New Age Navigation: Innovative Information Interfaces for Electronic Journals

Gerry McKiernan

ABSTRACT. While it is typical for electronic journals to offer conventional search features similar to those provided by electronic databases, a select number of e-journals have also made available higher-level access options as well. In this article, we review several novel technologies and implementations that creatively exploit the inherent potential of the digital environment to further facilitate use of e-collections. We conclude with speculation on the functionalities of a next-generation e-journal interface that are likely to emerge in the near future.

KEYWORDS. E-journals, interfaces, visualization, navigation

Where is the wisdom we have lost in knowledge?

Where is the knowledge that we lost in information?[1]

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D-LIB® MAGAZINE

Still Digital After All These Years

D-Lib® Magazine (dlib.org) is "a magazine about digital library issues for researchers, developers, and the intellectually curious" produced by the Corporation for National Research Initiatives (www.cnri.reston.va.us), a not-for-profit organization formed in 1986 to "foster research and development for the National Information Infrastructure." Since July 1995, *D-Lib Magazine* has published articles, discussions, project news, and conference and publication announcements about digital library research. It has no print analogue, nor has one been proposed. "[B]y testing the limits of writing in and for a wholly networked environment," the magazine itself was viewed from the onset as an "experiment in electronic publishing." From its inception, *D-Lib Magazine* was considered to be "a testbed for experiments in electronic publishing and advanced research in digital libraries." Indeed, its original editor, in her first editorial, was "most intrigued" and looked forward to publishing "substantive articles that . . . [took] advantage of the power of hypermedia. . . ."[2]

Semantic Analysis and Visualization

In the spirit of its original intent and philosophy, and in recognition of the need to explore alternatives to current information retrieval methods in digital collections, *D-Lib Magazine* recently published a review article that describes an innovative index to the magazine itself. With the full-text corpus of the magazine as the testbed, its authors document, illustrate, and demonstrate experimental digital technologies that seek to reduce the 'cognitive load' associated with conventional search options and provide users with a better understanding of online document collections.[3]

As observed by these investigators,

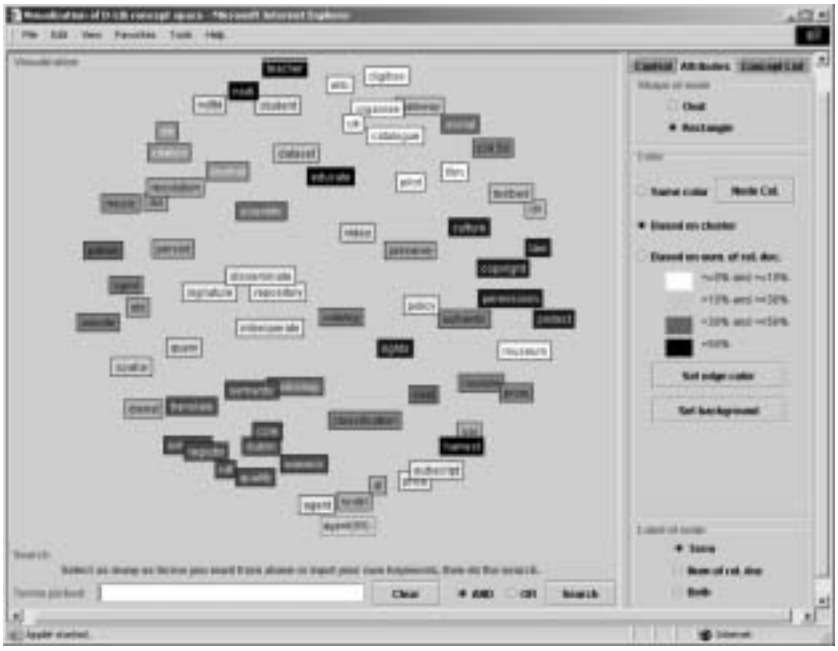
> Numerous IR [information retrieval] techniques have been developed to help deal with the information overload problem. These techniques concentrate on mathematical models an algorithms for retrieval. Popular IR models such as the Boolean model, the vector-space model, the probabilistic model and their variants are well established.
>
> From the user's perspective, however, it is still difficult to use current information retrieval systems.[4]

As an alternative to current conventional information systems, the researchers have developed a method that automatically generates the terms and their semantic relationships representing relevant topics covered in the corpus of a digital collection. The generated terms are called 'concepts,' and the generated terms and their semantic relationships are called the *Concept Space* (ella.slis.indiana.edu/~junzhang/dlib/IV1.html). Concepts are discovered using an algorithm

based on an automated thesaurus generation procedure. The concept space is visualized in a 2-D representation that 'roughly' shows the semantic relationships among concepts (see Figure 1). In the visualization, concept 'nodes' are labeled with the concept name by default. Moving the cursor over a node will display both the concept name and the number of documents within the corpus associated with it. The concept label and number of associated documents can be displayed concurrently by changing the 'label of node' option (see Figure 1, lower right corner). All nodes are initially color-coded based on cluster analysis; strongly related concept nodes are designated by the same color (e.g., blue). In the presentation, similar concepts are generally located close to each other; for example, 'copyright' is near 'permission' (see Figure 1, middle right).

Three tab panels ('Control,' 'Attributes,' and 'Concept List') (see Figure 1, upper right corner) offer users the ability to control and customize the visual-

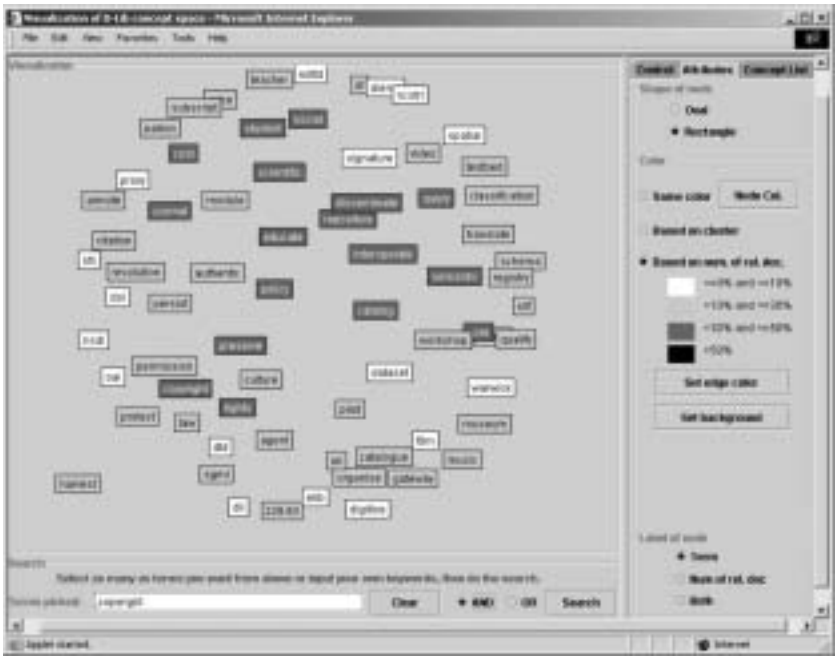
FIGURE 1. The visual display and search interface for *D-Lib® Magazine Concept Space* with a control panel and associated search box. The visualization section with the labeled concept nodes (center) and the control panels (right) occupy most of the screen. A search box is found at the bottom left of the display.



ization, among other options. The attributes panel, for example, allows the user to manipulate different visual attributes of nodes such as their shape, color, and label. An alternative visualization can display the relative percentage of documents associated with a concept in the *D-Lib Magazine* corpus by use of shade coding (see Figure 2). Concepts with fewer than 10% related articles are shown in white, while concepts that appear in more than 30% (but less than 50%) of the articles are shown as gray nodes; concepts that occur in more than 50% of the articles are shown in black. With this visualization, users can quickly determine, for example, that the concepts 'disseminate,' 'interoperability' and 'query' are discussed more frequently than are 'doi,' 'elib,' and 'ncstrl.'

The Concept Space interface allows the user to conduct searches on the collection by selecting labeled concepts directly from the visualization (e.g., 'copyright') or by inputting specific terms or phrases (see Figure 1, bottom left). Users can select as many concepts as desired from the visualization and

FIGURE 2. Users can display the relative percentage of documents associated with concept nodes of the *D-Lib® Magazine* corpus by selecting an alternative label option.



construct appropriate Boolean statements by selecting the appropriate operation ('AND' or 'OR') in the search box panel (see Figure 2, bottom left). Concept label terms can also be combined with keywords within a query. When the search button is clicked, the search results are displayed in a separate browser, and include the article title, author(s), and volume and issue number (if assigned) for each relevant document. By clicking the hyperlinked phrase ('Full text') found as the last field for each entry in the results listing, the associated full-text item is displayed (see Figure 3).[5]

ASTRONOMY AND ASTROPHYSICS SOM INDEX

Centre de Données Astronomiques de Strasbourg

The Centre de Données Astronomiques de Strasbourg (CDS) (cdsweb.u-strasbg.fr) is "an International Service under the Federation of Astronomical

FIGURE 3. The full text of articles and other items can be directly retrieved from the search results listing of a *D-Lib Magazine Concept Space* search.

and Geophysical Data Analysis Services (FAGS)" that "collects, homogenizes, distributes and preserves astronomical information." The main CDS services are *SIMBAD* (simbad.u-strasbg.fr/sim-fid.pl), a reference database for the identification and bibliography of astronomical objects outside the solar system; *VizieR* (vizier.u-strasbg.fr/viz-bin/VizieR), a search portal to astronomical catalogs, published tables, and other information sources; and *Aladin* (aladin.u-strasbg.fr/aladin.gml), "an interactive software sky atlas . . . [that allows] the user to visualize digitized images of any part of the sky."

CDS also maintains and distributes the *Dictionary of Nomenclature of Celestial Objects* (vizier.u-strasbg.fr/cgi-bin/Dic) *AstroWeb: Astronomy on the Web* (cdsweb.u-strasbg.fr/astroweb.html), as well as *StarPages: Astronomy Yellow Pages* on the Web (cdsweb.u-strasbg.fr/~heck/spages.htm). In addition, CDS hosts mirror copies of the *NASA Astrophysics Data System* (ADS) database (adswww.harvard.edu), and provides access to the full-text of select astronomical journals (e.g., *Astrophysical Journal*, *Astronomical Journal*, and *Publications of the Astronomical Society of the Pacific*), and to the article abstracts for Astronomy and Astrophysics, and its Supplement Series.[6]

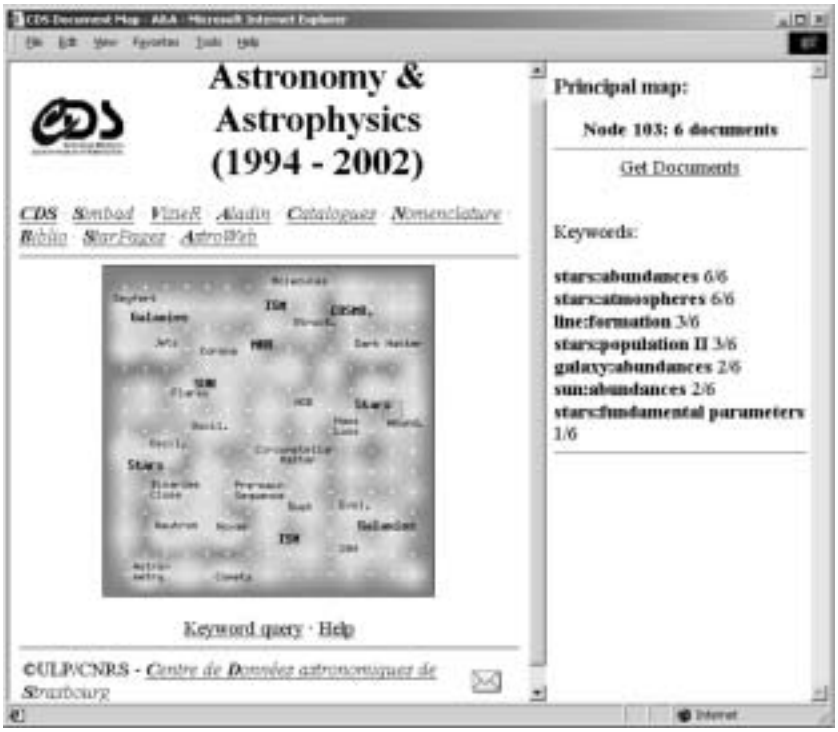
SOM Like It Hot

CDS is also actively involved in the development of bibliographic information retrieval tools, notably visualized indexes to digital collections. A premier example of this tool is the 'document map' developed for *Astronomy and Astrophysics* (simbad.u-strasbg.fr/A+A/map.pl) using the Kohonen Self Organizing Map (SOM) technique. The Kohonen SOM isan algorithm that automatically organizes documents into a two-dimensional grid so that related documents appear close to each other and general topics appear in well-defined areas. The SOM visualization is presented as a density map that graphically represents papers of similar content (see Figure 4, left frame).[7] Presently the SOM map for *Astronomy and Astrophysics* indexes more than 10,300 articles for the period 1994-2002.

To use the interface and retrieve relevant articles, users select an appropriate node (e.g., 'Stars') on the map; in turn, the keywords associated with the node are listed in a right-side frame (see Figure 4). An entry indicating the number of documents containing any of these selected keywords is displayed above the keyword listing in the frame (e.g., 'Principal Maps: Node 103: 6 documents'). Upon retrieving the search results ('Get Documents'), entries for those items assigned the selected keyword are displayed in the left-side frame where the SOM map had originally appeared (see Figure 5).

The full records for all entries may be retrieved by clicking the 'Fetch References' button at the top of the listing in the left-side frame. Upon selection, the full records for will be concatenated in groups of five (5) records (default) in this same frame, replacing the entry listing. Alternatively, the user may display the full record for an entry (e.g., *Abundances of light elements in metal-*

FIGURE 4. Screen print showing the base *Astronomy & Astrophysics* SOM map display (left side). The right frame displays a list of keywords retrieved after selecting the 'Stars' node (Node 103) (middle right) from the SOM map.



poor stars. I. Atmospheric parameters and a new T_eff_ scale) by selecting its associated hyperlinked bibliographic code (e.g., '1996A&A...314..191G').

A full record provides the standard bibliographic data and abstract, assigned keywords, links to an associated 'CDS file,' SIMBAD file, and 'full paper,' if available, as well as the corresponding record within the NASA ADS service. The ADS record offers access to the document full-text in a variety of formats, when available, as well as a separate link to the references in the source documents. In addition, the ADS service provides links to a listing of works that cite the article associated with the displayed record; to other documents in the ADS database with 'Similar Abstracts'; and to 'Also-Read Articles,' the set of articles displayed by users who also displayed the article currently being viewed.[8]

FIGURE 5. Upon retrieving the search results ('Get Documents') (see Figure 4, right frame), relevant entries for a selected keyword are displayed in the left-side frame where the SOM map had originally appeared.

If more than 30 articles are associated with a particular node, the user may request that a detailed SOM map for this cluster be generated ('Construct a local map'). From within a newly displayed local map, the user can then focus on one (or more) of the aspects of this particular grouping. Individuals may also identify and select relevant standardized terms or phrases using a 'keyword query' option. A listing of matching selected terms and phrases are listed in a right-side frame after the query is executed. Upon selecting an appropriate phrase, an associated SOM is created in the left-side frame with identical display or retrieval options as found in the principal SOM.

A Kohonen SOM document map has also been created for *Astrophysical Journal* (simbad.u-strasbg.fr/ApJ/map.pl) and the VizieR catalog service (vizier.u-strasbg.fr/cgi-bin/VizieR).[9, 10]

INSTITUTE OF PHYSICS

Institute of Physics Electronic Journals

The Institute of Physics (IOP) (www.iop.org) is "an international learned society and professional body for the advancement and dissemination of physics, pure and applied, and promotion of physics education." Founded in 1874, IOP is based in London, with offices and branches throughout the world. Today, it has more than 30,000 members worldwide. A wholly owned company, Institute of Physics Publishing (IOPP) is "a leading international publisher of journals, books and magazines in physics and a world leader in electronic publishing."[11]

Currently, IOPP publishes or provides access to more than three-dozen scholarly electronic journals in physics and other scientific disciplines. Available titles presently include:

- *Journal of Physics A: Mathematical and General*
- *Journal of Physics B: Atomic, Molecular and Optical Physics*
- *Journal of Physics: Condensed Matter*
- *Journal of Physics D: Applied Physics*
- *Journal of Physics G: Nuclear and Particle Physics*
- *New Journal of Physics*

as well as, among others,

- *Chinese Physics*
- *Classical and Quantum Gravity*
- *Combustion Theory and Modelling*
- *Journal of High Energy Physics*
- *Journal of Micromechanics and Microengineering*
- *Journal of Turbulence*
- *Measurement Science and Technology*
- *Modelling and Simulation in Materials Science and Engineering*
- *Nanotechnology*
- *Network: Computation in Neural Systems*
- *Physics in Medicine and Biology*
- *Plasma Physics and Controlled Fusion*
- *Semiconductor Science and Technology*
- *Smart Materials and Structures*
- *Superconductor Science and Technology*[12]

Searching, Searching, Searching

The IOP e-journal collection can be searched in combination or individually by title, abstract, author, or affiliation, or by exact phrase. All journals can be searched concurrently (default), or the user can select one or more specific journals from an alphabetized list. Alternatively, users can select and search a

journal from a categorized list (e.g., 'Condensed Matter and Materials Science,' 'Applied Physics,' or 'Computer Science'), or choose to search one of two IOPP 'EJs Collections,' *IOP Physics Reviews* or *BEC Matters*. The former collection "brings together review articles published in IOP's journals including topical reviews and reviews from the Institute's dedicated review journal–*Reports on Progress in Physics*,"[13] while the latter is "a special service for the Bose-Einstein condensation and matter wave community."[14]

Individuals may choose to search all available years (Jan. 1946 to present), or a particular annual period (e.g., 'Jan. 2000' to 'Dec. 2002'), by selecting the desired month-year from a drop-down menu. Currently, IOP is actively engaged in a project to digitize its entire journal archive retrospectively to 1874.[15]

Vivísimo

Results from a journal search may be displayed in a 'summary format' or an 'abstract format.' The former provides a citation format for list of relevant records, with links to the abstract, references, and the full text in PDF or HTML format, while the latter includes the elements found in the summary format and an associated abstract. As a default, entries for either format are displayed by date in reverse chronological order ('natural') (most recent first), in groups of ten records. Users may initially display, or subsequently redisplay records, in groups of 25, 50, or 100 records and/or sort (or resort) records by author, affiliation, or relevance. Records can also be sorted in strict chronological order ('reverse') (most recent last).

Alternatively, users may initially (or subsequently) *cluster* search results by the topics and subtopics found within the titles and abstracts of a retrieved set. Clustering is a technique that groups documents based on similarity. Within the IOP e-journal collection, clustering is available for searches that generate more than 25 records, and currently a maximum of 250 records can be clustered. The results that are clustered will depend on the sort options selected for the initial search (i.e., 'Date,' 'Author,' 'Affiliation,' or 'Relevance').[16]

Clustered results are grouped by appropriate topic (e.g., 'thin films,' optical fibre,' 'nonlinear optical,' etc.) and by "the overall rank of the individual search results in the search engine's output." The user can narrow a search within a cluster, by expanding the cluster and selecting a subcluster. Those records with which a cluster or subcluster is associated will be displayed to the right of the cluster tree (see Figure 6).

To generate its clusters, IOP has selected Vivísimo Clustering Engine™ (vivisimo.com), a technology that "uses sophisticated algorithms to cluster articles into meaningful topic categories, based on the words appearing in the abstract and title"; in this application, the full-text of an article is not processed. The Vivísimo engine does not employ a pre-defined taxonomy or controlled vocabulary; as a result the topic names for clusters and subtopics are generated directly from the search results.[17]

FIGURE 6. In the cluster display option in the Institute of Physics (IOP) electronic journal collection, the user can 'narrow' a search within a cluster, by expanding the cluster and selecting a subcluster. Those records with which a subcluster (or cluster) is associated will be displayed to the right of the cluster tree.

Vivísimo was founded in June 2000 by research computer scientists affiliated with the Computer Science Department at Carnegie Mellon University, Pittsburgh, Pennsylvania, where related research was originally conducted with support from the National Science Foundation.[18]

HIGHWIRE PRESS®

"In the Beginning . . ."

HighWire Press® (highwire.stanford.edu) is "an enterprise unit of Stanford University Libraries and Academic Information Resources . . . [that is commit-

ted to] charting new waters as [a co-publisher] of low-cost, graphically rich Internet editions of university and scholarly society e-journals. [It] works with [scholarly societies and responsible publishers] to publish, distribute, and archive e-journals, . . . providing a common user interface to its titles and hyperlinks to . . . [relevant] Web sources. The [overall] goal of HighWire Press is to 'return responsibility for scholarly publishing to those committed to the primacy of scholarly communication rather than profit taking.' "[19]

Its first online journal was the *Journal of Biological Chemistry (JBC*), which was made available in late May 1995. *JBC* was followed by *Science*, the journal of the American Association for the Advancement of Science (AAAS), and subsequently by the *Proceedings of the National Academy of Sciences of the United States of America*.[20] Today, HighWire Press hosts more than 340 electronic journals in the biological, medical, and physical sciences, as well journals in select fields of the social sciences.[21, 22] More than a dozen additional titles are scheduled to become available in 2003.[23]

The growing list of HighWire Press collaborating publishers, and their select publications, includes:

- American Medical Association
  - *Archives of Family Medicine*
  - *Archives of Internal Medicine*
  - *JAMA–The Journal of the American Medical Association*
- American Society for Microbiology
  - *Applied and Environmental Microbiology*
  - *Journal of Bacteriology*
  - *Molecular and Cellular Biology*
- British Medical Journal (BMJ) Publishing Group
  - *Gut*
  - *Heart*
  - *Thorax*
- Company of Biologists
  - *Development*
  - *Journal of Cell Science*
  - *Journal of Experimental Biology*
- Endocrine Society
  - *Endocrine Reviews*
  - *Endocrinology*
  - *Journal of Clinical Endocrinology & Metabolism*
- Lippincott, Williams & Wilkins
  - *Circulation*
  - *Hypertension*
  - *Stroke*

- Oxford University Press
  - *Annals of Botany*
  - *The EMBO Journal*
  - *Journal of Heredity*[24]

HighWire Press also currently provides "the largest archive of free life science articles in the world," offering access to nearly 440,000 full-text articles without charge, adding nearly 3,000 items each month.[25]

Eclectic Journals

HighWire Press was founded to ensure that its publishing partners lead the transition to the use of new technologies for scientific communication. As a major innovator in scholarly publishing, HighWire Press does not, however, simply "mount electronic images of printed pages; rather, by adding links among authors, articles and citations, . . . [and offering] advanced searching capabilities, high-resolution images and multimedia, and interactivity," its "electronic versions provide added dimensions to the information provided in the printed journals."[26]

Indeed, as stated in its original prospectus in June 1995, one of the key missions of the proposed "Networked Publishing project dubbed "The HighWire Press'" was to "use innovative network tools for capture, publishing, retrieval, reading, and presentation."[27]

Browse Articles by Topic

To assist users in identifying potentially relevant articles on a particular subject, HighWire Press has organized all e-journal titles by broad (e.g., 'Biological Sciences,' 'Medical Sciences,' 'Physical Sciences,' and 'Social Sciences') and general topics (e.g., 'Biological Sciences': 'Agriculture,' 'Biochemistry,' 'Cell Biology,' etc.). In selecting a specific general topic (e.g., 'Cell Biology'), the associated general subtopics are subsequently displayed (e.g., 'Cell Physiology,' 'Cellular Structures,' 'Cellular Types,' 'Systems Biology') with an indication of the number of associated articles for each (e.g., 'Cell Physiology (515,871)'). In addition, a ranked listing of journals that publish on a general topic is also provided.

From within a general topic, users can subsequently display articles that are categorized under specific subtopics (e.g., 'Cell Physiology,' 'Cellular Structures,' 'Cellular Types,' 'Systems Biology') by selecting a hyperlinked subtopic of interest. Within HighWire, articles are also categorized to a very high degree of specificity (e.g., 'Cell Biology > Cellular Structures > Mitogens > Mitogenic Pathway') (see Figure 7). In selecting a specific subtopic, a list of records for relevant articles (or Medline abstracts) is displayed in relevancy order. Among various options, users can select items from the listing and display these with

abstracts, or choose to export records for use in bibliographic software packages ('Download to citation manager'). For subscribed and free journals, readers can display the full-text for an entry in PDF or HTML format, where available (see Figure 7).

The topics and subtopics for HighWire Press articles have been assigned using the Semio automated categorization software technology provided by Entrieva (www.entrieva.com), a "leading provider of information categorization solutions."[28]

TopicMap

Within HighWire Press, users may also browse specific topics or subtopics by using a *TopicMap*, a special Java applet designed to display standardized topics and subtopics in a graphical form that provides a "sense of context"

FIGURE 7. Within HighWire, articles are also categorized to a very high degree of specificity (e.g., 'Cell Biology > Cellular Structures > Mitogens > Mitogenic Pathway').

while navigating a large, tree-structured database. As of December 31, 2002, there were more than 30,400 established topics and subtopics (see Figure 8).

TopicMap is based on the Star Tree SDK for Java, licensed from Inxight Software, Inc. (www.inxight.com).[29] Inxight was established in 1996 by Xerox Corporation as part of the Xerox New Enterprises initiative ". . . to capitalize on breakthrough user interface, linguistic and information access technologies invented and developed at the Xerox Palo Alto Research Center (PARC) and the Xerox Research Center Europe."[30]

When TopicMap is launched, it appears in a separate window. A left click of a topic node (e.g., 'Cell Biology') will reposition it to the center of the TopicMap display (see Figure 9); a left click-and-drag allows the user to change the specific location of a node and its associated subtopics.[31] A double left-click on a topic node will display the associated categories or records in the original window.[32]

FIGURE 8. Users can also browse general topics and lower level subtopics using *TopicMap*, a special graphical Java applet.

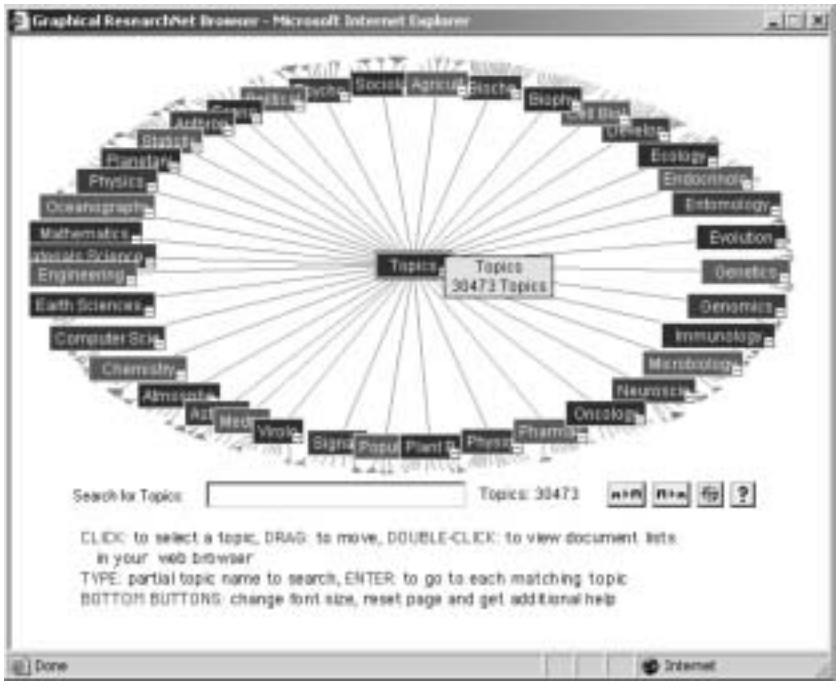
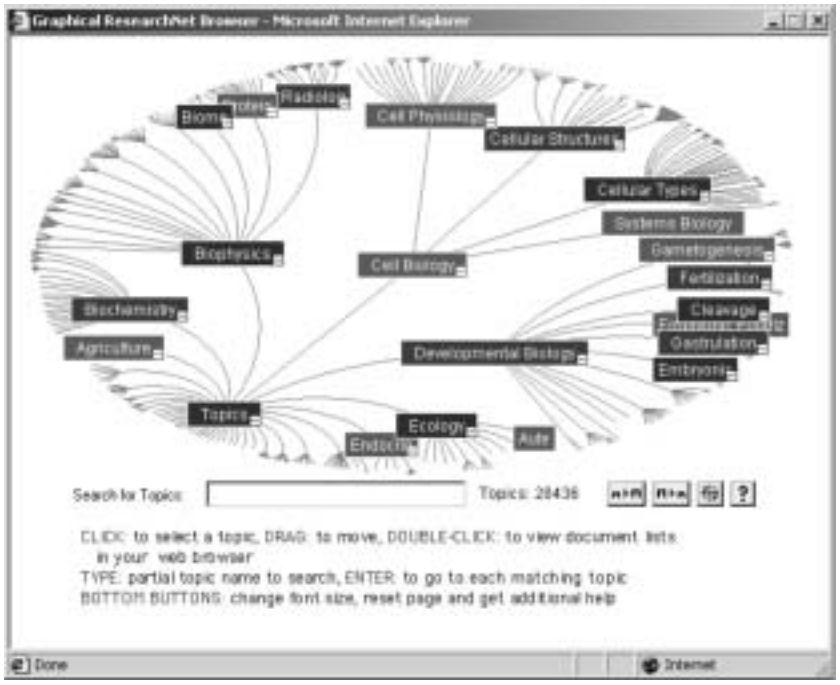


FIGURE 9. A left click of a *TopicMap* node (e.g., 'Cell Biology') will reposition the topic to the center of the *TopicMap* display.



The TopicMap can also be searched and subsequently browsed for the occurrence of broad or narrow topics by entering a candidate term or phrase (e.g., 'Cell Biology'), subtopic (e.g., 'Cellular Structures'), or a subtopic at lower levels in the topic hierarchy (e.g., Mitogens; Mitogenic Pathway), in a search box ('Search for Topics') located beneath the hyperbolic tree display (see Figures 8 and 9).

Citation Map

In select cases, search results entries will include other or alternative display options (e.g., 'Abstract,' 'Free Summary,' '*e*xtra: Supplemental Data,' and 'Citation Map') among others. The latter display option, a *Citation Map*, is "a graphical representation of the articles citing or cited by . . . [a] selected arti-

cle" (see Figure 10) and is "based on the references found in the full text articles of the HighWire-hosted journals."[33]

> [G]iven a starting reference, Citation Map finds all articles related by citations either citing the article, or cited by the article. The result set is expanded outward from the starting article to make a collection of all the articles related by citation to the starting article. By noting the number of times each article in the collection is cited, the related papers with the greatest impact are graphed, along with the citing/cited-by relations among the articles in the collection. This shows . . . the most important papers related to a starting article, as well as temporal and 'line-of-cite' relationships between these articles.[34]

A listing of the cited articles (and citing articles, where available) from the Citation Map will be displayed beneath the map, in order by the most frequently cited, with the identical display configuration and retrieval options previously noted for search and/or browse results.

FIGURE 10. The *Citation Map* is a graphical representation that depicts "the most important papers related to a starting article, as well as temporal and 'line-of-cite' relationships between these articles."

Topic-Search from Individual Search Results

In a recently introduced enhancement, individual records retrieved from a search display the subtopics assigned to an article. For any or all records, a user can select any subtopic ('ANY checked topics') or all subtopics ('ALL checked topics'), and subsequently execute a search ('Search for articles matching checked topics') (see Figure 11, right side).

Clustering

To facilitate the identification of the *specific* subject content of search results, HighWire Press also recently introduced a functionality that permits users to manipulate an 'Instant Index' of the search results (see Figure 12, top half). After an initial results display, the user can display a ranked list of subject content for the retrieved search results subset. From this categorized list,

FIGURE 11. A recently introduced HighWire Press enhancement enables a user to select any or all subtopics to an article from within retrieved results, and then execute a new search on the selected subtopics.

FIGURE 12. A recently introduced HighWire Press functionality provides an 'Instant Index' of the *specific* subject content of search results.

the user can display those records associated with the specific subject content (e.g., 'Infants; Pediatrics') (see Figure 13) and subsequently retrieve the full-text, where available, for items of interest. Clustering is available for searches with a minimum of 50 results, and will be applied to a maximum of the first 500 records.[35] Content categorization is a specific implementation of Vivísimo (vivisimo.com), the document clustering technology also utilized by the Institute of Physics Publishing (IOP) for its e-journal search results (q.v.).

Keyword-in-Context (KWIC)

To assist users in evaluating the potential relevancy of results of an Internet search engine query, it has become common practice for many services to only not highlight the search terms (or phrases) in a results list, but to include the textual context(s) of the term or phrase with the results entry as well. Recog-

FIGURE 13. From the 'Instant Index,' the user can select from a ranked listing (left side) and subsequently display associated records (right side).

nizing the inherent benefit that context offers in the information seeking process, HighWire Press recently incorporated a keyword-in-context feature.

In addition to TopicMap, Citation Map, clustering, and other current and recently introduced features, HighWire Press plans to make available several additional innovative search, browse, and display functionalities.

Browse Journals by Topic and Link to Articles from Ranked Journals

As previously noted, HighWire Press users can currently browse articles using a linear topic hierarchy (e.g., 'Cell Biology > Cellular Structures > Mitogens > Mitogenic Pathway'). In a forthcoming enhancement, readers also will be able to browse *journal titles* by subtopic within a topic hierarchy using the identical linear topical pathways available for articles. By default, journal titles in such displays are listed in descending order by 'focus.' In this context, 'focus' is defined as the "emphasis or proportion by the intensity of a journal on the topic relative to other journals. . . . " Alternatively, users may display a listing of journals for a specific topic or subtopic by number of articles that a journal has published on a selected subject ('frequency'), or in alphabetical or-

der by journal title. From any of these displays, users are able to browse articles within a journal by a topic (or subtopic) by selecting a hyperlinked option ('Browse articles on this topic').

MatchMaker

To further facilitate the identification of articles on a subject, HighWire Press will soon offer a *MatchMaker* service for author or keyword searches, providing a matching set of articles based on a weighted set of subtopics. From a starting citation or result set, MatchMaker extracts a pattern of relevant subtopics and displays these as a series of horizontal bar charts in a 'MatchMaker Topic Pattern' (see Figure 14). If desired, the user can reduce the relative weight on a subtopic by clicking on one or more of the bars, or increase the weight by clicking on the space to the right of a bar. A search can then be executed using the modified pattern ('match on changed MatchMaker pattern'). Articles that best match an original or revised pattern are listed in relevancy order.

FIGURE 14. In a 'MatchMaker Topic Pattern,' the relative weight of subtopics is displayed as a series of horizontal bars.

LONDON BUSINESS SCHOOL LIBRARY

London Business School

Founded in 1965, the London Business School (LSB) (www.london.edu) is "one of the pre-eminent international business schools . . . consistently ranked in the top ten of world business schools." It employs more than 90 world-renowned faculty and enrolls more than 1,000 graduate students and 4,500 executive education participants each year. Its library offers users a wide range of specialized as well as general print and electronic resources, including more than 20,000 books, 60 electronic databases, 1,000 serial titles, international and historic annual reports, market research reports, and more than 8,000 working papers from 32 institutions.[36]

In addition to a Web-based online catalog, the London Business School library provides access to a number of major electronic resources, most notably:

- Butterworths *Accountancy Direct* (online accounting reference resource);
- *EconLit* (economics and finance bibliographic database);
- *Factiva* (multilingual content covering nearly 8,000 sources, including Dow Jones and Reuters Newswires and *The Wall Street Journal*);
- *IDEAL Online Library* (electronic journals from Academic Press and other publishers);
- *Hoover's Online* (company, industry, and market intelligence database);
- *Investext Plus* (investment research reports);
- *JSTOR* (science, social science, and arts and humanities electronic journals);
- *ProQuestDirect* (abstract and index database of business and management journals, with full-text);
- *PsycARTICLES* (full-text of American Psychological Association journals); and
- *ScoRe* (a national catalogue of company reports in British libraries).

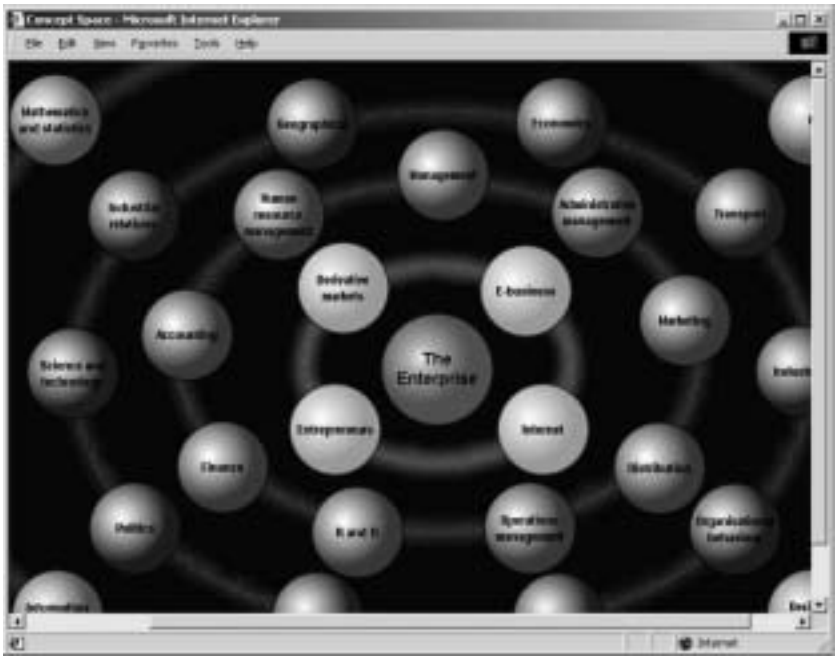
Material in the London Business School library is organized according to the *London Classification of Business Studies* (LCBS), a specialized classification scheme and thesaurus for the business literature and resources used by a number of British and international business schools, corporate libraries and information centers. Aslib published the second edition of LCBS in 1979. Subsequently the classification and thesaurus has been updated and amended by the London Business School, with the most recent version published in July 2001. A Web version of the classification and thesaurus is available as *Concept Space*, a graphical representation with associated links to organized collections of global and institutional electronic resources.[37]

Concept Space

Concept Space (conceptspace.london.edu) is a visual search tool for business concepts linked to a variety of select information resources made available to LSB-affiliated staff and students. Within Concept Space, users can explore relationships between business terms, phrases, and concepts *(*see Figure 15), and directly link to a range of sources. While a text version is also available, the graphic version of Concept Space is "dynamic" and "is best for displaying the relationships between concepts."

After selecting a major concept (e.g., 'Operations management') from the initial graphics screen, the user can subsequently explore "the relationship of the selected term to other terms in the same subject area." The nature of these relationships is depicted by the color and distance of a colored sphere from the central concept. The term and/or phrases relationships are coded as follows (see Figure 15):

FIGURE 15. Within *Concept Space*, users can explore relationships between business terms, phrases, and concepts using a graphical interface.



- Main term (e.g., 'The Enterprise') in Red
  By clicking on a selected major term, additional details about the term can be displayed. These include notes on the use of the term, its synonyms, and its class mark in the London Business School Library;
- Broader terms (e.g., 'Mathematics and Statistics') in Green
  Terms shown in the color green are more general terms in the subject hierarchy. One can view the wider context of a term by clicking on it;
- Narrower terms (e.g., 'Industrial relations') in Blue
  Terms shown in blue are more specific terms or sub-categories in the subject hierarchy;
- Related terms (e.g., 'Operations management') in Purple
  Terms shown in purple are other subject terms of potential interest
- Highlighted terms (e.g., 'Entrepreneurs') in Yellow

In selecting a term or phrase for focus (e.g., 'Operations management'), the user is presented with a new window (see Figure 16) in which a series of related concepts are presented. From within this screen the user may select a narrower term (e.g., 'Production methods') and browse its associated concepts, or execute a search within one or more groups of electronic LSB library resources for the initial concept. By clicking the 'Search related sites' hotlink (or its associated globe-like icon) located within the left-side frame of the screen (see Figure 16), the user is presented with categories of relevant information resources (i.e., 'Business books,' 'Business articles,' 'Academic,' 'Companies and competitors,' 'Find out more') (see Figure 17). In selecting a specific resource (e.g., 'NBER Working Papers' from the 'Academic' category), the source is searched using the term or phrase associated with the particular selected concept (e.g., 'Production methods') (see Figure 18).

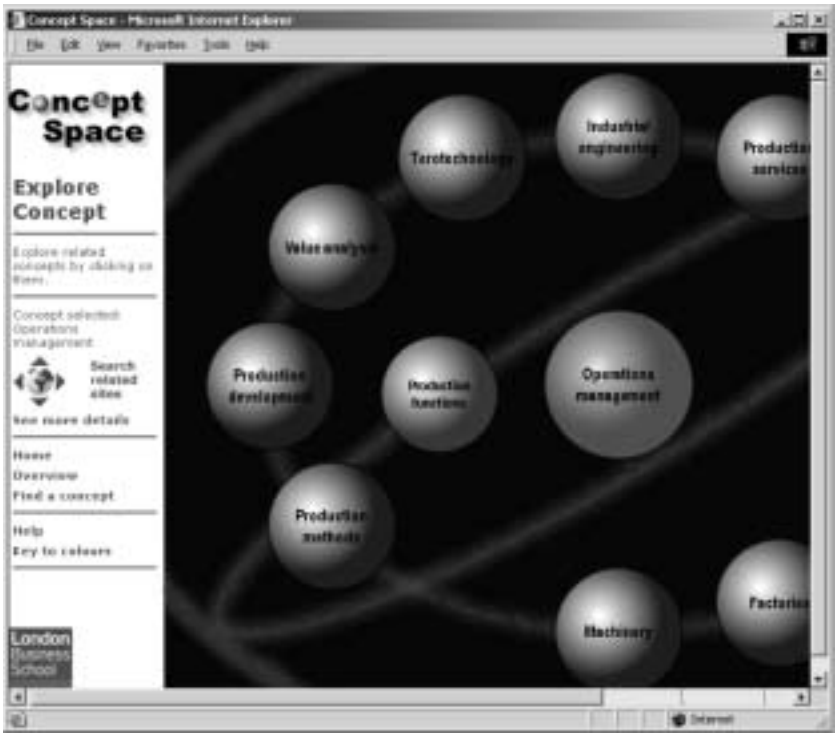
Concept Space is an interface to a subset of electronic resources from the London School of Business. In addition, due to licensing requirements, access to certain resources may be limited to staff and students. Concept Space was developed for London Business School Library by TLA Ltd. (www.tlaweb.net, a Web technology and content developer).

UTRECHT UNIVERSITY LIBRARY

Utrecht University

Established in 1636, Utrecht University is one of the oldest universities in Europe, recently commemorating the 365th anniversary of its founding. It currently offers the widest range of courses of any university in the Netherlands, with more than 14 faculties and 70 degree courses.[38] Current faculties include Arts, Biology, Geographic Sciences, Mathematics and Computer Science, Philosophy, and the Social Sciences. In addition, there are the faculties of

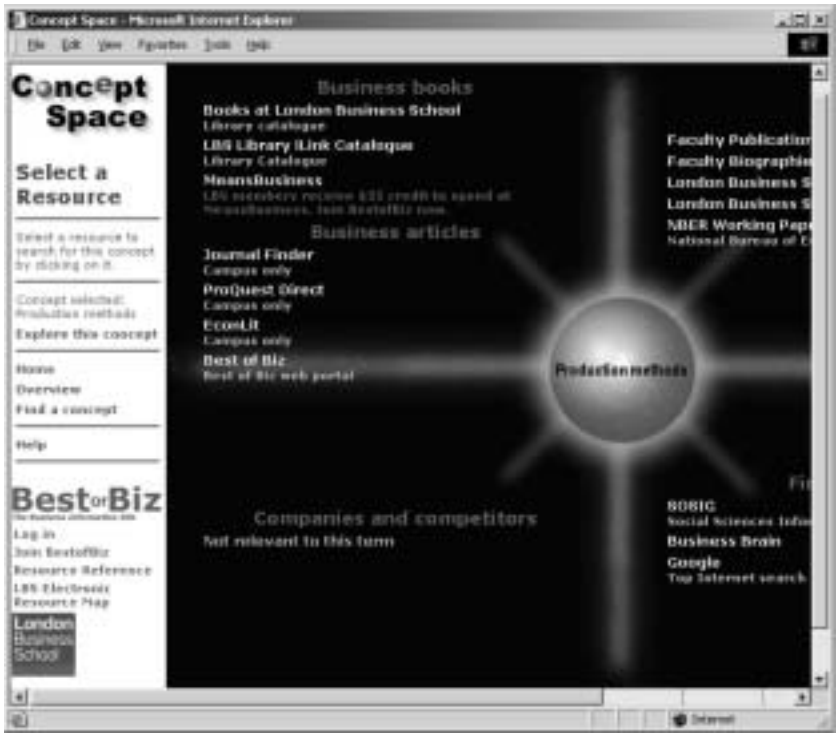
FIGURE 16. In selecting a term or phrase for focus in *Concept Space* (e.g., 'Operations Management'), the user is presented with a new window in which a series of related concepts are presented. From within this screen, the user may select a narrower term and browse its associated concepts, or execute a search within one or more groups of electronic London School of Business library resources for the initial concept ('Search related sites').



Medicine, Pharmaceutical Sciences, and Veterinary Medicine.[39] In 2001, it had an enrollment of more than 22,400 students, with more than 3,100 enrolled in the Faculty of Medicine alone, and nearly 5,000 enrolled in the Sciences.[40]

In addition to its print collection, the Utrecht University Library offers its faculty, staff, and students access to a wide variety of electronic information sources that include bibliographic and abstract databases (e.g., *Medlin*e, *Nursing and Allied Health*, *PsycINFO*), select Internet sites, full-text doctoral dissertations, and e-journals.[41]

FIGURE 17. After clicking the 'Search related sites' hotlink (or its associated globe-like icon) located within the left-side frame of the screen (see Figure 16), the user is presented with categorized lists of information targets from which a search on a selected concept can be executed (right frame).

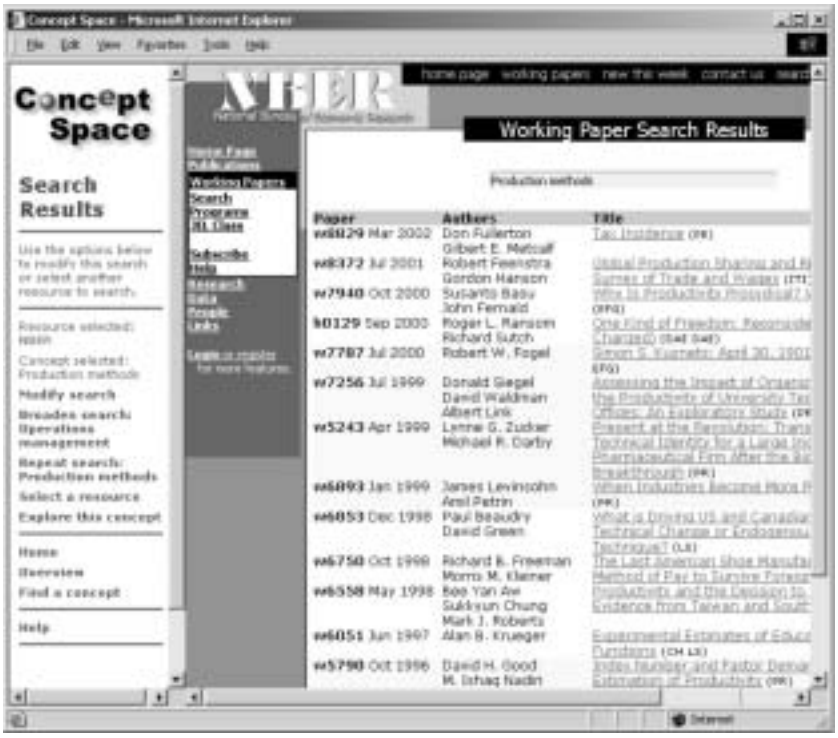


To demonstrate enhanced access to select electronic resources offered by Utecht University, MediaLab (www.medialab.nl), a Dutch firm specializing in 'knowledge mining' and creation of 'intelligent' Intranet and Internet sites,[42] has applied its *AquaBrowser* technology to select electronic medical information resources made available by the university library.

AquaBrowser

The AquaBrowser is "a software tool that presents large amounts of information from different sources in a playful and exciting manner." The AquaBrowser

FIGURE 18. After selecting a specific target, the source is automatically searched using the term or phrase associated with the particular selected concept, and the results subsequently displayed in the right-side frame.



enriches a query (e.g., 'pancake') by linking to related terms (e.g., 'crepe,' 'pizza,' 'pita'), by providing context (e.g., 'breakfast,' 'birthday,' 'syrup') and offering direct relations (e.g., 'flour,' 'butter,' 'batter') that may lead to "surprising discoveries" (e.g., 'caviar').[43]

There are several components to the AquaBrowser system, including various tools that gather, analyze, and create linkages from a range of electronic sources (e.g., databases, Web sites, CD-ROMs, etc.). 'Liquid Filters' extracts information from various sources and transfers it to the 'Liquid Knowledge Builder.' The source material itself is cached in the 'IGOR' database (see below). The knowledge builder analyses all the information extracted by the filters. An integrated dictionary is utilized in the analysis, which can be enhanced

by the incorporation of a subject thesaurus. Subsequently, mathematical models are created based in part on the frequency and clustering of terms.[44]

IGOR is the AquaBrowser's 'black box.' Among its components and functionalities are:

- a freetext search engine (a searchable index of all the words in a corpus);
- rankers (rankers provide 'fuzzy' answers to specific questions);
- a co-occurrence generator (this generator analyses texts from source databases and creates statistical and semantic relations between constituent terms and phrases);
- a translation unit (the translation component provides automatic translations of queries and keywords into 'other languages, specific jargon, archaic dialects, or technical phrases');
- a fuzzy alternative generator (this generator creates correct and incorrect variations of terms and phrases);
- stemmers (stemmers isolate the semantic stem of a term facilitating a search for synonyms and variants).[45]

The 'Liquid Context Builder' is the system's 'top layer' that "enriches the user's queries and keep track of all the steps in the search [process]." In addition, the context builder produces the list of results and the 'cloud of associations' that lead "the way to more relevant information along different routes." Upon execution of a search, the 'cloud of associations' (see Figure 19, right side) and portions of the records (see Figure 19, left side), are displayed in the AquaBrowser.[46]

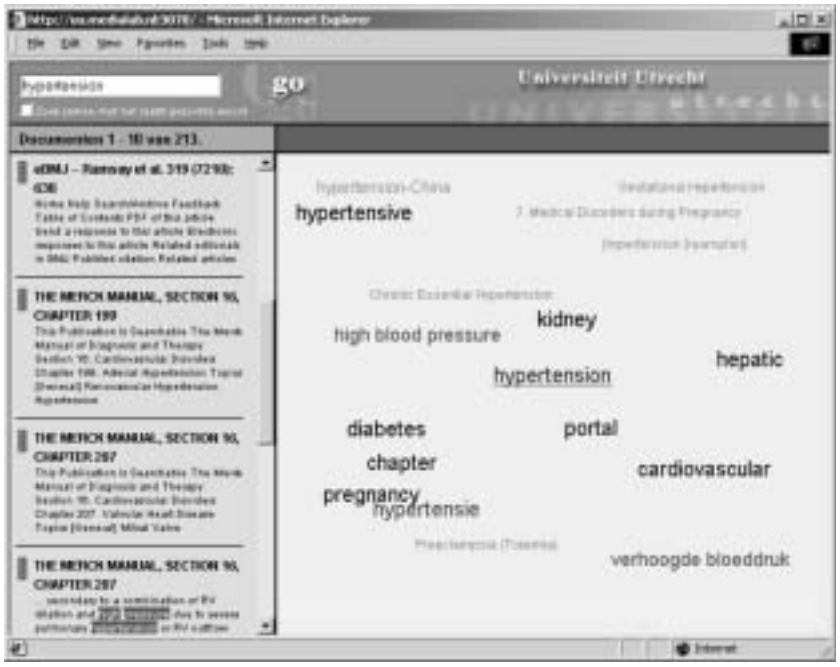
The AquaBrowser interface offers a "graphical depiction of search results and associations' " that allow the user to search, browse, and "follow the 'cloud of associations'" generated initially from target sources or from a specific query (e.g., 'hypertension')[47] (see Figure 19). The 'cloud of associations' contains associations as well as synonyms, translations, spelling variations, and typographical errors. Upon selecting an entry from results listing displayed in a left-side frame, the associated document is displayed in a right-hand frame (see Figure 20).

Among its many other applications, AquaBrower has been applied as an interface to online public catalogs, namely that of the Netherlands Association of Public Libraries (NBLC) (zoeken.bibliotheek.nl/index.html) and in the eLibraryHub (aqua.elibraryhub.com) of the National Library Board (NLSB) of Singapore.[48]

CONCEPTUAL ACCESS

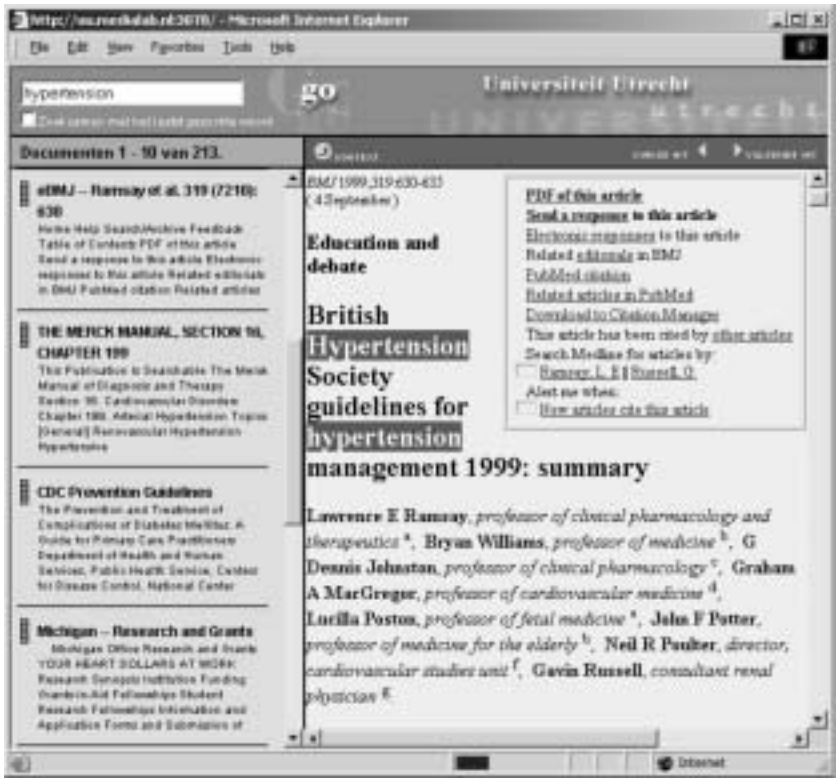
In an effort to enhance access and use of their respective collections, a select number of e-journals have begun to offer novel search, retrieval, and display alternatives that employ emerging and experimental information technologies. In some collections, users are able to browse detailed linear hierarchies (e.g.,

FIGURE 19. The *AquaBrowser* interface offers a "graphical depiction of search results and associations" that allow the user to search, browse, and "follow the 'cloud of associations' generated initially from target sources or from a specific query (e.g., 'hypertension')."



HighWire Press) or expand folders in which content has been automatically categorized (e.g., Institute of Physics Electronic Journals). In others, they can dynamically interact with two-dimensional visualizations of content to explore topics and their associated articles, or other information resources (e.g., *Astronomy and Astrophysics* SOM Index, AquaBrowser, Concept Space, *D-Lib Magazine* index, HighWire Press). Each of these broad approaches not only provides enhanced *subject* access to their respective collections, but more importantly, offer higher levels of access that are paradoxically advanced, yet intuitive. Such *conceptual* access enables users to perform not only standard subject searching and browsing, but more significantly, allows them to dynamically navigate the semantic space of related or associated terms and phrases for a given subject, a feature and functionality unavailable in print journals, and uncommon in most digital collections.

FIGURE 20. In *AquaBrowser*, upon selecting an item from the search results displayed in a left-side frame (e.g., 'eBMJ–Ramsay et al. 319 (7210):630'), the associated full text document is displayed in a right-hand frame.



"A PICTURE IS WORTH A THOUSAND WORDS"

Visual Interfaces

The first International Workshop on "Visual Interfaces to Digital Libraries" was held on June 28, 2001, in Roanoke, Virginia, at the inaugural ACM/IEEE Joint Conference on Digital Libraries. This one-day workshop attracted an international audience of 37 researchers, practitioners, and graduate students with interests in information visualization, digital libraries, human-computer interaction, library and information science, computer science, and geography.

The primary aim of the workshop was to raise awareness of several interconnected fields of research related to the design and use of visual interfaces for digital libraries.[49]As noted in a workshop report, good visualizations can:

- reduce visual research time;
- provide a better understanding of complex data sets;
- reveal otherwise unnoticed relationships;
- offer multiple perspectives on datasets; and
- convey information effectively.[50]

Information Visualization

Information visualization may be defined as "the use of computer-supported interactive visual representation of abstract data to amplify cognition. Its purpose is not the pictures themselves, but insight. . . . Information visualization is part of the new media made possible by the development of the real-time visual computer."[51] Such a medium can potentially expedite the search for information, enhance the recognition of patterns, and enable the use of "perceptual inference and perceptual monitoring." In addition, the medium itself can facilitate information interaction and manipulation.[52] Succinctly stated, "information visualization is a highly efficient way for the mind to directly perceive data and discover knowledge and insight from it."[53]

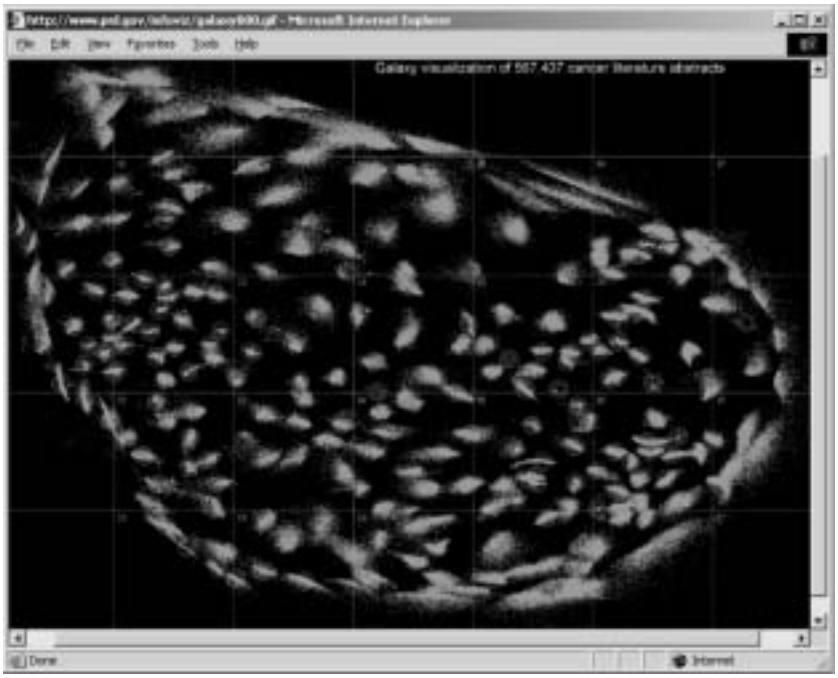
SPIRE™

One of the major research centers in the United States involved with the development and application of information visualization technologies is the Pacific Northwest National Laboratory (PNNL) based in Richland, Washington. Among its notable projects is SPIRE™–the Spatial Paradigm for Information and Exploration, a suite of information visualization tools intended to help users "explore a large number of textual documents with an intuitive spatial metaphor."[54] Of the varied SPIRE technologies (www.pnl.gov/infoviz/spire/spire.html), Galaxies and ThemeView™ are particularly noteworthy.[55]

The Galaxies visualization (www.pnl.gov/infoviz/spire/spirehelp/pages/visualizations_galaxies.html) "uses the image of stars in the night sky to represent a set of documents. [In this presentation], [e]ach document is represented by a single 'docustar.' [Documents that are closely related] . . . cluster together, while unrelated documents are separated by large distances. [In Galaxies], [s]everal analytical tools are provided . . . [that] allow users to investigate . . . document groupings, query the document contents, and investigate time-based trends" (see Figure 21).[56]

In the ThemeView™ visualization (formerly ThemeScape™) (www.pnl.gov/infoviz/spire/spirehelp/pages/visualizations_themeview.html), "the topics or themes within a set of documents are shown as a relief map of natural ter-

FIGURE 21. A Galaxies visualization of more than a half-million cancer literature abstracts.



rain. The mountains in the ThemeView indicate dominant themes. The height of the peaks indicates the relative strengths of the topics in the document set. Similar themes appear close together, while unrelated themes are separated by larger distances. ThemeView provides a visual overview of the major topics contained in a set of documents" (see Figure 22).[57] Concisely described, a ThemeView visualization is

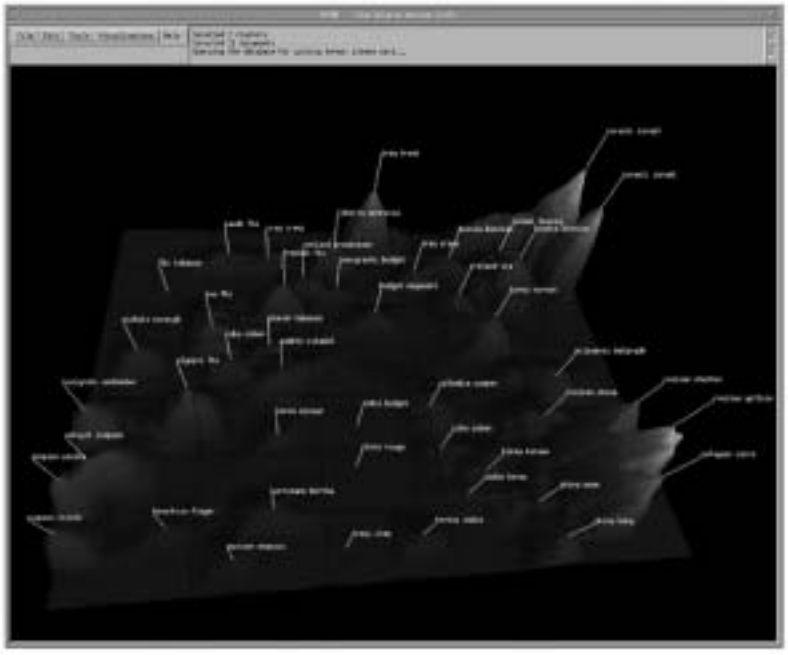
> a 3-D feature map that shows where major concepts and themes are located in . . . [a] database. Through a simple image, ThemeView visualizations can summarize the contents of an entire database, identify where major concepts are located, and detail the interrelationships between them. Combined with the thematic query tool, a ThemeView display becomes both a visual and interactive approach to exploring database contents.[58]

THE FUTURE IS NOW!

Although only a select number of electronic journal collections currently offer innovative and novel interfaces, one can expect that such enhancements will soon become commonplace as digital collections become larger and more complex, and the need for advanced navigation features and functionalities becomes more widely recognized. Likewise, as computer processing and communication technologies continue to improve, one can predict that two-dimensional visualized e-journal interfaces in time will be superseded by three-dimensional interfaces such as those offered by ThemeView, and similar technologies.[59, 60, 61, 62, 63]

One could envision, for example, the next-generation HighWire Press TopicMap as a TopicLandscape. In such a ThemeView transformation, broad and general topics and lower-level subtopics would be presented as labeled peaks, plateaus, and valleys, permitting a user to readily identify and navigate

FIGURE 22. A ThemeView visualization depicting major and minor themes and topics and their relationships as peaks, plateaus, and valleys within a sample document corpus.



the dominant and subordinate themes for an entire digital corpus, or one of its sectors. Within this digital landscape, a user could easily browse related topics or directly retrieve documents of interest, at any level. As an adjunct, or separately, a Citation Galaxy or Citation ContourMap would permit the user to navigate key and related citations for a specific topic in two or three dimensions, and then subsequently display the associated full-text articles within a right-hand frame, or a separate window. While such functionalities and features are not currently offered by HighWire Press, or other e-journal vendors, it is not unreasonable to believe that such New Age Navigation could emerge as the next-generation interface for e-collections in the not-too-distant future.

NOTES

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- Figure 3: *D-Lib Magazine* and the Corporation for National Research Initiatives (CNRI);
- Figures 4 and 5: Soizick Lesteven, Computer Engineer, Centre de Données Astronomiques de Strasbourg (CDS) (Images copyright CDS);
- Figure 6: Lucy Pearce, Senior Product Manager, Institute of Physics Publishing;
- Figures 7 through 14: John Sack, Director HighWire Press®, Stanford University;
- Figures 15 through 18: Helen Edwards, Head of Information Services, London School of Business Library;
- Figures 19 and 20: Yangkie Kwee, Project Manager, MediaLab, B.V., the Netherlands;
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