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Frontier of Information Visualization and Visual Analytics in 2016

Journal of Visualization, 2017

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General Information

This paper is a cross-section survey by taking 70 latest literatures to obtain insights into the ecology of Information Visualization and Visual Analytics field in 2016.

1. Audience

Target community: Visualization

Target users: Ordinary people

2. Paper type

Survey

Research Problems

In Information Visualization and Visual Analytics field (especially in 2016):

1. What challenges have been covered recently?
2. How the research works are distributed?
3. What new research trends are there?

Why Choose This Paper?

1. Present a literature description space based on well-known visualization frameworks
2. Provide a comprehensive overview of the research progress
3. Summary the research topics of interest
4. Identify the newly emerging research directions and discuss the future trends
5. Show how to write research summary in bottom-top approach

Literature Descriptors

1. **Basic Information** (4):
title, major affiliation, venue, etc.
2. **Data Domain** (8):
textual, spatial, temporal, multi-dimensional, hierarchical, network, hybrid, general.
3. **Visual Design Philosophy** (5):
stand-alone, multi-view, mixed-in, add-on, physical.
4. **Exploring Philosophy** (7):
overview-detail, brush-link, exploration-recommendation, query, progressive, interaction enhanced exploration, immersive.
5. **Challenge** (15):
usability; assessment; prior knowledge; education and training; scalability; aesthetic; dynamics; causality, visual inference, and predictions; semantics; data quality and uncertainty; data provenance; data stream; integration; knowledge domain visualization; synthesis.

Literature Descriptors

Visual Design Philosophy

1. **Stand-alone**: emphasizes one major diagram and others serve as auxiliaries;
2. **Multi-view**: refers to the interface with multiple coordinate visual components;
3. **Mixed-in**: is to design one hybrid visualization based on two or more existing visualizations;
4. **Add-on**: is to add visual enhancement while preserving the design of original one;
5. **Physical**: takes the objects in reality as the medium of visualization.

Literature Descriptors

Exploring Philosophy

1. **Overview-detail**: explores globally first and then perform detail analysis on demand;
2. **Brush-link**: provides the connecting exploration among multiple views;
3. **Exploration-recommendation**: takes the exploration (e.g., labelling) of users as input and responses users with feedback accordingly;
4. **Query**: implies those systems based on information retrieval;
5. **Progressive**: updates the result iteratively during the exploration;
6. **Interaction enhanced exploration**: improves exploring experience by interaction recording and recovering;
7. **Immersive**: emphasizes on embedding users in the visualization environment.

Literature Descriptors

Challenge

1. **Usability**: asks for low-cost, ready-to-use information visualization systems and techniques;
2. **Assessment**: includes understanding of elementary perceptual-cognitive tasks, measurement of visual quality;
3. **Prior knowledge**: requires to adapt information visualization systems to the accumulated knowledge of their users;
4. **Education and training**: refer to the need to spread and communicate the knowledge of visualization inside as well as outside the field;
5. **Scalability**: requires continual performance as the scale increases;
6. **Aesthetic**: asks for insightful and visually appealing information visualizations;
7. **Dynamics**: needs to deal with the changes over time;
8. **Causality, visual inference, and predictions**: understands the technology and comprehend the logic, reasoning and common sense;
9. **Semantics**: requires to recognize complex coherences with human beings;
10. **Data quality and uncertainty**: poses the challenge of analyzing data with quality problems or uncertainty;
11. **Data provenance**: asks for the understanding where data come from;
12. **Data stream**: requires to deal with the streaming data;
13. **Integration**: requires integration with automatic analysis, database, statistics, etc.;
14. **Knowledge domain visualization**: requires conveying of information structures with knowledge;
15. **Synthesis**: requires the solution to a series of heterogeneous problems.

Research Methods

1. Extract descriptors based on well-known visualization frameworks and challenges to depict a research publication from multiple aspects
2. Perform a peer review among all authors to code literatures with the descriptors
3. Conduct a mixed quantitative and qualitative analysis to gain insights into the current research progress

Analysis Workflow

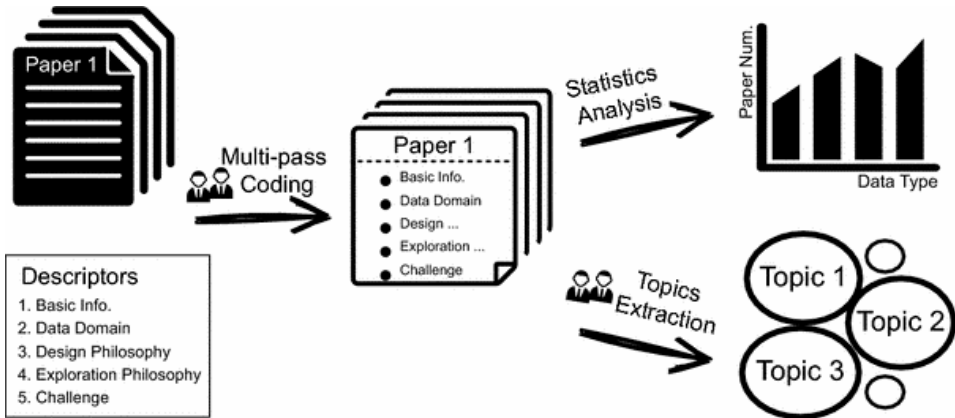


Figure 1: Workflow of literature analysis: a unified set of descriptors is derived for information visualization and visual analytics; literature is multi-pass coded with descriptors by authors; and insights are obtained from a mixed quantitative and qualitative analysis

Results

1. IEEE VIS 2016 accepts 70 full journal-track papers
 - 1). 37 from InfoVis
 - 2). 33 from VAST
2. Publication Distribution¹
 - 1). 42 certain visualization or visual analytic methodologies
 - 2). 28 evaluation, theory or performance improvement

¹<https://link.springer.com/article/10.1007/s12650-017-0431-9>

Results

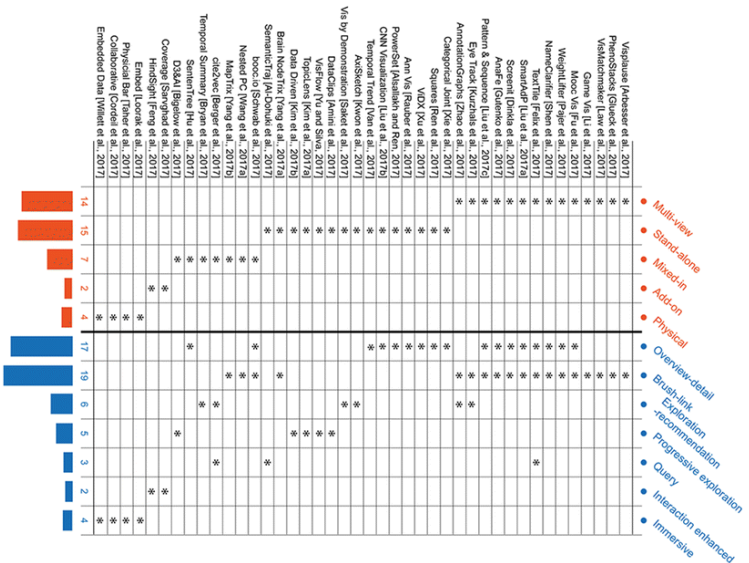


Figure 2: Distribution of 42 Publications over Different Design and Exploration Philosophies

Take-Home Message


1. Research trend

- 1). Classical topics keep being solved, such as graph visualization, multi-dimensional visual analytics.
- 2). Visual analytics is applied in more and more domains, with advanced **machine learning** integrated.
- 3). The **communication** and **story-telling capability** of visualizations is under exploration.
- 4). Theories and models of visualization field are proposed to consolidate the foundation of the discipline.
- 5). New design and exploration philosophies, such as visualization by demonstration.
- 6). **Immersive analytics** and **physical visualization** emerge as a new research of interest in recent years.

2. Literature survey method

- 1). Top-bottom surveying approach: based on the opinion and experiences of the authors
- 2). Bottom-top surveying approach: takes every single publication as input data and performs analysis to draw the conceptual map of domain

References

-  Min Lu, Siming Chen, Chufan Lai, Lijing Lin, and Xiaoru Yuan. Frontier of information visualization and visual analytics in 2016. *Journal of Visualization*, 20(4):667–686, Nov 2017.