

Visual Interfaces to Digital Libraries: Motivation, Utilization, and Socio-technical Challenges

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Abstract. The accelerating rate of scientific and technical discovery, typified by the ever-shortening time period for the doubling of information – currently estimated at 18 months [1] – causes new topics to emerge at increasing speed. Libraries have a hard time just cataloguing the large amount of produced documents. Scientists and practitioners who must read and process relevant documents are in need of new tools that can help them to identify and manage this flood of information. Visual Interfaces to digital libraries apply powerful data analysis and information visualization techniques to generate visualizations of large document sets. The visualizations are intended to help humans mentally organize, electronically access, and manage large, complex information spaces and can be seen as a value-adding service to digital libraries. This introductory chapter motivates the design and usage of visual interfaces to digital libraries, reviews diverse commercially successful systems, discusses major challenges, and provides an overview of the chapters in this book.

1 Motivation

Digital Libraries (DLs) [2] are content-rich, multimedia, multilingual collections of documents that are distributed and accessed worldwide. Given that they are becoming the main repository of mankind’s knowledge, the design of useful interfaces to access, understand, and manage DL content has become an active and challenging field of study.

Today, our primary means of accessing DLs are search engines that typically retrieve very large amounts of more or less relevant documents. Search interfaces lack the ability to support information exploration, making it increasingly difficult for scientists and practitioners to gain a “big picture” view of DLs, to locate germane resources, to monitor the evolution of their own and other knowledge domains, to track the influence of theories within and across domains, etc.

Visual interfaces to DLs exploit powerful human vision and spatial cognition to help humans mentally organize and electronically access and manage large, complex information spaces. The aim is to shift the user's mental load from slow reading to faster perceptual processes such as visual pattern recognition.

Visual interface design draws on progress in Information Visualization (IV) [3], a field rooted in geography and scientific visualization. The IV field is not even 10 years old, but is growing quickly. It is both far-reaching and of interdisciplinary nature - spanning areas such as IR, WWW, DL, and HCI - and has tremendous potential to improve/change information access, processing, and management.

IV research as well as research on visual interfaces to DLs is facilitated by several factors: the explosion of information available digitally; the decreasing cost of storage and computing power; larger hard disk sizes which support faster information access; accelerated graphics processors and high resolution color monitors; alternative user interfaces; 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.

Well-designed visual interfaces reduce visual search time (e.g., by exploiting low-level visual perception); provide a better understanding of a complex data set (e.g., by exploiting data landscape metaphors); reveal relations otherwise unnoticed (e.g., by exploiting the mind's ability to see relationships in physical structures); enable a data set to be viewed from several perspectives simultaneously; and offer effective sources of communication.

Visual interfaces to DL's aim to provide rapid and efficient access to enormous amounts of multimedia knowledge and information; provide new ways to analyze document collections; help leverage information from previous users (e.g., annotations, digital dog ears, footsteps); and facilitate information sharing and collaborations.

2 Utilization

Three common usage scenarios for visual interfaces to DLs 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 [4]; (2) gain an overview of the coverage of a digital library and to facilitate browsing; and (3) visualize user interaction data in relation to available documents in order to evaluate and improve DL usage. These three scenarios are exemplified below using commercially successful products that can be interactively explored online.

Visual Interfaces for Search and Browsing. Today, most search engines display matching documents in long scrolling lists. KartOO¹, developed in France by cousins Laurent and Nicolas Baleyudier, organizes search results retrieved from relevant web

¹ <http://kartoo.com/>

search engines by topics and displays them on a 2-dimensional map, cf. Fig. 1. Each document (here, relevant Web page) is represented by a ball. The size of the ball corresponds to the relevance of the document to the query. Color-coded links suggest how the documents interrelate. Resting the mouse pointer over a "ball" causes a brief description of the contents to appear.

Alternatively, the user can move the pointer over a topic in the list on the left and two buttons, plus (+) and minus (-), appear. The plus button adds the topic to the search. The minus button eliminates the sites relative to this topic. The green bar on the right of the screen indicates how many Websites are related to a request.

By showing the semantic links between retrieval results, KartOO gives the user perspectives about things that one could not see in an ordered list. KartOO processes about 150,000 requests each day, and log data has shown that users do use the links to navigate the information space.

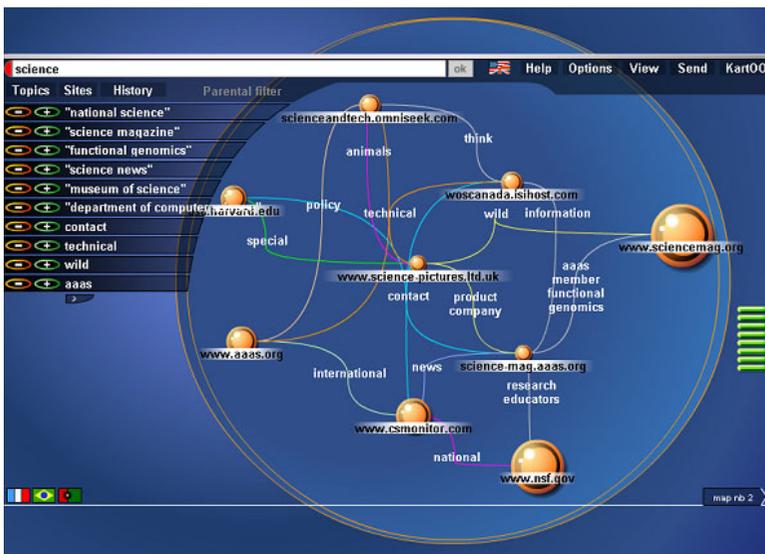


Fig. 1. The KartOO visual search interface

Visual Interfaces for DL Overview. Antarcti.ca System Inc.'s Visual Net™ product was applied to create a sample visual interface to the National Library of Medicine's PubMed database, in particular the Anatomy/Body Regions section². The initial data map, Fig. 2, shows the top-level Medical Subject Headings (MeSH) categories arranged alphabetically in rows from left to right, top to bottom, e.g., Anatomy, Anthropology, etc. The colored areas represent the documents filed under each top-level category, with the size indicating the number of citations. The shape of the areas is arbitrary but supports recognition of different areas.

² <http://pubmed.antarcti.ca/start>

Users of this interface gain an immediate overview of available categories and the number of documents these categories contain. They can click on an area of interest to zoom into the corresponding area, causing an enlarged version of the area to appear further subdivided into subcategories, if there are any. The subcategories are listed in the legend on the left, and labeled in bold on the map (see Fig. 3).

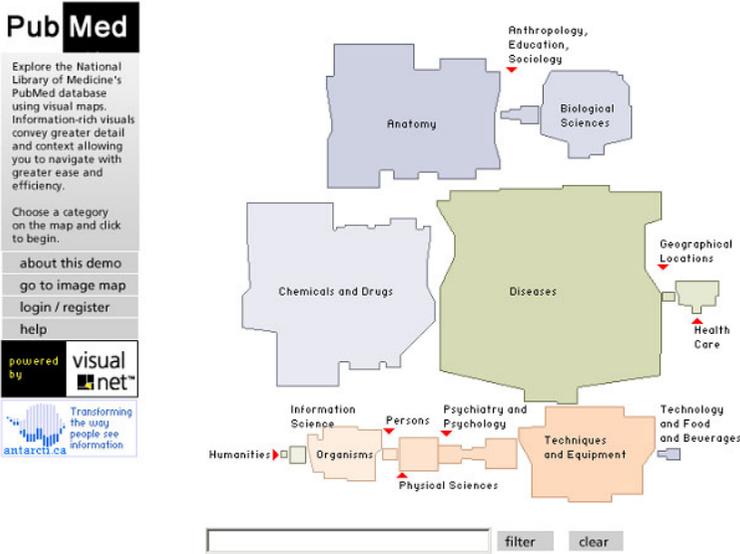


Fig. 2. Antartici.ca System Inc.'s visual interface to the PubMed database

Alternatively, users can filter out documents of interest by entering a keyword in the search window. Matching documents will be marked on the map to facilitate visual browsing based on the Boolean search result.

On the map, individual citations are represented using target graphics and non-bold titles. The target graphics indicates how new the citation is; if the article is written in English; if the citation involves human or non-human subjects; if it is a review article; or if the citation has been published within the last three months.

Mousing over a target displays the article title, author, date of publication, and PubMed ID number. Clicking on a citation name or target retrieves the citation summary from the PubMed database. The number of citations that exist in a particular part of the database is indicated at the bottom left of the map. Visual Net implements a customizable ranking system called visibility so that only the most visible citations are displayed on any map.

Visualizing User Interactive Activities. Tools developed by Visual Insights³ can be employed to analyze huge volumes of online customer behavior data, e.g., every visit, click, page view, purchasing decision, and other fine-grained details.

³ <http://www.visualinsights.com/>

Stephen G. Eick's chapter in this book further describes the underlying techniques and details inherent in different visualizations, and discusses common usage scenarios.

3 Socio-technical Challenges

The discussions at the two workshops on Visual Interfaces to Digital Libraries and the many follow-up suggestions and feedback provided by the workshop participants resulted in the identification of diverse socio-technical challenges associated with the design of visual interfaces to digital libraries. The following list represents a core set of challenges.

- Research on any (visual) interface to DLs should be based on a detailed analysis of users, their information needs, and their tasks.
- Visual interfaces provide new means to interact with data – for example, they provide an overview of what is covered by a DL, enable users to filter out relevant documents and to examine relationships among those documents. However, today's users are used to retrieval interfaces exclusively and their first reaction is to use them for the retrieval of specific documents, thereby neglecting their more robust potential value.
- Ideally, visual interfaces to DLs connect users not only to data, but also to expertise, i.e., they are collaborative.
- Simple but rich visualizations with constant information density are desirable.
- Faster, incremental, scalable ordination, mapping, and layout algorithms are needed.
- Research on how to extend 2D geographic representations to n-dimensional representations while preserving neighborhood relationships is needed.
- Good labeling, i.e., the selection of meaningful words and their display without over-plotting, is a key issue.
- It is often desirable to provide multiple perspectives to one data source.
- Federated searching of text, image, video, spatial data needs to be supported.
- Users want personal baskets to store previously selected document sets.
- Modularize visual interfaces and agree upon interface protocols to connect them to diverse DLs. Usability & usefulness studies are needed to improve interfaces and to specify what does and does not work.
- Strong collaborations among librarians and programmers help to improve the design usability of interfaces considerably.

Many of these challenges are further analyzed in the final chapter of this book, in which we propose a top-ten problem list in order to define a research agenda for visual interfaces to digital libraries.

In addition, a data and software repository is desirable for IV education and research and for facilitating the implementation and comparison of new (commercial) applications (which in turn challenge the development and improvement of the algo-

rhythms), the exploration of new ideas, the consultation with others working on related topics, and the dissemination of results.

4 The Organization of the Book

This book contains five parts. The first part introduces visual interfaces to documents, document parts, document variants, and document usage data. George Buchanan, Ann Blandford, Matt Jones and Harold Thimbleby illustrate how spatial hypertext can be applied for user-centered data access and interaction in digital libraries. Michael Christoffel and Bethina Schmitt describe a desktop virtual reality interface that uses the Quake game engine to make accessing traditional digital libraries “as easy as a game.” Carlos Monroy, Rajiv Kochumman, Richard Furuta and Eduardo Urbina introduce the Interactive Timeline Viewer (ItLv), a tool that enables the user to explore the difference between various versions of the same document. Mischa Weiss-Lijn, Janet McDonnell and Leslie James report an empirical evaluation of GridVis, a system designed to help the user navigate through relevant paragraphs within a document using interactively visualized metadata. Stephen Eick, our invited speaker in 2001, reports his work at Visual Insights on the visual analysis of Website browsing patterns. Since the Web has become the ultimate 'digital library', effective methods for analyzing the usability of Web pages are urgently needed to better utilize the vast amount of data available online.

Part two is devoted to visual interfaces for image and video documents – a very timely research topic given the recent widespread adoption of digital photography and home video production. Research in this field provides additional challenges in terms of handling diverse and large-scale multimedia data. Adrian Graham, Hector Garcia-Molina, Andreas Paepcke and Terry Winograd’s paper describes a system that exploits ‘bursts of activity patterns’ in order to organize thousands of images visually for “extreme temporal photo browsing.” Mike Christel’s paper reports the findings of the Informedia project, in particular the access of news video libraries through dynamic information extraction, summarization, and visualization. Anselm Spoerri presents Souvenir, a system that uses handwritten notes as index and visual interface to access audio and video documents.

The third part of this book focuses on the visualization of knowledge domains. This line of research applies advanced data mining and visualization techniques to generate interactive visualizations. These visualizations exploit the power of human perception and spatial cognition and help users organize and access large, complex information spaces. Jan Buzydlowski, Howard White and Xia Lin describe how term co-occurrence analysis can be used to generate maps of author and publication networks in real-time as a visual interface to DLs. Kevin Boyack, Brian Wylie and George Davidson demonstrate the use of VxInsight, a commercial tool developed at Sandia National Laboratories, for analyzing and visualizing interrelated fields such as information visualization, human-computer interaction, and cognitive psychology.

Part four highlights cartographic interfaces to digital libraries and the role of cartographic principles in designing easy-to-understand and easy-to-use visual inter-

faces. Andre Skupin introduces cartographic methods, their advantages, challenges, and practical issues concerning production of information visualization maps. Guoray Cai describes a visual interface to a geographic digital library, called GeoVIBE, which combines a traditional information retrieval approach – the vector-space model – with geographic maps that visualize spatially referenced portions of documents for users to access documents. TeongJoo Ong and John Leggett describe an online interface to the Digital Flora of Texas library collection that is actively used by botanists and botanically-interested non-specialists. Dan Ancona, Mike Freeston, Sara Fabrikant and Terry Smith present work in progress on visual explorations for the Alexandria Digital Earth Prototype. They discuss the significance of using geographical location as an index to information.

The final part is entitled “Towards a General Framework”. Rao Shen, Jun Wang and Edward Fox describe a lightweight protocol between digital libraries and visualization systems. The protocol can be seen as a first step towards modularization and standardization of DLs, knowledge discovery tools, and IV services. In the final chapter, Chaomei Chen and Katy Börner identify a list of top-ten problems for future research on visual interfaces to digital libraries.

Both workshops featured a large number of systems demonstrations. Many demos are linked from the workshops’ webpages⁴. Systems demonstrated in 2001 include:

- VGeo Virtual Reality by Virtual Reality Software & Consulting
- LVis - Digital Library Visualizer by Katy Börner, Andrew Dillon & Margaret Dolinsky
- Starwalker by Chaomei Chen
- VxInsight™ by Kevin W. Boyack
- AuthorLink and ConceptLink by Xia Lin et al.
- Gridvis by Mischa Weiss-Lijn
- Integrated Data and Metadata Browsing by Mark Derthick
- GeoVIBE by Guoray Cai
- Librarea a 3-D Library Project by Jack Colbert
- FullView by Lorraine Normore

Systems demonstrated in 2002 include:

- PubMed, Map.Net, and VCDeal map by Tim Bray, Antarti.ca Systems
- Interactive Information Visualization in the Digital Flora of Texas by John Leggett, Texas A&M University
- 2D and 3D Visualization of Large Information Spaces by Carlos Proal, Universidad de las Americas-Puebla, Mexico
- Ted Nelson's ZigZag by Nicholas Carroll, Hastings Research
- James Burke’s Knowledge Web by Patrick McKercher
- Collaborative Visual Interfaces to Digital Libraries by Katy Börner
- Visualizing Knowledge Domains by Katy Börner, Chaomei Chen, and Kevin W. Boyack

⁴ <http://vw.indiana.edu/visual01> and <http://vw.indiana.edu/visual02/>

We hope that the two workshops and this book crystallize the state of the art in visual interfaces to digital libraries. We also hope that this collection of the latest works will inspire further research and applications. Enjoy.

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