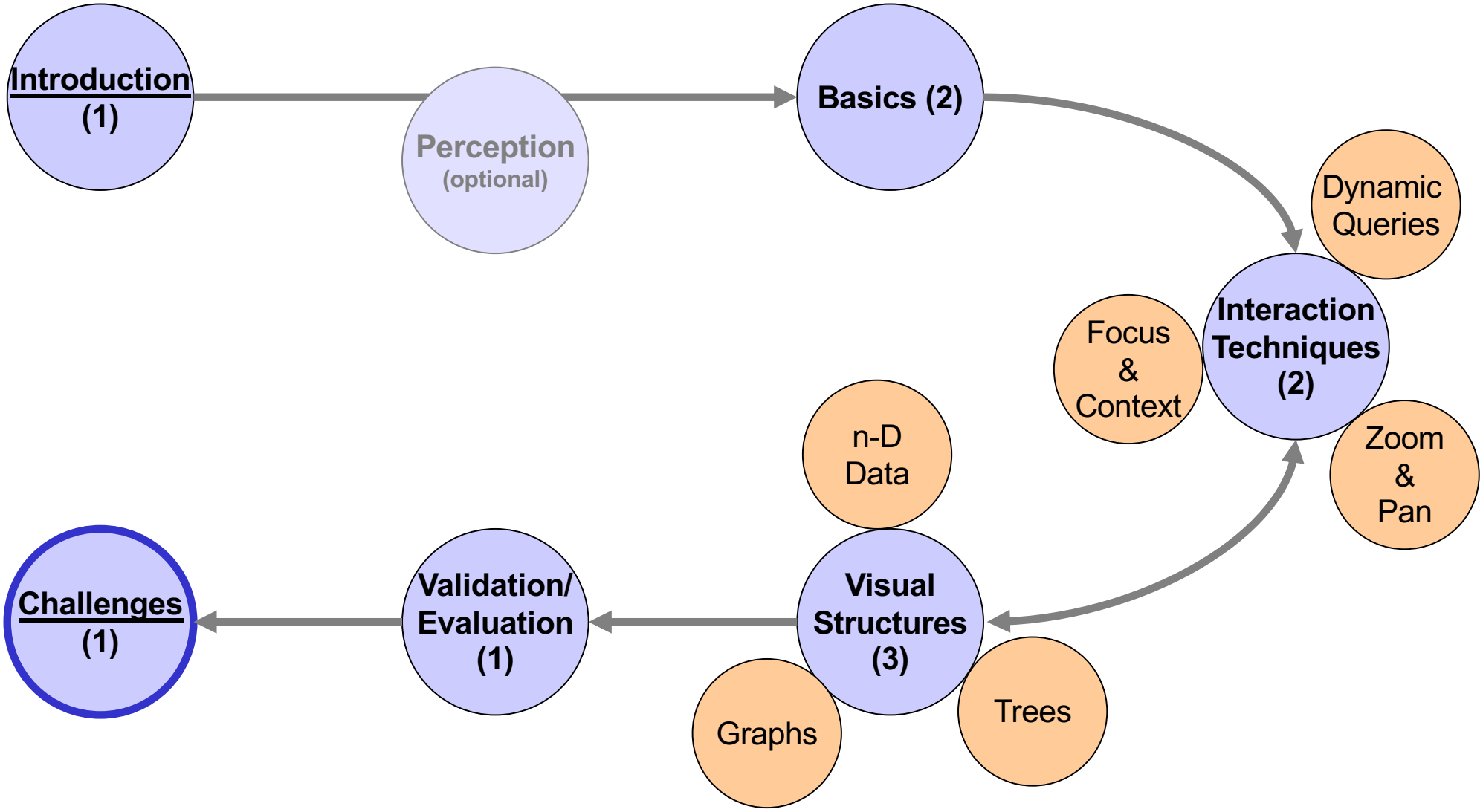
Information Visualization

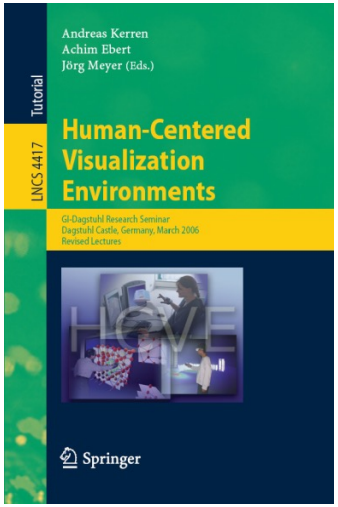
8. InfoVis Research Challenges

TNM111: 10 Lectures



8.1 Background

- Human-centered challenges
  - Interdisciplinary collaboration
  - Evaluation of usability and effectiveness
  - Understanding of elementary perception and cognition
  - Previous knowledge (adaptability, …)
  - Education and training
  - Development of effective visual metaphors
  - Optimal abstraction level
  - Effective interaction and exploration
  - Representation of data quality
  - Collaborative visualization
  - Aesthetics
  - Multimodality (sonification, haptics, …)
- Technical and other challenges
  - Scalability
  - Coordinated views
  - Representation of high-dimensional and time-dependent data
  - Research must be better transformed into practice
  - Data filtering
  - Benchmarks
  - Quality metrics
  - Display devices
  - …



[LNCS 4417, 2007]

8.2 Top 10 Challenges

- The given 10 big InfoVis problems/challenges are based on my LNCS 4417 book, recent research trends, and the following paper from 2005:
  - [C. Chen. „Top 10 Unsolved Information Visualization Problems“. IEEE Computer Graphics and Applications, 25(4), pp. 12-16, 2005.]
- Problems 1-4 are *human-centered* challenges
- Problems 5-9 are more *technical* challenges
- The remaining problem 10 focuses on challenges of a specific *application area*

8.2.1 Evaluation

- Empirical studies are still challenging, even though nobody has doubts about their benefits
- We need new evaluation methods that are especially designed for InfoVis
  - Problem: Currently, we use standard techniques from other fields (cp. Chapter 8)
  - In InfoVis, the user interacts with the visualization exploratively, i.e., the process of the better understanding is affected by a stepwise approach to find the needed information

8.2.2 Perception & Cognition

- The general understanding of perception and cognition must be inspected in context of InfoVis and, if necessary, adapted
- There is often a disparity between complex user tasks (e.g., browsing and searching) and the evaluation of single visual components (e.g., preattentive perception)
- Increased *cognitive load*
  - Recent VA tools support a large number of complex visual representations that can easily become overwhelming for users
  - People may refuse to use them in worst case

8.2.3 Prior Knowledge

- How does InfoVis handle prior knowledge of the users?
- One distinguish
  - Prior knowledge how the user uses an InfoVis system
  - Prior knowledge from the application domain, i.e., how the user interprets information
- How can we support a better use of prior knowledge?
  - Design decisions during the development process of a visualization
  - Adaptive InfoVis systems, …

8.2.4 Education and Training

- Researchers and users should know basic principles from visual communication and semiotics (internal aspect)
- For an insider, the value of InfoVis is clear. That is usually not the case for people who are *not familiar* with InfoVis ideas and tools
- We need case studies that are visible to outside the community, tutorials (also for non-experts) and the knowledge of problems in the application domains that can be solved by InfoVis techniques

8.2.5 Intrinsic Quality Measures

- The lack of quantifiable quality measures will delay the development progress of the whole field of InfoVis, especially its evaluation and selection of suitable algorithms/techniques
- Example for a general quality metric
  - Stress level (minimization of global distortion) with Multidimensional Scaling (MDS)
    - Aim of MDS: Projection of high-dimensional data to 2 or 3 dimensions
    - The lower the stress level is, the better the MDS-solution

8.2.6 Scalability

- Scalability is a well-known problem in InfoVis
- There are many examples
  - Huge networks
  - Huge n-dimensional data
  - Data streams
  - …

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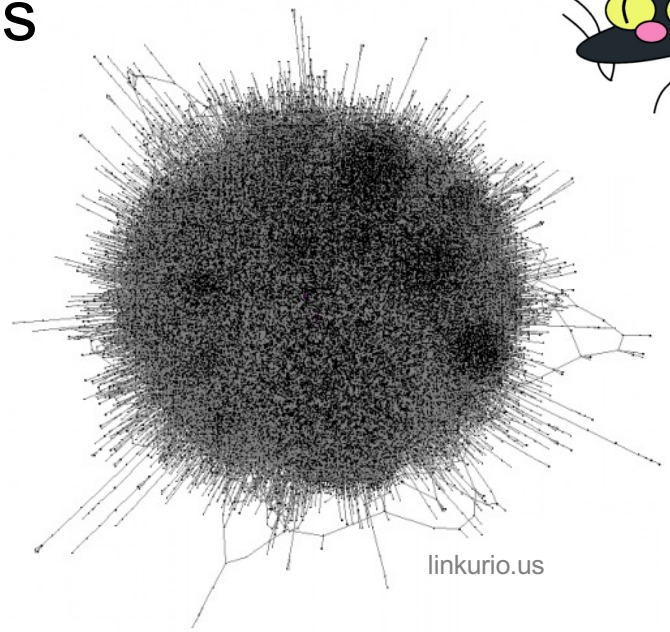
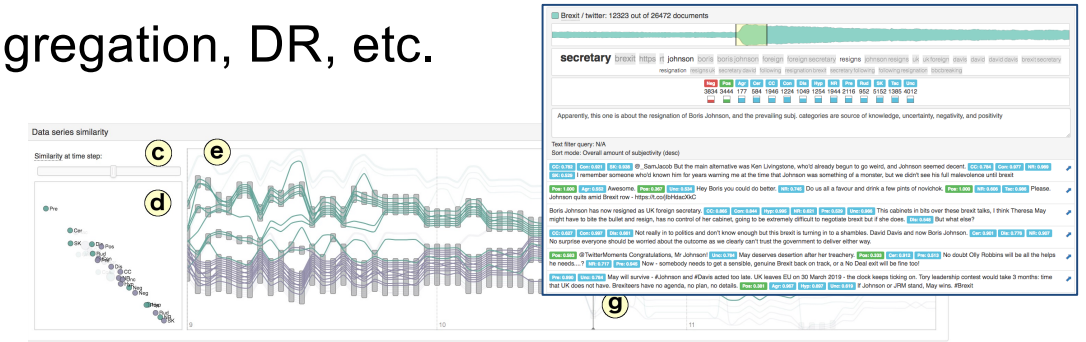


linkurio.us

- Problems can be found in the *computability* (supercomputers are not very common in InfoVis) as well as in the *visual representation*

8.2.7 Heterogeneous Data

- Critical real-world analytical problems are often based on large heterogeneous data sets
  - Networks, nD-data, texts, original data, derived data, …
  - Scalability is an issue here (cf. previous slide), but also the heterogeneity itself
- Example: Visual Text Analysis
  - Original texts plus derived data (bag of words, similarity measures, topic networks, …) and their visualization
    - Overviews based on aggregation, DR, etc.
    - Provide textual context
    - Distant/close reading
    - …



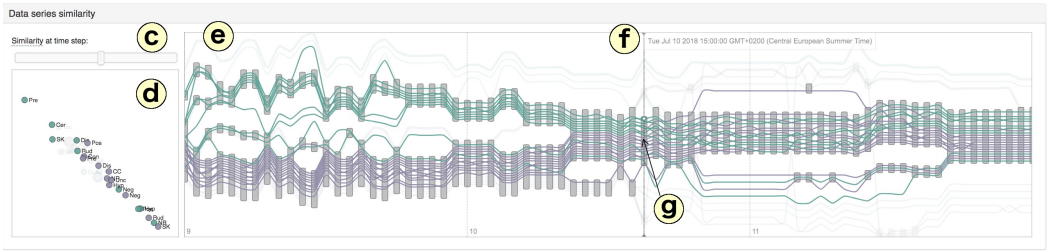
https://doi.org/10.1007/s12650-020-00684-5

8.2.8 Complex Data Streams

- In the 90s, the visual structure was in the center of interest
  - For example, cone trees, parallel coordinates, etc.
- ∃ tendency to focus on dynamic properties

⇒ *Time-series* (cf. TNM098)

- Important tasks that must be addressed
  - Trend analyses of gigantic temporal data sets
  - Discovering of changes within the data
  - …

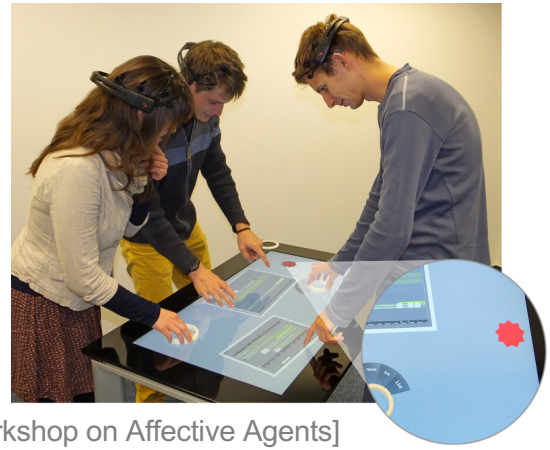


https://doi.org/10.1007/s12650-020-00684-5

8.2.9 Beyond the desktop

- Going beyond the standard approach of sitting (alone) in front of a standard PC with a mouse
  - Immersive analytics
  - Novel interaction possibilities
  - Collaboration
  - …

- Taking into account the current working situation, emotional state of the user (measured by devices), etc.

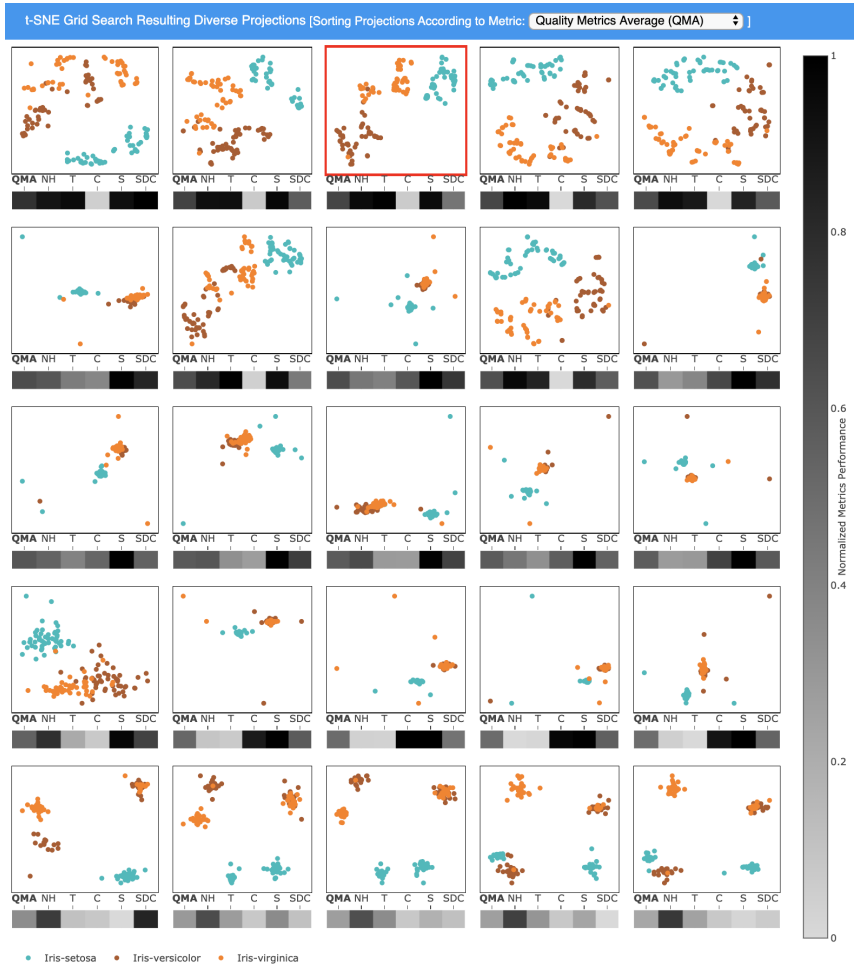


[2014 Workshop on Affective Agents]

https://doi.ieeecomputersociety.org/10.1109/MCG.2014.82

8.2.10 XAI and Vis

- Using visualization for *Explainable AI* (XAI) is a recent research challenge
  - Visualizing (real-time) online training processes for steering these processes themselves
  - Vis for hyperparameter exploration
  - Vis for model comparisons
  - Visualization for minimizing the impact of bias
  - …



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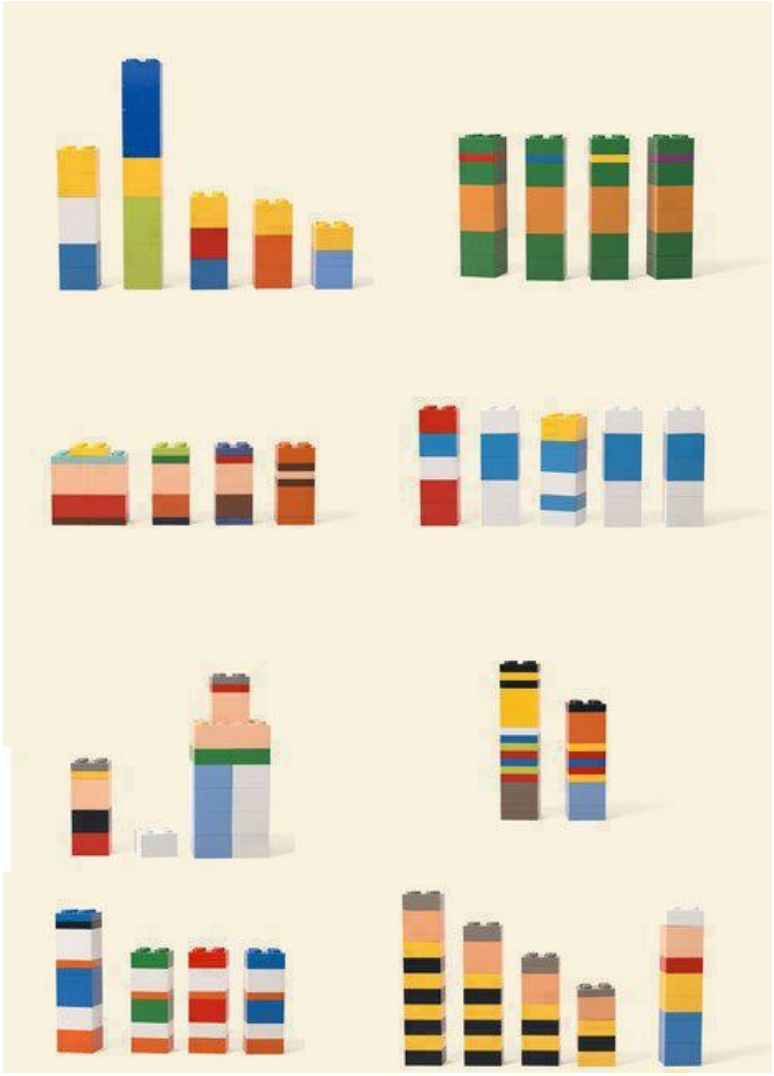

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