Interaction for Visual Data Analysis

Christian Tominski
Institute for Visual & Analytic Computing
University of Rostock
2020-01-17
The purpose of computing is **insight**, not numbers.
— Richard Hamming, 1962

*Visualization* offers a method for **seeing the unseen**. It enriches the process of **scientific discovery** and fosters **profound and unexpected insights**.
— McCormick et al., 1989
Focus on Interactivity

“A graphic is not ‘drawn’ once and for all; it is ‘constructed’ and reconstructed until it reveals all the relationships constituted by the interplay of the data. The best graphic operations are those carried out by the decision-maker himself.” — Bertin, 1981

“Interaction is the fuel for analytic discourse.” — Thomas & Cook, 2005

“It is through the interactive manipulation of a visual interface – the analytic discourse – that knowledge is constructed, tested, refined and shared.” — Pike et al., 2009

“While visual representations may provoke curiosity, interaction provides the means to satisfy it.” — Tominski & Schumann, 2020
Focus on Interactivity

• Phases of the visualization process

• But what about the phases of the interaction process?

Adapted from Card et al., 1999
Human Action Cycle

Norman’s stages of action and levels of processing

Adapted from Norman, 2013
Interaction Costs

Gulf of Execution

• Difficulty to perform interaction
  • Can I do this?, Where is the necessary functionality?, Which device do I use?, How do I execute the command?

Gulf of Evaluation

• Difficulty to understand response
  • Was there a reaction at all?, Where did the interaction take effect?, What has changed?, How well do intent and effect match?
Focus on Interactivity

Interaction is a powerful tool for analytic discourse

only if

the costs for interaction are kept low

↓

Good interaction design and implementation
A Basic Example

Demo: Interacting with events in SpiraClock  (Dragicevic & Huot, 2002)

- Lightweight
- Smooth
- Efficient
- Natural

https://vcg.informatik.uni-rostock.de/~ct/software/SpiraClock.js/SpiraClock.html
Outline

Interaction for visual data analysis

- **Lightweight**: Interactive lenses
- **Smooth**: Understandable and engaging interaction
- **Efficient**: The CompaRing for comparative analyses
- **Natural**: Naturally inspired visual comparison
Lightweight Interaction

• What does **lightweight** mean?
  • Interaction with preferably local and transient effect
  • Easy to perform and undo
  • Easy to understand and evaluate

• **Example: Interactive lenses**
Lightweight Interaction

Interactive lenses (Tominski et al., 2017)

• Model
  • Select
  • Lens function
  • Join

• Effects
  • Alteration
  • Suppression
  • Enrichment

ChronoLenses, Zhao et al., 2011 (alteration)
Sampling Lens, Ellis & Dix, 2006 (suppression)
Extended Excentric Labeling, Bertini et al., 2009 (enrichment)
Lightweight Interaction

• Demo: Graph Lenses

https://vcg.informatik.uni-rostock.de/~ct/software/iGraph.js/iGraph.html
Outline

Interaction for visual data analysis

• **Lightweight**: Interactive lenses

• **Smooth**: Understandable and engaging interaction

• **Efficient**: The CompaRing for comparative analyses

• **Natural**: Naturally inspired visual comparison
Smooth Interaction

• Why smooth interaction?
  • Make result of interaction easy to recognize and understand
  • Make interaction engaging and enjoyable to use

• How to achieve smooth interaction?
  • Continuous visual representation
  • Continuous direct manipulation
Smooth Interaction

Make result of interaction **easy to recognize and understand**

• **Instantaneous** change
Smooth Interaction

Make result of interaction **easy to recognize and understand**

- **Gradual** change
Smooth Interaction

Make interaction **engaging and enjoyable** to use

- Demo: Hybrid 2D/3D Visualization of Movement Trajectories
Outline

Interaction for visual data analysis

• **Lightweight**: Interactive lenses
• **Smooth**: Understandable and engaging interaction
• **Efficient**: The CompaRing for comparative analyses
• **Natural**: Naturally inspired visual comparison
Efficient Interaction

- **Efficiency criterion**
  - Balance benefits and costs wrt. the **task at hand**
- Many tasks and corresponding **interaction patterns** (Sedig & Parsons, 2013)
  - **Unipolar**: Arranging, assigning, blending, **comparing**, drilling, filtering, navigating, selecting, ...
  - **Bipolar**: Collapsing/expanding, composing/decomposing, linking/unlinking, storing/retrieving, ...
- Efficiency depends on data analysis situation
- Example: **Visual comparison**
Efficient Interaction

Visual Comparison

• Compile set of objects to be compared
  → Costs for selecting objects

• Carry out visual comparison
  → Costs for moving eyes back and forth between objects

• Understand data in context
  → Costs for navigating between objects
Efficient Interaction

Visual Comparison with the CompaRing
Inspired by “Bring & Go” (Moscovich et al., 2009)

• Dynamic rearrangement of data objects to be compared
• Semi-automatic selection of comparison candidates
• Navigation shortcuts for studying data in context
Efficient Interaction

Dynamic Rearrangement

• Cost reduction: The user does not need to collect the necessary information, but the system brings the information to the user!
Efficient Interaction

Selection
• Classic selection
  • Manually mark $n$ objects
• Semi-automatic selection
  • Manually mark 1st object
  • Automatically compute and select the $n - 1$ most similar objects

Navigation
• Classic navigation
  • Manual zoom and pan operations
• Navigation shortcuts
  • Slots trigger navigation to slot object
  • Automatic viewport animation

• Cost reduction: Single click vs. $n$ clicks
• Cost reduction: Single click vs. repetitive manual operations
Efficient Interaction

• Demo: Visual comparison with CompaRing

https://vcg.informatik.uni-rostock.de/~ct/software/CompaRing/index.html
Outline

Interaction for visual data analysis

• **Lightweight**: Interactive lenses
• **Smooth**: Understandable and engaging interaction
• **Efficient**: The CompaRing for comparative analyses
• **Natural**: Naturally inspired visual comparison
The design of natural interaction systems is focused on recognizing innate and instinctive human expressions in relation to some object, and return to the user a corresponding feedback that has the characteristics of being both expected and inspiring.

— Baraldi et al., 2009

• Problem: Can interaction with a computer be natural at all?
• Alternative: Naturally inspired interaction

• Next: Naturally inspired interaction for visual comparison
Natural Interaction

Motivating example: Comparison in a tabular visualization

- Standard procedure
  - Navigate to pattern A
  - Store A in short-term memory
  - Scroll to another pattern B
  - Compare B to mental image of A
- **Ineffective** and **error-prone**

- **Goal:** General interaction solution based on natural human behavior
Natural Interaction

How humans compare information printed on paper

Side-by-side  Shine-through  Folding
Natural Interaction

Replicate natural comparison behavior

• Zoomable multiple-views comparison workspace
  • Views show visual representations of data
  • Sub-views can be extracted for being compared
  • Visual cues
  • Navigation shortcuts
Natural Interaction

Replicate natural comparison behavior

• Side-by-side
  • Move sub-views assisted by snapping mechanism

• Shine-through
  • Make views semi-transparent

• Folding
  • Peel off view
  • No corner-grab, but simple heuristic to compute the fold
Natural Interaction

- Demo: Naturally inspired visual comparison
Natural Interaction

Open question

• Which interaction works best depending on analysis situation?
• Aspects to consider
  • Occlusion
  • Eye movement
  • Blending of information
  • Visibility of original data and differences
Recap

Interaction for visual data analysis

• Lightweight
• Smooth
• Efficient
• Natural

• What next?
Research Topics

• **Progressive** visual data analysis
  • Process large data progressively
  • Quickly compute and show first partial result
  • Refine and show increasingly mature results
Research Topics

• **Multi-modal** interaction
  • Combine several interaction modalities (mouse, touch, pen, speech)
  • Cope with un/availability of modalities
  • Avoid discontinuities and conflicts

Tangible Views, Spindler et al., 2011

Multi-display environments, Eichner et al., 2015

Proxemic interaction, Lehmann et al., 2011
Research Topics

• **Guidance**
  • Provide computer generated assistance during visual data analysis
  • Detect when and what degree of guidance is required
  • Design helpful yet unobtrusive visual cues

Navigation recommendations, Gladisch et al., 2013

Guidance model for visual analytics, Ceneda et al., 2017
Thank you!

https://ivda-book.de