Visualization (SCE5836)

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Objectives

This course introduces students to the field of data visualization. As an overview of the field, it discusses what Visualization is, its objectives and applications, the most general and common techniques available, and the types of data being visualized. It further presents the main algorithms and data structures. It introduces and discusses actual visualization systems. It also examines areas of application and open research problems.

Rationale

The research area of visualization has evolved from computer graphics. It studies methods, techniques, and algorithms to map information into visual representations. (Initially, visualization focused mainly on numerical data – as is mostly encountered in science and engineering and financial applications, but it has expanded its horizons to cover qualitative data, as is often collected in the social sciences, and often referred to as "Information Visualization," to distinguish it from "Scientific Data Visualization.") The main premise behind such approaches lies in the expectation that a visual representation of the information can help improve the detection of clusters, groups, and categories within the information, as well as the understanding of the relationships among them. Such help might prove of particular contribution in the analysis of large bodies of information, such as data bases / sources representing bioinformatics data, e-commerce Web site traffic, or large financial institutions transactions, among other. Visualization is a field that is still in its relative infancy; with the continuous growth in the amounts of data collected, and continuing competitive pressure to utilize such data optimally, visualization is becoming one of a number of tools being called upon to help with these tasks. With this, a growing number of open problems are awaiting to be solved by researchers. This course aims, partially, at preparing students to partake in this growing and exciting research field.

Tentative topics and outline

1. Introduction: Visualization
    a. Why?
    b. What is?
    c. History
    d. Types:
        i. Scientific visualization
        ii. Data and information visualization
        iii. Software visualization.

2. Problems and challenges
3. Visualization as part of the scientific method
4. The use of computers for data analysis
5. Reliable and robust representations
6. Semiotics
7. Visual computing: Computer graphics, images processing, and vision for visualization
8. Perception: optimizing the human "consumption" of information and the visualization process
9. Human-information (and human-computer) interaction techniques
10. Basic and advanced visualization techniques
    a. Classification of visualization techniques
    b. Data types: Classification and organization
    c. Volumetric techniques: surfaces and volumes, and their comparison
    d. Vector and tensor visualization
    e. Color, texture, icons and glyphs
    f. Visualization of large (and huge) data sources
11. Sonification: the use of sound to represent information (can we effectively use other senses?)
12. Visualization systems and interfaces
13. Applications and examples
14. Advanced interaction techniques, virtual reality in visualization
15. Distributed and collaborative visualization
16. Advanced topics: visualization for data mining
17. Visualization for the 21st century: a major shift to a new computational model, mobile+cloud.

Course requirements and student evaluation

Students' performance will be evaluated based on the following assignments and requirements:

- Bibliography summaries [10%]: Extensive reading of the current literature (broadly defined to include books, papers, Web sites of appropriate content level, software tools); at least 2 per week, compiled and submitted weekly by the class's day/time. Please provide for each entry a BibTeX record, including a short abstract, explaining the value of the entry.
- Two short class presentations [15%, 15%]: Each one should be about 20 minutes long, followed by a questions-and-answers and discussion session (similar to a paper presentation at a conference). One should cover a chosen topic from those discussed in class and/or assigned as a reading. The other one should cover a relevant topic (e.g., a visualization problem, technique, tool, an interesting application) that has not been discussed in class.
- Two short survey papers (maximum 2,000 words) [15%, 15%]: Each paper should survey a relevant topics, either discussed in class or not. These can be complementary to your class presentation. Survey papers must have some "value

added" (i.e., they should introduced some additional knowledge to what was presented and discussed in class). Papers will be due mid- and end-of-semester.
- Term project [30%]: A significant implementation project. Students should start thinking about ideas for projects as soon as possible, and get instructor's approval before starting.
- Participation in class discussions [no specific weight assigned, but will be factored in borderline cases].

In all of these categories (class presentations, survey papers, and the project), there are several directions you can take: 1. Focusing on a particular visualization technique, tool, or software, and evaluating it with a variety of datasets; 2. Focusing on a particular dataset and analyzing it with a variety of techniques and tools; 3. A combination of both approaches.

The overall emphasis will be on research and advanced work.

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