then terrify the public

So The InfoVis problem is…

- Finding (very) complex relationships…
- Which may not be present everywhere
- Within very large…
- High-dimensional…
- Data sets…
- That you may not have known you were looking for in the first place

A 'haystack' problem:

"See that haystack? Go and see if there's anything interesting about it."

InfoVis example application

- Dr. John Snow's Cholera diagram
- Exploratory Data Analysis
  - Also Visual Data Mining
- Done without knowing what caused Cholera!

Graphical Displays

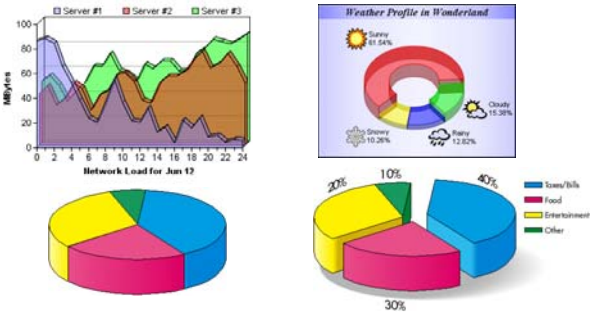
- Line plots
- Scatter plots
- Bar charts
- Pie charts
- Stacked charts
- Star plots
- Donut charts
- Various glyphs
- Maps – very trendy!
- Parallel coordinates

- Almost always 2D
  - 3D is trouble!
- Combined in diverse ways

Displays

- Simplistic – as simple a picture as possible
- Minimalist – as little UI as possible
- Highly interactive
  - Complex selection mechanisms
  - Filtering
- Highly coordinated (multiple views)

3D bad!...

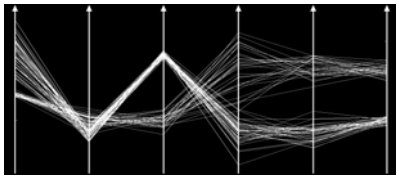


…when there is no logical mapping from the data to a 3D space

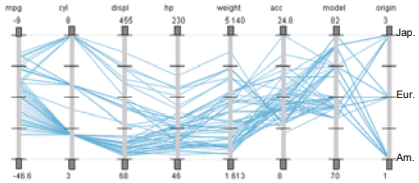
Interaction

- Project carried out by Daniel Ericsson
  - Exjobb project based on a PhD student's work
- Coordinated and multiple views
- Using parallel coordinates and animation to convey changes when selecting and filtering

Parallel Coordinates — Clusters (6D example)

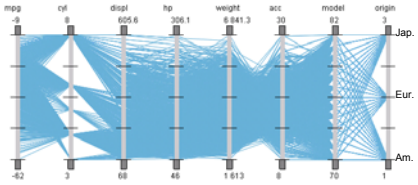


Parallel Coordinates



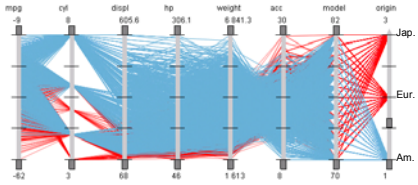
- 50 objects from the data set of cars
- PC shows structure of the data

Parallel Coordinates



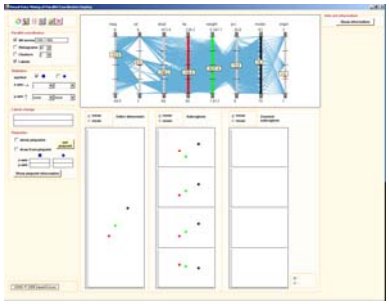
- 3000 objects
- Overlapping lines
- Cluttered PC display

Parallel Coordinates



- Good for detecting correlations, but
- Hard to see overall distribution of values
- Does not always scale well with large data sets.
- Changes are hard to track

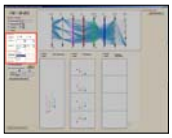
Visual Data Mining Display (VDMD)



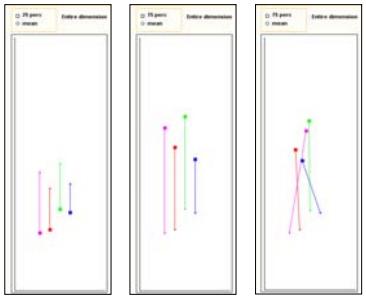
Application and GUI for examining and exploring data displayed with parallel coordinates.

Extract and display statistics from selected dimensions in a separate view.

Change of variables



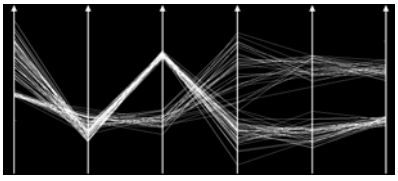
x-axis: median



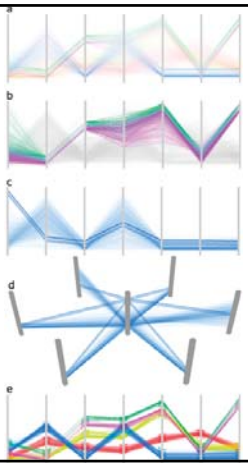
Volume rendering in IV

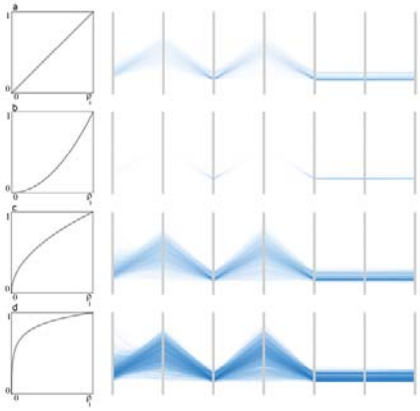
- Jimmy Johansson – PhD student
- Using techniques of volume rendering to examine large, time-varying data sets.
- Used fragment shaders and graphics hardware to render data sets and then manipulate them in real time
- Very large data sets in real time.

Parallel Coordinates — Clusters (6D example)



Jimmy's PC clusters…

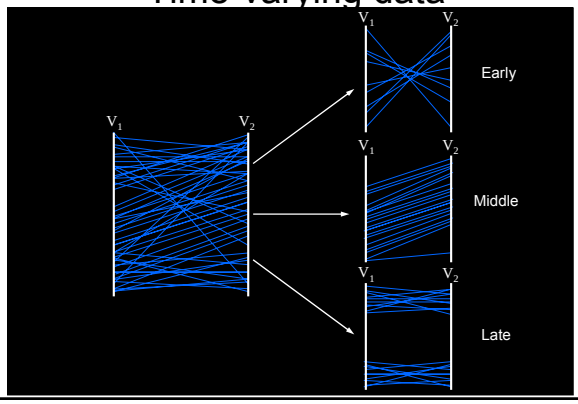




Time-varying data

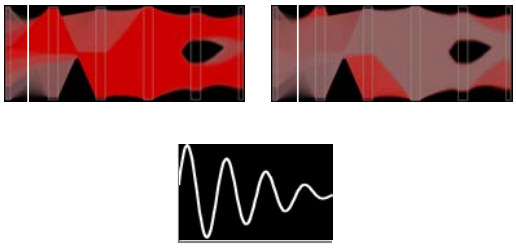
- Time-varying data is a big challenge in visualization
  - Expands data sizes
  - Often hard to represent
  - People are bad at remembering features
- Volumetric representation allows multiple time steps to simultaneously displayed

Time-varying data



Results (100 items, 500 time steps)

- Depth cue parallel coordinates



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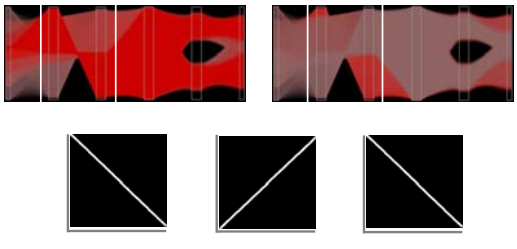

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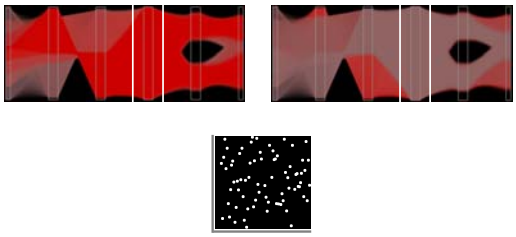

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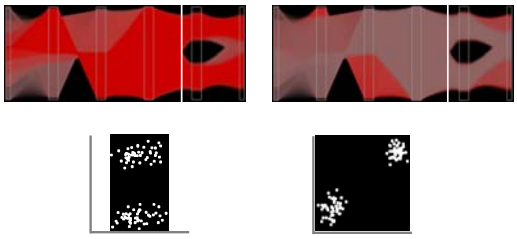
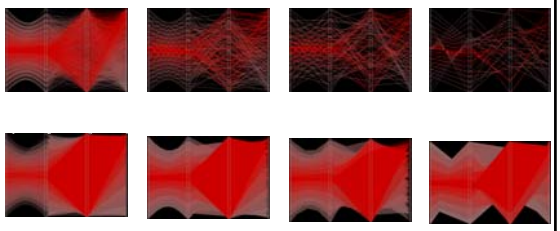


Also allows data reduction



PC through volume graphics

- Lets us:
  - Visualize actual data values at each time step
  - Visualize changes between time steps
- Allows Interactive analysis of large multivariate data sets over thousands of time steps
- Permits us to reduce the data with less loss of information

Data Mining

- Approach to find relationships in data
  - That you don't know are there
  - That the data was not collected for
- 'Post-Analysis'
- Very interesting from the point of view of many sciences, businesses and other fields.

Visual Data Mining

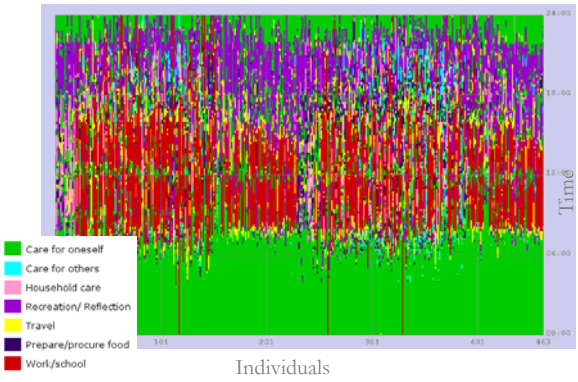
- The process of data mining can be
  - Done by InfoViz – Visual Data Exploration
    - Not really practical though – small data only
  - Vastly aided by visualization
    - Patterns extracted are the representations to show
    - InfoViz helps you interpret and analyse the patterns
      - Valid/Invalid
      - Interesting/Uninteresting

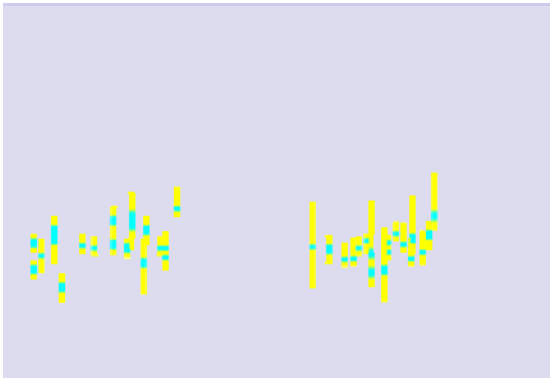
Everyday Life Discoveries:
Mining and Visualizing Activity Patterns in Social Science Diary Data

Katerina Vrotsou, NVIS, Linköping University, Sweden
Kajsa Ellegård, Tema-T, Linköping University, Sweden
Matt Cooper, NVIS, Linköping University, Sweden

Patterns in Social Science

- Everyday life exploration
  - Individuals, groups, populations
- Time-use data, activities diaries
  - Series of activities
  - Large databases





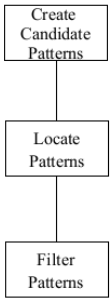
Patterns in Social Science

- Activity patterns
  - Activity sequences that aim to achieve larger projects
  - "drive car" →"drop off child" → "drive car"
    ⇨ *get child to school*
  - Work time and division of labour

Our Objectives

- To combine:
  - Sequential data mining
  - Visualization and
  - Interaction
- to enable the user to study the everyday lives of populations and analyse their activity patterns.

Algorithm – adapted AprioriAll

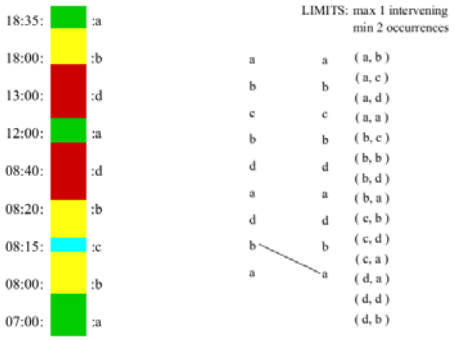


- **Join** existing patterns to create **new valid** candidate patterns
- Locate candidates in the activity data – **match**
- Filter matched patterns according to **user restrictions**

Filtering

- Time of Day Limit
- Pattern Duration Limit
- Minimum – maximum intervening activities
- Occurrences Limit
- Active People Limit

Algorithm: singles → doubles



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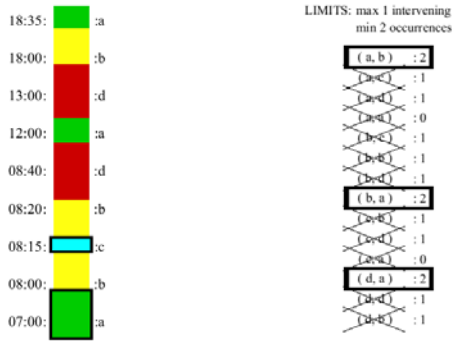

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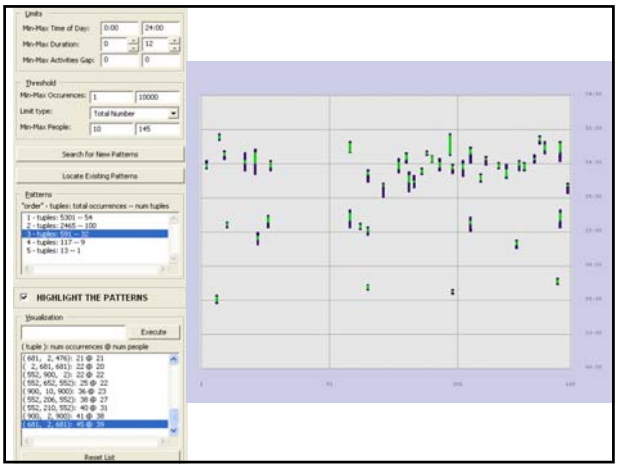
Choice of Algorithm

- Sequential data
  - Patterns = activity sequences
- Finds **all** patterns
  - Discover the unexpected
- Computation time
  - Candidate creation
  - Constraints



Conclusions

- Large number of candidate patterns
  - Large datasets → time consuming
- Filtering
  - Trivial patterns
  - *"sleep" – "wake up"*
- Alternative search algorithms
- Alternative representations

Conclusions to this talk

- InfoViz is far less focussed on computer graphics than SciViz
- More focussed on:
  - (combinations of) simple representations
  - Sophisticated representations
  - Sophisticated interaction
- It's often more mathematical and deals with even larger problems than SciViz
- The two are merging once again, however.