**Brushing & Linking**

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**Part I Overview**

- **Brushing**  
  - Allowing the user to move a region around the data display to highlight or select groups of data points.

- **Linking**  
  - Visually indicating which parts of one data display correspond to that of another

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**Visual Queries for Finding Patterns in Time Series Data**  
Harry Hochheiser, Ben Shneiderman, University of Maryland, Computer Science Dept.  

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**Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases**  

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**TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility**  
Tamara Munzner, Francois Guimbretiere, Senan Tkacik, Z. Zhang, and Yunheng Zhou,  
SIGGRAPH 2003
Part I Overview

- Idea from the previous three applications
  - Brushing and linking are often used together in multiple views applications

Part II Guidelines for Using MV

- Why to use Multiple Views?
  - Can’t display everything in one view
    - Scale:
      - Many attributes
      - Many items
    - Complex data
      - Multiple data tables (Relational databases)
      - Multiple data types (e.g. tables, images)
    - Need different visualizations for different parts of data

- When to use multiple views?
  - About view selection
  - About view presentation
  - About view interaction

- About view selection
- About view presentation
- About view interaction

- Why to use multiple views?
  - When to use multiple views?
    - About view selection
    - About view presentation
    - About view interaction

- Problems need to be resolved

VizCraft: A Multidimensional Visualization Tool for Aircraft Configuration Design

WEAVE: a system for visually linking 3-D and statistical visualizations, applied to cardiac simulation and measurement data

What is a Multiple View system?

- Systems that use two or more distinct views to support the investigation of a single conceptual entity.

How can views differ from each other?

- Differ in the data set
- Differ in the visual representation

Part II Guidelines for Using MV

- Problems need to be resolved

- Why to use multiple views?
- When to use multiple views?
  - About view selection
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- About view selection
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- About view interaction

Three dimensions on which the model of the multiple views are based

Part II Guidelines for Using MV

- Aspects of impact on the system utility
  - Cognitive aspect
    - The time and effort required to learn the system
    - The load on the user's working memory
    - The effort required for comparison
    - The effort required for context switching
  - System aspect
    - Computational requirements
    - Display space requirements

- 1. Rule of diversity
  Use multiple views when there is a diversity of attributes, models, user profiles, level of abstraction, or genres.
  - Major positive impacts on utility
    - Working memory
  - Major negative impacts on the utility
    - Learning
    - Computational overhead
    - Display space overhead

- 2. Rule of complementarity
  Use multiple views when different views bring out correlations and/or disparities.
  - Major positive impacts on utility
    - Working memory
    - Effort for comparison
    - Context switching
  - Major negative impacts on the utility
    - Learning
    - Computational overhead
    - Display space overhead

- 3. Rule of decomposition
  Partition complex data into multiple views to create manageable chunks and to provide insight into the interaction among different dimensions
Part II Guidelines for Using MV

3. Rule of decomposition
- Partition complex data into multiple views to create manageable chunks and to provide insight into the interaction among different dimensions
- Major positive impacts on utility
  - Working memory
  - Effort for comparison
- Major negative impacts on utility
  - Learning
  - Computational overhead
  - Display space overhead

4. Rule of parsimony
- Use multiple views minimally.
- Major positive impacts on utility
  - Learning
  - Computational overhead
  - Display space overhead
- Major negative impacts on utility
  - Working memory
  - Effort for comparison
  - Context switching

Part II Guidelines for Using MV

Problems need to be resolved
- Why to use multiple views?
- When to use multiple views?
  - About view selection
- How to use multiple views?
  - About view presentation
  - About view interaction

5. Rule of space/time resource optimization
- Balance the spatial and temporal costs of presenting multiple views with the spatial and temporal benefits of using the views.
- Major positive impacts on utility
  - Computational overhead
  - Display space overhead
- Major negative impacts on utility
  - Working memory
  - Effort for comparison

6. Rule of self-evidence
- Use perceptual cues to make relationships among multiple views more apparent to the user.
  - Highlighting
  - Spatial arrangement
  - Coupled interaction
- Major positive impacts on utility
  - Learning
  - Comparison
- Major negative impacts on utility
  - Computational overhead
Part II Guidelines for Using Multiple Views (MV)

7. Rule of consistency
- Make the interfaces for multiple views consistent and make the states of multiple views consistent.
  - State: data & user’s viewpoint
  - Interface affordances
- Major positive impacts on utility
  - Learning
- Major negative impacts on the utility
  - Computation overhead

8. Rule of attention management
- User perceptual techniques to focus the user’s attention on the right view at the right time.
  - Memory
  - Context switching
- Major positive impacts on utility
  - Learning
  - Comparison
- Major negative impacts on the utility
  - Computation overhead

Critique
- Pros
  - Good motivation
  - Nice guidelines and well organized
  - Illustrate guidelines with real applications
- Cons
  - The analysis of “context switching” is confusing
  - Examples are evaluated against only one or two of the guidelines.

Part III VizCraft

Guidelines for Using Multiple Views in Information Visualization

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WEAVE: a system for visually linking 3-D and statistical visualizations, applied to cardiac simulation and measurement data

Goal
- Define and set major design parameters in the conceptual design stage.
- Each design can be viewed as a point in a multidimensional design space.
  - The point should satisfy constraints
  - 29 parameters to be considered
  - The point should minimize the objective function.
    - Take-off gross weight (TOGW)
Part III VizCraft

- Difficulties
  - Evaluating the point is computational expensive
  - A single aerodynamic analysis cost 1/2 to several hours
  - High dimensionality
  - 10-30 parameters
  - Impractical for many approaches that often applied to optimization problem
  - Difficult for visualizing the design space

- What does VizCraft do?
  - Evaluate the design with visualization for analyzing the design individually
    - Objective function
    - Constraints violation
    - Graphical view
  - Evaluate the design with visualization for analyzing the design in contrast to other designs
    - Investigate a database of designs

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Walkthrough

- Walkthrough

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Critique

- Pros
  - Good use of parallel coordinates

- Cons
  - No user study or evaluation
  - No colormap for the lines in the parallel coordinates
  - One may not always lucky enough to discover the patterns in the parallel coordinates
  - Provide linking between design space and constraint space will be a plus
Typical visualization can only display only one variable at a time.
- Little quantitative analysis
- Little comparison of variables
- No relationship between behavior and structure

Evaluation using the 8 guidelines
1. Diversity (three models of data)
2. Complementarity (structure vs. behavior)
4. Parsimony (showing on demand)
6. Self-evidence (excellent linking and brushing)
5. Space/time resource optimization
3. Decomposition
7. Rule of consistency
8. Rule of attention management
A quite good multiple view application
Part IV WEAVE

- **Critique**
  - **Pros**
    - Good use of brushing and linking
    - Transparent linking between 3-D visualization and statistical presentation
  - **Cons**
    - No user study or evaluation
    - Relatively less information about the WEAVE system itself

Reference

- http://www.sims.berkeley.edu/courses/is247/s02/lectures/waterson.ppt