Capturing, Visualizing, and Sharing the Process of Data Analysis

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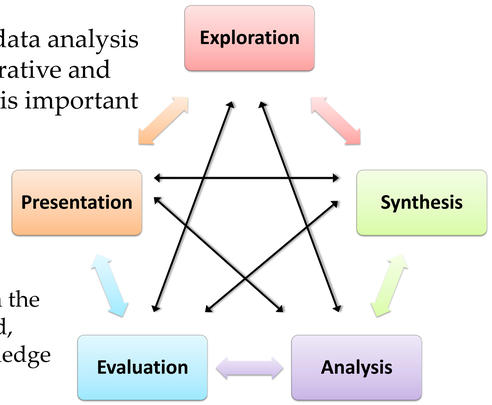
Motivation

The subjective process of visual data analysis and knowledge discovery are iterative and complex. Capturing this process is important for:

- Helping analysts keep track of analytic activities and thoughts, biases and uncertainty in the discovered knowledge.
- Situating discovered knowledge in the context in which it was created and, thereby facilitating effective knowledge sharing.
- Helping system designers build useful tools by identifying patterns commonly used in knowledge discovery.

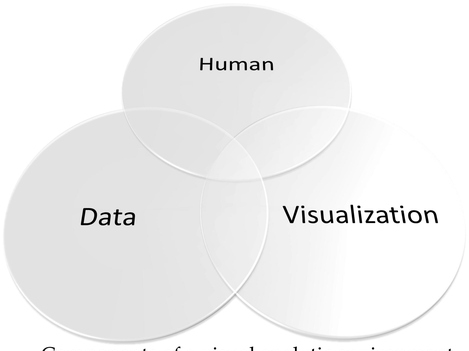


Nexus of activities comprising the scientific process (Gahegan, 2004)

Challenge

Visual analysis integrates three components: data, visualization, and thinking.

- Each component operates at a different level of abstraction.
- Transitions in human thinking, visualization, and data are not necessarily synchronous. Human thinking does not always prompt changes in visualization. Visualization does not always prompt changes in data. Thus, transition in human thoughts, visualization, and data occur at different time intervals.



Components of a visual analytic environment

The challenge is, thus, to manage different aspects of the analytical process for each component.

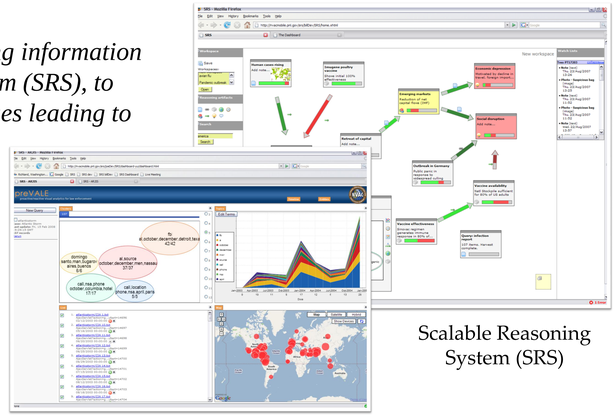
Data
- Sourcing
- Provenance

Visualization
- Defining visual settings of views
- Synchronizing settings between views
- Interactions with views

Human Cognition
- Planning
- Annotations
- Assumptions, hypothesis.

A Prototype

The goal of this work is to extend an existing information analysis tool, the Scalable Reasoning System (SRS), to capture and represent the cognitive processes leading to knowledge discovery.



Scalable Reasoning System (SRS)

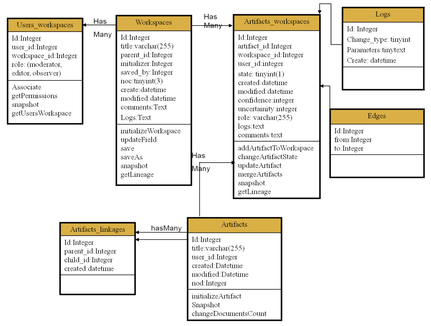
1 The Scalable Reasoning System

- A Web-based visual analytic software
- Support for end-to-end analytic activities
- Service-Oriented-Architecture (SOA)
- Organizes facts, information, and knowledge as nodes and links

2 Capturing Analytic Activities

a. **Identify actions** supported by SRS and determine their equivalent cognitive tasks.

b. Develop a **hybrid database** schema to store state of data and system over time.



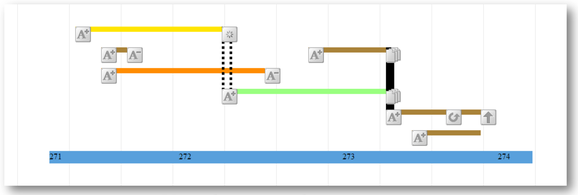
Hybrid Database Schema

Actions	Cognitive Tasks
1. Create an artifact	An information unit to keep track of
2. Delete an artifact	Information that is no longer relevant or important
3. Add documents to an artifact	Identifying documents belonging, supporting, or related to an information unit
4. Remove documents from an artifact	Documents that seem irrelevant to the overall information contained by an artifact
5. Merge artifacts	Group two different kinds of information
6. Create a new child artifact	Subset of overall information that needs to be separately highlighted, saved, or analyzed
7. Convert a node to a link	This information provides a link between two information units
8. Convert a link to a node	This information no longer provides a linkage between two different information
9. Add a source node to a link	This information provides support in the context of information provided by the link.
10. Add a target node to a link	This information is derived in the context of information provided by the link.
11. Remove source node of a link	This information no longer supports the target information in the context of information provided by the link.
12. Remove target node of a link	This information can no longer be derived in the context of information provided by the link.

Actions supported by SRS

3 Visualizing Analytic Activities

- A timeline based visualization represent analytic activities.
- Each icon represents task from the table above.
- Each row represents different tasks performed on a single information unit.
- Each line represents the duration over which an information artifact persists.
- Line color indicate the state of an information artifact, such as assumption, hypothesis, fact, resource, annotation, etc.



Visualizing analytic activities

Summary

Recent advances in visual analytics facilitate data analysis and knowledge discovery. However keeping track of important analytic activities and human thinking necessary to analyze, evaluate, and share discovered knowledge is still a challenge. This research explores these challenges and develops a prototype solution to capture, visualize, and analyze the process of data analysis.

By identifying visual interactions and actions afforded by SRS and establishing relationships between these actions and cognitive tasks, we are developing an infrastructure to capture analytic processes. An interactive timeline visualization represents important decisions of an analyst and the context in which these decisions were made.

References

Gahegan, Mark. "Beyond Tools: Visual Support for the Entire Process of GIScience." Exploring Geovisualization. Ed. J. Dykes, Alan M. MacEachren and M. J. Kraak. New York:Pergamon, 2005. 75-91.

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