Interactive Visualization as a Visual Dialog for Data Investigation

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Visualization?

- Many different conceptions around...
- Here: **Data Visualization**
  - data from
    - measurements, e.g., medical imaging
    - computational simulation, e.g., industrial simulation
    - scientific modeling, e.g., dynamical systems
  - visualization for
    - exploration – detecting the unknown
    - analysis – confirming/rejecting hypotheses
    - presentation – dissemination
- Examples:
  - visualization for disseminating climate scenarios
  - medical visualization for intervention planning

Visualization History in Short

- The int’l scientific field of visualization: ~20ys. old
- Lot’s of progress:
  - volume rendering
  - flow visualization
  - information visualization
  - etc.
- Milestones
  - IEEE VisWeek
  - EuroVis (2011: Bergen!)
  - etc.
- New challenges, e.g., visual analytics
So how’s visualization doing then?

- **Very well!**
  - it’s a *booming research field*  
    (more researchers, more publications, more funding, …)
  - it’s paralleling the *increasingly visual world*  
    (“everything” is getting graphical these days)
  - it’s also *selling*  
    (SpotFire, Tableau, MeVisLab, Amira, vtk, …)

- **Limitations:**
  - usually costly (esp. in terms of time, etc.)
  - often for experts only – and there aren’t too many!
  - often somehow a “dead end street” – “just” showing the data
A Challenge in Visualization

- A picture says more than a thousand words – great!
- Seeing is understanding – great!
- ...
- Not enough?
  - implicit information (not immediately visible in the data)
  - quantitative results needed (visualization often qualitative)

Goal: making visualization a tool
- iterative & computational
- embedded in work flow

A Layered Information Space

- Metaphor of a (deep) sea of information
- Explicitly represented information (the data) on top, implicitly represented information below (in layers)

user, task

data
relational information
complex information
features

example:
some flow data

temp.  vel.  ...
Interactive Visual Information Drill-Down at levels of varying complexity:
- show & brush
- relational analysis
  - feature definition in DNF (disjunctive normal form)
- complex analysis
  - attribute derivation (**today’s focus**)
    - attribute transformations, e.g., normalization
    - derivatives, differences
    - local statistics
    - ...
  - advanced brushing
- feature-based (appl.-dependent) analysis
Analysis of Fronts

- color = normalized temp.

- color = vertical wind direction
Analysis of a Climate Simulation Dataset

- Data: aggregated from large-scale climate simulation (simulation of CLIMBER model, by PIK.de)
  - >30 time series, e.g., Greenland temperature, ...
  - over 500 years each
  - for 10×10 simulation runs

- Challenges:
  - data characteristics (nature of the data/simulation)
    - mix of frequencies along time series
    - discrete values series
  - advanced analysis questions
    - which series remain stable over time?
    - outliers?

Northern hemi-sphere ice area, mix of different periods
Sample Analysis of Sea Ice Changes

Starting from the multi-frequency times series

Q: any large-scale changes?

1. smoothing of curves
2. 1st order derivation
3. smoothing of derivatives
Sample Analysis N-Atlantic Fresh Water

Starting from the discrete value series

Q: any atypical curves?

1. smoothing of curves
2. another smoothing iteration
3. 1st order derivation
Making Visualization Quantitative

Measuring in visualization
- what can we see? (⇒ perceptual psychology)
- important: show scales, legends, values!
- interpolation or discretization?
A Large Space of Color Maps

- Continuous vs. discrete maps
- Diverging vs. sequential maps
- Continuous vs. paired maps

Making Visualization Quantitative

- Measuring in visualization
  - what can we see? (⇒ perceptual psychology)
  - important: show scales, legends, value
  - interpolation or discretization?
  - transformation into quantitative scales
    plus value-accurate interaction
Conclusions

- **Visualization** has come a decades **long** and **very positive** way!
  - great technology available, e.g., in VolViz or FlowVis
  - visualization for the masses, e.g., Gapminder, etc.

- **Interesting visualization challenges:**
  - making visualization a visual dialog between the user and the data
    - interactive
    - iterative
    - computational
  - embedding visualization within the work flow
    - making visualization quantitative
    - export from visualization

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