Modern Interaction for Visual Analytics

Christian Tominski
Institute for Visual & Analytic Computing
University of Rostock
2021-07-01
From Data to Insight
From Data to Insight
From Data to Insight
From Data to Insight
From Data to Insight
Visual Analytics

Gain **insight** into large **data** to **understand** complex **phenomena**
Visual Analytics

• Interplay of:
  
  *If answer can be computed, do:*
  
  **Computation**

  *If answer cannot be computed, add:*
  
  **Visualization**

  *If visual representations do not suffice, add:*
  
  **Interaction**

Many real-world problems are here!
Visual Analytics

"Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces."

— Thomas & Cook, 2005
Interaction for Visual Analytics

Visual analytics loop requires **high degree of interactivity**

- **Direct manipulation** (Shneiderman, 1983)
  - Interaction directly with the visual representation
  - Physical actions
  - Constant visual feedback
- **Fluid interaction** (Elmqvist et al., 2011)
  - Promote flow
  - Keep users engaged
  - Immerse users in data analysis activity
Interaction for Visual Analytics

Standard approach
• Basic graphical user interface
• Standard mouse and keyboard interaction

Goals for modern approach
• Go beyond traditional interaction modalities
• Strive for in-situ interaction
• Reduce interaction costs
Outline

Modern interaction for Visual Analytics

1. **Exploration**
   - Physical navigation in front of display wall (Lehmann et al., 2011)
   - Tangible views above tabletop displays (Spindler et al., 2010)

2. **Adjustment**
   - Lenses for adjusting the visual representation (Tominski et al., 2017)
   - Responsive matrix cells for adjusting the data (Horak et al. 2021)

3. **Comparison**
   - Naturally inspired interaction for visual comparison (Tominski et al., 2012)
   - The CompaRing for cost-efficient visual comparison (Tominski, 2016)
Exploration

• Hierarchical graph
  • Multi-scale graph representation
  • Expand node to get more detail
  • Collapse sub-graph to abstract

• How to support exploration in modern VA environments?
  1. Large high-resolution display walls
  2. Tabletop surface displays
Physical Navigation in Front of Display Wall

• What
  • Hierarchical graph visualized on large high-resolution display wall
  • Utilize the space in front of display wall for interaction
  • Control level of detail/abstraction by moving toward or away from display

• Principle
  • Proxemic interaction: Spatial relationships (e.g., proximity, orientation) between objects utilized for interaction (Marquardt & Greenberg, 2015)

• How
  • Tracking system captures users position and head orientation
  • Subdivide interaction space into zones with increasing distance from wall
Physical Navigation in Front of Display Wall
Physical Navigation in Front of Display Wall
Tangible Views above Tabletop Displays

• What
  • Hierarchical graph visualized on tabletop display plus tangible views
  • **Tangible view**: display and interaction device at the same time
  • Control level of detail/abstraction by lifting and lowering tangible view

• Principle
  • **Tangible interaction**: Manipulation of tangible objects (Hornecker & Buur, 2006)

• How
  • Cardboard onto which visualization is projected
  • Cardboard tracked in the space above the tabletop display
  • Definition of interaction vocabulary
Tangible Views above Tabletop Displays

- **Interaction vocabulary**

  - **Translate**
    - Vertical
    - Horizontal

  - **Rotate**
    - Vertical
    - Horizontal

  - **Gesture**
    - Tilt
    - Shake

  - **Freeze**
    - Vertical
    - Horizontal

  - **Appearance**
    - Color
    - Shape

  - **Gesture**
    - Flip
    - Wipe
Tangible Views above Tabletop Displays

Hierarchical graph

Parallel coordinates

Space-time cube

https://www.youtube.com/watch?v=Pw-rINj2IAY
Outline

Modern interaction for Visual Analytics

1. **Exploration**
   - Physical navigation in front of display wall (Lehmann et al., 2011)
   - Tangible views above tabletop displays (Spindler et al., 2010)

2. **Adjustment**
   - Lenses for adjusting the visual representation (Tominski et al., 2017)
   - Responsive matrix cells for adjusting the data (Horak et al. 2021)

3. **Comparison**
   - Naturally inspired interaction for visual comparison (Tominski et al., 2012)
   - The CompaRing for cost-efficient visual comparison (Tominski, 2016)
Adjustment

• Adjust the visual representation
  • Use different visual encodings and different layouts to facilitate different tasks
  • **Example 1**: Interactive lenses

• Adjust the data
  • Correct wrong or missing values
  • Experiment with “what-if” scenarios
  • **Example 2**: Responsive Matrix Cells
Lenses for Adjusting the Vis. Representation

An interactive lens is a lightweight tool to solve a localized visualization problem by temporarily altering a selected part of the visual representation of the data.

— Tominski et al., 2017

ChronoLenses, Zhao et al., 2011
Sampling Lens, Ellis & Dix, 2006
Extended Excentric Labeling, Bertini et al., 2009
Lenses for Adjusting the Vis. Representation

**Graph Lenses** *(Tominski et al., 2009)*

[Image of graphs demonstrating the use of graph lenses]

[Link to Graph Lenses resource](https://tinyurl.com/GraphLenses)
Responsive Matrix Cells for Adjusting the Data

- **Data**: Structure and **attributes** of multivariate graph
- **Visualization**: **Matrix**
  - Lower triangular matrix: Edges (and weights) between nodes
  - Upper triangular matrix: Pair-wise node similarity based on attributes
- **Question**: How to access and edit attribute values?
Responsive Matrix Cells for Adjusting the Data

• **Approach:**
  • Focus+context resizing of cells
  • Embed views into matrix cells
  • Views respond to size changes
  • When there is enough space, *data values can be edited directly in the views*
  • Visualization updated on the fly

https://tinyurl.com/ReMaCe
Outline

Modern interaction for Visual Analytics

1. **Exploration**
   - Physical navigation in front of display wall (Lehmann et al., 2011)
   - Tangible views above tabletop displays (Spindler et al., 2010)

2. **Adjustment**
   - Lenses for adjusting the visual representation (Tominski et al., 2017)
   - Responsive matrix cells for adjusting the data (Horak et al. 2021)

3. **Comparison**
   - Naturally inspired interaction for visual comparison (Tominski et al., 2012)
   - The CompaRing for cost-efficient visual comparison (Tominski, 2016)
Comparison

• Among the most important tasks in Visual Analytics (Gleicher et al., 2011)

• General procedure
  1. Select objects to be compared
  2. Carry out visual comparison
  3. Understand data in context

• Examples:
  1. Naturally inspired interaction techniques
  2. Consideration of interaction costs

A > B ?
Naturally Inspired Visual Comparison

• How do people compare information in the real world?
Naturally Inspired Visual Comparison

- Replicate natural behavior as interaction techniques for visual comparison

https://www.youtube.com/watch?v=3qOMmX_Sk_Q
The CompaRing: Reducing Interaction Costs

Costs of visual comparison

1. Compile set of objects to be compared
   *Costs for selecting objects*

2. Carry out visual comparison
   *Costs for moving eyes back and forth between objects*

3. Understand details and context
   *Costs for navigating between objects*
The CompaRing: Reducing Interaction Costs

Combine interactive and automatic means

1. Semi-automatic selection of comparison candidates
2. Dynamic rearrangement of data objects to be compared
3. Navigation shortcuts for studying data in context
The CompaRing: Reducing Interaction Costs

Cost reduction

The user does not need to collect the relevant information, instead the system brings the information to the user!

https://tinyurl.com/CompaRingDemo
Outline

Modern interaction for Visual Analytics

1. Exploration
   - Physical navigation in front of display wall (Lehmann et al., 2011)
   - Tangible views above tabletop displays (Spindler et al., 2010)

2. Adjustment
   - Lenses for adjusting the visual representation (Tominski et al., 2017)
   - Responsive matrix cells for adjusting the data (Horak et al. 2021)

3. Comparison
   - Naturally inspired interaction for visual comparison (Tominski et al., 2012)
   - The CompaRing for cost-efficient visual comparison (Tominski, 2016)
Modern Interaction for Visual Analytics

• Take home
  • Interaction is a key component of Visual Analytics
  • Six examples of modern interaction for Visual Analytics
  • Flexible access to information directly where and when it is needed

• Future Work
  • Interaction across views and devices
  • Conflict-free integration of several interaction modalities
  • In-depth cost analysis of interaction
  • Toolkit support
  • ...
Read more!

https://ivda-book.de