Progress toward digital libraries: Augmentation through integration

Guest Editor's Introduction
By Gary Marchionini and Edward A. Fox

"Hey, you librarian people, etc., the producers of your information, that world's going to change a lot with the computerization of its generation. And the world of your users is going to change a lot. And you can't sit there in the middle of that thinking you're going to just be monitoring the same kind of freight and storage as you used to." – Douglas Englebart reflecting on a paper he presented in 1959

In his first professional paper, even before 1960, Douglas Englebart spoke to the theme quoted above. Today, this insight applies even more strongly, as groups outside the library and information science community play increasingly important roles in developing digital libraries (DL). This special issue presents a collection of papers that illustrate the diversity of problems that DL research addresses and suggests that an integrated view is necessary to deal with the challenges of change predicted by Engelbart 40 years ago.

The field of digital libraries deals with augmenting human civilization through the application of digital technology to the information problems addressed by institutions such as libraries, archives, museums, schools, publishers, and other information agencies. Work on digital libraries focuses on integrating services and better serving human needs, through holistic treatment irrespective of interface, location, time, language and system. Although substantial collections may be created solely for the use of individuals, we consider sharable resources one of the defining characteristics of libraries. Libraries connect people and information; digital libraries amplify and augment these connections. Considerable progress has been made on specific problems related to DLs, and we argue that the potential of DLs to augment the collective intelligence is dependent on uniting diverse perspectives and results related to such connections.

Digital library work occurs in the context of a complex design space shaped by four dimensions: community, technology, services, and content (see Figure 1).
- Because information is a basic human need, and libraries have evolved into an important institution to help communities of humans communicate in spite of differences in time and space, one key dimension of the design space is labeled "community" and reflects social, economic, political, legal, and cultural issues. This dimension includes the needs, information-seeking behaviors, and attitudes of the individuals within a community. This dimension is exceedingly complex and has to date received the least amount of attention.
- Technology serves as an engine pushing the field, leading to continual shifts in solutions that coalesce around what is necessary, desirable, and feasible. DL researchers have leveraged technical progress in networking, storage and retrieval, multimedia representation, and user interface design to link people to DLs and DLs to each other.
- Services reflect the functionality afforded by systems serving the community of users. Access services that facilitate search and browsing have been central to DL research thus far, but there is great need for attention to reference and question answering, on-demand help and fostering of citizenship and literacy, and mechanisms to simplify participatory involvement of user communities (e.g., contributions of time and materials).
- Content is often what one thinks of first in a library – books, journals, maps, art, music, and innumerable other forms and genres of expression that may have representations either outside computers, inside them, or in both versions. DL research has made good advances in digitization and representing content, and considerable work is underway to leverage metadata to transparently connect people to content in different DLs.

To date, DL researchers have mainly addressed problems on one or two specific dimensions in order to develop building blocks for an integrated DL vision. Our perception is that progress along these dimensions is uneven, mainly driven by work in technology and content with research and development related to services and especially community lagging. Figure 1 depicts these dimensions with points added
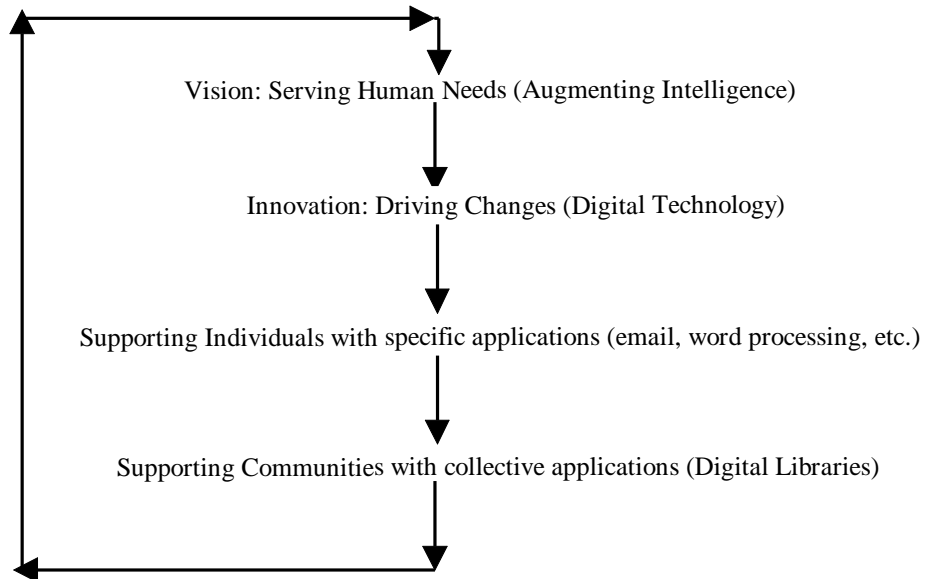
on each to represent research and development progress. Note that the overall "shape" of the DL design space today (the region defined by the dotted lines) is non-symmetrical, stretched further toward the technical and content dimensions. We will surely see continued progress along each of these dimensions, with good examples included in this volume. As the design space continues to evolve and hopefully gains more symmetry, an integrated vision of DLs will emerge that amplifies current capabilities and creates new capabilities—augments the collective intelligence.

Figure 1. Digital Library Design Space Dimensions

Community

Technology

Services

Content
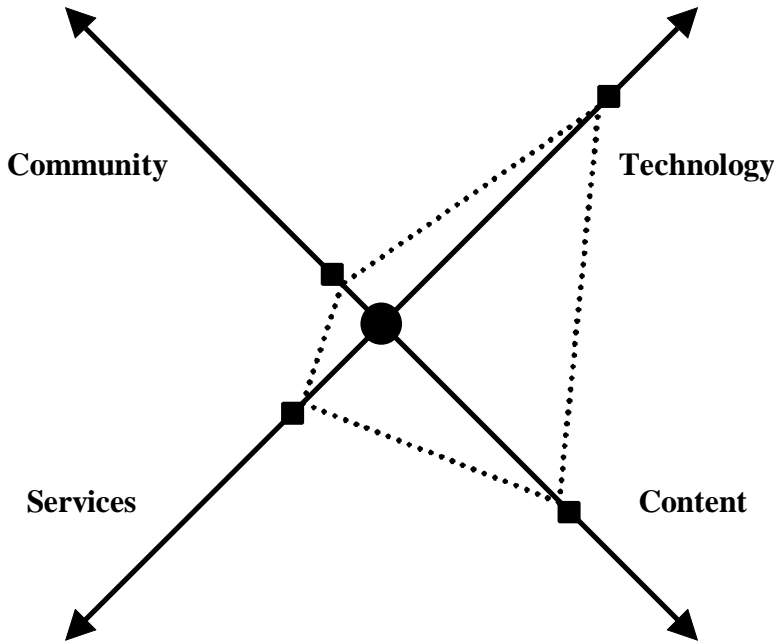
In studying DLs we see process and evolution, not just a static picture. Each aspect of work on digital libraries influences other efforts as part of a rich interplay of activities. We summarize some of the main phases in Figure 2, noting that the overall situation is an iterative one, because of both external changes and internal forces to support quality improvement and customization. The figure denotes a process of innovation that is rooted in human needs and stimulated by visions of how those needs may be met. Innovations are first applied locally to individual or particular needs and then applied to collective needs. In the figure, the instantiation of the general process to the particular case of DLs is represented by parenthicals.

Figure 2. Cycle of Human Augmentation

Vision: Serving Human Needs (Augmenting Intelligence)

Innovation: Driving Changes (Digital Technology)

Supporting Individuals with specific applications (email, word processing, etc.)

Supporting Communities with collective applications (Digital Libraries)

A good beginning for DLs as innovations is the basic need of individuals for information. This can be coupled with visionary statements (e.g., Englebart, 1963; Licklider, 1965) that motivate work that serves those human needs, especially augmenting intelligence and information processing capabilities. Throughout human history, technical innovations have been based on the science knowledge base of the time and designed iteratively to solve various needs. Digital technology is a prime example of the second half of the twentieth century.

Given need and vision, and bolstered by the driving or supporting force of technological innovation, digital library researchers first targeted supporting individual needs with a range of specific applications (e.g., search engines based on pre-computed indexes, client/server networking architectures, email feedback, etc). While much work of this nature is still proceeding, other efforts have emerged that more broadly address the "community" dimension discussed above. Collaboration technology helps enable collective applications through integrated digital libraries (e.g., collaborative search and filtering, multicast networking, shared digital spaces, chat rooms, etc.). These emerging solutions greatly enhance human capabilities to connect to each other and to shared information resources. They enable "shariums" where people not only collaborate to help solve information problems but also leverage technology to go beyond the severe limitations of physical libraries to encourage and facilitate contributions of information objects (e.g., books must be cataloged, stored, and preserved)—digital library patrons can play important roles as contributors, librarians, and curators rather than only borrowers (Marchionini, 1998). This is one example of how integrated view of DLs can enable new types of services.

In one sense, digital libraries fit in the same world as information retrieval systems, hypertext systems, and database systems. Yet, it may be more accurate to consider digital libraries as "middleware", although certain instantiations may be complete down to the lowest levels of computing and communication technologies, or up to the highest level of direct interaction with users. Certainly, digital libraries play more of an integrative role than other information systems, even those handling multimedia collections. One might consider digital libraries as "super information systems", charged with "pushing the envelope" to focus on a unified and activity-supportive treatment of user needs. Today, it is sometimes necessary to add an extra layer to accomplish a least-common-denominator level of integration, implicit in the phrase "virtual library". In the future, as suggested by the papers in this issues, we can do much better.

The papers in this special issue fall into three categories. First, there is an opinion piece by Christine Borgman, one of the first library and information science experts to actively promote work on digital libraries, followed by a Delphi study of DL experts' opinions about DL issues. These two articles fit into our first category, invited papers discussing history and activities in the field. Second, there are three papers describing detailed studies about understanding users. Third, five papers deal with extensions beyond traditional libraries, including those enabled by new technologies as well as required by the distributed and multilingual nature of the worldwide scholarly community. We explore each of these categories and the related papers in more detail below.

History and Activities about Digital Libraries

Christine Borgman's opinion piece sets the stage for understanding the complexity of DL research and development by explicating two distinct definitions for DLs. She argues that one community, adopting the technical view, focuses on content and technical infrastructure and thus creates definitions and research agendas that build upon database and networking techniques. In contrast, library practitioners begin with managing large-scale operations that serve communities of interest. Borgman bolsters her case with language from important documents in the short history of DLs. These competing perspectives cause disorientation and tension in the early stages but promise to yield richer and more robust understandings and implementations if we can work to integrate these diverse approaches.

Thomas Kochtanek and Karen Hein provide a report on a Delphi study undertaken to identify opinions on issues related to digital libraries such as definitions, the roles of groups and individuals, usage fees, and relationships between physical and digital libraries. The results demonstrate the strong opinions on issues such as user fees, a client-centered orientation on the part of respondents, and a practical consensus that

digital libraries will impact physical library staff and services. After this piece, this issue moves into a set of eight detailed studies in two key areas.

Understanding Digital Library Users

Three papers cover a range of studies, from using journal articles, to working with a focused digital library collection, to supporting university researchers. These papers advance our understanding of human information-seeking behavior as a socially-dependent phenomenon and link results to practical issues of designing DL services and systems.

Ann Bishop pushes the envelope of information behavior research to consider not only how scholars access journal articles but how they interpret, extract, and apply information in those articles to produce new scholarly works. Bishop's work is an excellent example of advancing DL research by integrating the fruits of technical development with empirical studies of how people make use of the system to advance their personal and professional agendas. The DeLIver system leverages SGML markup to augment traditional electronic retrieval so that information seekers can search on and for specific document components such as affiliations, captions, and citing as well as cited works. By studying how scholars use this system, a more fine-grained assessment of how ideas are stimulated and flow across scholarly communities is possible. Bishop notes how expertise influences which components are used (seasoned scholars are able to work at coarser levels such as tables of contents while graduate students work at detailed text levels). She traces how specific components retrieved influences thinking, are adapted to existing knowledge structures, and are used in the production of new documents.

Robert Downs and Edward Friedman provide results from a phased set of studies that first investigated user needs as a basis for making specification before creating the system, and then evaluated that system within this human-centered framework. A field study in a special collection of scholarly material led to a coarse model of information seeking that included query composition, index processing, and contextual searching as key phases. Based upon the case study, literature review, and system feature review, system specifications were written and a small digital library was created of the full text of twenty-eight books from a special collection. Downs and Friedman discuss the importance of working within the scholarly community to encourage participation in the evaluation effort, reinforcing the contextual nature of DL research and development. Their results show two distinct learning styles, minimalists who only use features included in tutorial training and progressive learners who continue to learn new features as they apply the system. Their experiences reinforce design guidelines from related research such as the importance of highlighting query terms in texts and providing both searchable text and bit map page displays.

Lisa Covi presents the results of extensive interviews with scholars in four disparate fields to determine how they use print and electronic information resources to do their research. She describes mastery material skills as situated in communities of practice and illustrates the importance of considering context in DL design. She characterizes the different search strategies, materials selection skills, and field integration skills used by researchers in molecular biology, sociology, computer science, and literary theory. This framework reinforces the importance of understanding communities when designing DLs.

Extending and Integrating through Digital Libraries

Five papers cover a broad range of extensions beyond traditional digital library services. Two deal with distributed situations, including multi-level searching that integrates across DLs. One deals with multilingual concerns, another with multimedia (digital video), and another with visualization. Thus, these papers integrate across:
- disciplines
- institutions
- cultures and languages
- different digital libraries, and
- senses and representations.

Charles Viles and James French address the problem of searching across many different DLs. They develop the concept of content locality to describe the degree to which similar documents appear in different DLs. They provide two metrics for assessing content locality and report results from experiments in two DL settings. Their work provides a technical approach to filtering and possibly weighting the spectrum of DLs available to best meet the needs of information seekers.

Mark Chignell, Jacek Gwizdka, and Richard Bodner provide another attack on the problem of picking the right DLs to include in a search. They report results from two experimental comparisons of WWW search engines based on automated relevance assessments by a panel of other search engines. They use a variety of dependent measures of effectiveness, including: query processing time, number of broken links per result set, number of duplicate links per result set, four types of retrieval precision, differential ranking within first 20 hits, search length (number of non-relevant documents before a given number of relevant are found), and several qualitative hit counts. DL developers will find this a good set of potential measures for evaluating their systems as well as for developing meta-search engine design.

Douglas Oard and Philip Resnik address the growing problem of searching multilingual DLs by providing automatic gloss translations that allow searchers to quickly obtain the gist of documents in different languages. They present results from an experiment comparing performance of people categorizing business ads in English or in Japanese with English glosses. They found that subjects using the gloss translations performed somewhat more poorly than those using the English statements, but much better than an automated classifier and random assignment. These results are promising for DLs as global collections and users increasingly share common infrastructure.

John Gauch, Susan Gauch, Sylvain Bouix, and Xiaolan Zhu present a digital video library system (VISION) that digitizes, compresses, and automatically indexes news broadcast video using off-the-shelf hardware. An integrated approach to video segmentation combines brightness, pixel changes across frames, and color distributions across frames. The indexing is based on closed-caption text and a graphical user interface allows users to specify queries and efficiently view segments at different bandwidth settings. Experimental testing demonstrates the effectiveness of using video, audio and close-captioning in an integrated fashion. Most importantly, VISION is an operational system that will continue to evolve and provide DL developers with options for including video data for broader communities with diverse bandwidth capabilities.

Chaomei Chen presents powerful visualizations of information spaces that are meant to aid people in exploring concepts and seeing connections in DLs. Using latent semantic indexing to develop a similarity matrix and pathfinder scaling techniques to cluster documents, VMRL renderings are produced. Based upon a primitive set of mappings (e.g., sphere color maps onto source or year, radius onto size, etc.) these models can be actively explored by users. Several examples related to the hypertext and human-computer interaction literature are provided for specific document collections. Co-citation maps also are presented for the collections to demonstrate the visualization possibilities.

Conclusions

Digital libraries are moving into a second phase in their speedy evolution. The nine papers in this issue serve as a recap of some of the best work in the first phase of growth, and provide a glimpse of what accomplishment is likely in the future. We see keen interest in, development of methods for, and analysis of results from, studies of digital library users. Understanding the use of digital libraries, even to a small degree, is crucial for moving to better treatment of user needs. Understanding the potential of new technologies, and exploring how these can lead to new services also helps us move forward to extend the envelope of digital library capabilities. DL research and development is challenging because it inevitably must deal with all dimensions of the design space. Progress is marked by advances along each of these dimensions—pushing the envelope on communication, technology, services, and content—work exemplified by the papers in this issue.

Realizing the larger vision of DLs will eventuate from the integrated effects of these different dimensional advances. This is where augmentation of the collective intelligence lies. Advances on each dimension

yield faster and better capabilities—what we might consider amplifications. Augmentation—new capabilities that empower new kinds of human performance and creativity will result from the combined effects of these various amplifications. We offer this issue as a collection of exemplars of work that pushes the envelope of the DL design space and look forward to implementations that build upon these research efforts to realize the vision of serving human needs for information and communication.

References

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