Visual User Interfaces

Challenges and Opportunities

This article discusses visual interfaces to digital libraries: background, purposes, and challenges for futher research.

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In his invited speech at the second international workshop on "Visual Interfaces to Digital Libraries" held in conjunction with the Joint Conference on Digital Libraries (JCDL) [1] in 2002, Tim Bray, founder of Antarcti.ca Systems (http://antarctica.net), demonstrated how little search engine user interfaces have changed their appearance over the last five years. A revisit of Google's™ or Yahoo's™ user interface several years ago using Brewster Kahle's Wayback Machine at http://www.archive.org is very instructive. Bray also pointed out that a web browser's window can only display a rather limited amount of text and that most web service providers such as Amazon or today's digital library interfaces are reaching this limit.

Visual user interfaces have been regarded as one of the most promising routes in resolving this paradox. They exploit powerful human vision and spatial cognition to help humans mentally organize, electronically access, and manage large, complex information spaces. Carefully designed visual user interfaces can shift the user's mental load from slow reading to faster perceptual processes such as visual pattern recognition. Visual interfaces should support information exploration and enable researchers and practitioners to gain a "big picture" of documents available in digital libraries, locate germane resources, monitor the evolution of knowledge domains, and track the influence of theories within and across domains.

Increasingly, the design of visual interfaces is drawing upon the latest advances in information visualization [2] as well as the mainstream study of digital libraries. The influence from information

visualization has been accelerated due to a number of factors: the explosion of digital information, the reduced cost of faster and larger storage and computing power, and the rapidly expanding connectivity between systems. Current research is also spurred by existing mismatches between computer displays and the human perceptual system as well as discrepancies between computer controls and human motor functions.

Three common usage scenarios for visual interfaces to document resources are to:

1. support the identification of the composition of a retrieval result, understand the interrelation of retrieved documents to one another, and refine a search [3];

1. gain an overview of the coverage of a digital library and to facilitate browsing; and

1. visualize user interaction data in relation to available documents in order to evaluate and improve document usage.

These three scenarios are exemplified in [1] using commercially successful products that can be interactively explored online.

A variety of issues concerning the design and implementation of visual user interfaces for digital libraries have been addressed by the participants of the two international workshops on "Visual Interfaces to Digital Libraries", which were held at the Joint Conference on Digital Libraries (JCDL) in 2001 and 2002, respectively. Researchers, practitioners, software developers/vendors, and graduate students in information visualization, digital libraries, human-computer interaction, library and information science, and computer science came to this interdisciplinary forum and shared their findings and plans. A collection of extended versions of papers in these two workshops will appear in an edited book entitled *Visual Interfaces to Digital Libraries* (in the *Lecture Notes in Computer Science,* Volume 2539, 2002).

In particular, the book covers (I) visual interfaces to documents, document parts, document variants, and document usage data, (II) visual interfaces for image and video documents — a very timely research topic given the recent widespread adoption of digital photography and home video production, (III) visualization of knowledge domains that apply advanced data mining and visualization techniques to generate interactive visualizations that help users organize and access large, complex information spaces, (IV) cartographic interfaces to digital libraries and the role of cartographic principles in designing easy-to-understand and easy-to-use visual interfaces, and (V) a future directions part comprising suggestions on protocols for the modularization and standardization of visualization components for digital libraries as well as a list of top-ten problems for future research on visual interfaces to digital libraries.

More detailed descriptions of the top-ten problems are available in [4]. In a nutshell, the top-ten challenges and crucial research problems in our list are identified as follows:

1. Theoretical Foundations

Research in visual interfaces of digital libraries as a whole lacks solid theoretical foundations. Some

exciting candidates include bibliometrics, scientometrics, knowledge tracking, and knowledge discovery. These areas have special requirements related to special tasks. Many of these areas have indeed developed their own approaches to visual interfaces.

2. Empirical Foundations

It is crucial to make clear what has been empirically proven to be useful and beneficial. Which types of design have worked well in some cases, but not others? Examples in areas such as visual information retrieval, visual information exploration, and empirical studies of information visualization are likely to provide valuable clues.

3. Scalability

Visual scalability is particularly relevant to the design of visual user interfaces. Interfaces that can handle multiple scale representations are among the most promising solutions to the problems of scalability.

4. Labeling

There are two aspects of the problem of labeling in visual interfaces. One aspect involves the display of readable labels, and the other involves selecting meaningful labels.

5. Individual Differences

How should visual interfaces accommodate individual differences? Research in human-computer interaction has shown that individual differences can be the most significant factor in one's performance.

6. Supporting Collaborative Work

How should we integrate social structures with the organization of the underlying digital library to support collaborative work? How should we evaluate whether a particular visual interface is useful in a collaborative setting?

7. Benchmarking and Standardization

The lack of benchmarks and standards contributes, in part, to the current suboptimal situation.

8. Evaluation

Evaluation is an integral part of the design and development of visual interfaces as well as digital libraries as a whole. Evaluative studies are needed to determine what has worked and what hasn't.

9. Personalization

Pro-active, customized, and personalized information delivery is an increasing trend in digital libraries. Visual interfaces are in a good position to organize and re-organize the way an underlying digital library

is presented to a client, tailored accordingly to the client's background and access history.

10. Standardization

Modularization and standardization of digital library services and information visualization services will save valuable resources from having to be re-invented.

We hope that this list provides a starting point to define a set of major research questions and their priority, to help researchers in the field define their research, to find collaborators and combine efforts, and to contribute to a general theory of information visualization.

Both workshops featured a large number of systems demonstrations. Many demos are linked from the workshops' web pages at http://vw.indiana.edu/visual01 and http://vw.indiana.edu/visual02. We hope that these demonstrations, and the book *Visual Interfaces to Digital Libraries*, will familiarize a wider audience with current research on visual interfaces as well as inspire further research and applications.

In 2003, the "Visual Interfaces to Digital Libraries" workshop was merged with the JCDL-workshop on "Document Search Interface Design and Intelligent Access in Large-Scale Collections" (http://xtasy.slis.indiana.edu/jcdlui/uiws.html). The title of the combined workshop was "Information Visualization Interfaces for Retrieval and Analysis (IVIRA)" (http://vw.indiana.edu/ivira03). It was held at JCDL in Houston, Texas, May 31, 2003. Organizers were Javed Mostafa and Katy Börner. The IVIRA workshop covered both theoretical and experimental research on the development, usage, and evaluation of effective interfaces to digital libraries. Of particular interest was research exploiting visualization to support improved browsing, retrieval, analysis, and understanding of domains represented in digital libraries.

The recently held Arthur M. Sackler Colloquium on "Mapping Knowledge Domains" provided another venue for research on visual interfaces to digital libraries. The Colloquium was sponsored by the National Academy of Sciences and took place May 9-11, 2003 in the Beckman Center of the National Academy of Sciences, Irvine, California. Opened with a keynote by Eugene Garfield, the Colloquium brought together leading experts in data bases, data format and access, data analysis algorithms, and visualization and interaction design. The complete list of talks, posters, and system demos — many accompanied by audio files and slides — is available at the Colloquium's web page (http://vw.indiana.edu/sackler03) .

We look forward to see many of the attendees again at the International Symposium on Knowledge Domain Visualization IV03-KDViz (http://www.graphicslink.demon.co.uk/IV03/KDViz.htm) organized by Chaomei Chen or at IV04-KDViz to be jointly organized by Chaomei Chen and Katy Börner.

References

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