Physical Environments for Digital Libraries: Supporting In-Situ Collaborative Work and Large Format Materials Using Interactive Surfaces

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ABSTRACT
Digital libraries build on a long history of interdisciplinary research combing the fields of libraries and digital technologies. Ironically, many digital libraries today are still narrowly focused on remote access using traditional desktop environments, and largely unconnected with physical libraries. The Interaction Group Laboratory in the School of Information at The University of Texas at Austin is working on improving the integration of digital and physical libraries. This paper reports on four projects that aim at improving the support for people conducting collaborative work and using digital libraries in-situ within a physical library context. The paper reflects about the overall lessons learned throughout these projects, and outlines a research agenda for tackling the major remaining challenges for integrated libraries.

Categories and Subject Descriptors
H.3.7 [Information Storage and Retrieval]: Digital Libraries – systems issues, user issues.

General Terms
Design, Experimentation, Human Factors, Standardization.

Keywords
Digital libraries interfaces, large format materials, in-situ collaborative work.

1. INTRODUCTION
Digital systems and libraries have been closely associated for a long time. During this time, the field evolved from focusing on automating libraries, to improving access by presenting and delivering information online, to providing services, to supporting users in various contexts.

Initially the focus of the field was on catalogs, which were the primary way for people to access library contents [3]. By the 1950s there was a variety of developmental and commercial computer systems specifically designed for libraries [22]. As time went by, researchers increasingly expanded their focus to include more aspects. During the 1960s and 1970s library automation systems were developed that focused on backend tasks such as acquisition and circulation such as Online Public Access Catalogs (OPAC) [3]. These developments continued during the 1980s. By the 1990s the term “digital library had stuck as the term to use for this field” [12 pg. 24]. The fields of networking, hypertext, information retrieval, and human-computer interaction had developed considerably and influenced digital libraries to expand its focus from backend functionality to frontend library aspects such as delivery and presentation of information. Internet and the Web drove the research to focus on remote access, federated resources, and larger and more diverse user communities [21]. During this time, much of the digital libraries research delved around technical and content aspects [14]. However, the field of computer supported cooperative work brought into focus concepts such as collaboration and social interactions [9, 20, 31]. These aspects were emphasized during the 2000s along with an increased focus on mobile devices [2, 6, 7, 33], curation and preservation [30], and contextualization [27].

The long-standing connection between digital systems and libraries has produced valuable solutions for library tasks that range from automatic index search [22] and digital catalogs [3] to automatic metadata generation [24], browsing support [10], and recommendation services [14]. Ironically, in spite of the clear and significant relationship between digital systems and libraries, digital libraries have been often considered as separate from physical libraries.

While modern library institutions have both digital and physical presence, it is only recently that the field is explicitly addressing the need to better integrate digital and physical libraries. This paper builds on the view that digital and physical libraries complement each other. It investigates the idea of working in-situ (in physical spaces at the library) using specialized digital technologies, specifically large interactive surfaces that support collaborative work and large-format materials.

The paper is structured as follows. Section 2 sets the context and discusses the related work. The next section discusses the work conducted by Interaction Group Laboratory. It presents four projects and explains how they contribute to integrating digital and physical libraries. The following section summarizes the lessons learned from these projects and outlines a research agenda based on the remaining challenges. The final section rounds up the discussion by presenting the conclusions.

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2. MOTIVATION AND RELATED WORK

Digital libraries are complex socio-technical systems [5] that require investigating both people and systems. On one hand it is vital to understand the various stakeholders, which vary across many dimensions and change constantly [1]. On the other hand, it is critical to solve the enabling technical challenges. This duality has made the research on digital library multidisciplinary and integrative. In face of this, it is ironic that physical and digital libraries are still not integrated.

A contributing factor to the poor integration is the gap between the real world interactions and the computer representations. Pierre Wellner's Digital Desk provided an early view of a seamless integration between physical office tools such as pens and paper with virtual environments [19, 32]. Research areas such as augmented reality and ubiquitous computing look into bridging this gap. Augmented reality investigates how to use everyday objects to interact with digital objects [25], and proposes three approaches: augmenting the users, augmenting the objects, and augmenting the environment. Ubiquitous computing explores the integration of digital media and computation within a given environment. For example, Reilly et al explore the augmentation of paper maps with location-specific information accessible via handheld computers [28]. An important insight offered by augmented reality and ubiquitous computing is that people will configure (and re-configure) their space and tools according to their specific situation [4].

Another factor contributing to low integration between digital and physical libraries is the difficulty in creating and organizing links between the physical and digital objects. Grønbæk et al explore this aspect from the perspectives of geo-spatial hypermedia [18] and physical hypermedia [17]. Geo-spatial hypermedia focuses on modeling and linking real world buildings and landscapes with hypermedia information. Physical hypertext focuses on the more general issue of organizing materials in mixed digital and physical environments. Incorporating these insights, Furuta et al. focus on supporting this connection within digital libraries [13], recognizing that physical objects are in many cases the basis for scholarship and therefore digital libraries must provide users with a way to interact with them (or at least with a representation). More recently, researchers have started to explicitly focus on the issue of integrating physical and digital libraries. For example, Buchanan explores the connection between workspace provided by physical libraries and the services supported by digital libraries [8]. Specifically, Buchanan addresses three challenges: creating a context-aware infrastructure, adapting the library software architectures, and designing the interaction with a mixed media library.

Bridging the physical and digital environments often requires specialized systems. Some library resources such as large-format materials like maps and works of art are simply not well appreciated when scaled down, and they require some specialized interfaces. At the same time, many informational tasks also require specialized systems and environments. For example, when making group decisions, users often require very large displays that support collaboration. Desktop interfaces do not match these scenarios. Digital libraries need to move beyond traditional desktop interfaces.

Gerken et al. proposed a ‘blended library’ in which physical libraries provide a place that merges physical and digital interactions using ubiquitous computing technologies such as handheld devices, public walls, and group tables [15]. Interactive

large surfaces are conducive for in-situ collaborative work and group interactions [29, 26]. Interactive tabletop displays support face-to-face interactions that are particularly well-suited for small groups and decision making tasks. Large public walls support shoulder-to-shoulder interactions, are well-suited for larger groups and presentations, and are more suitable for reading and analyzing large format resources like maps and works of art. Furthermore, interactive surface can be augmented to support both: interacting with digital objects using physical objects and managing the links between physical objects and their digital representations. For example, Grammenos et al. discuss an augmented reality approach that uses pieces of paper as personal, location-aware, interactive screens in addition to a large interactive table [16].

The separation between physical and digital interactions is diminishing, as library researchers are increasingly working on integrating and blurring the seams between them. However, the diversity of users, activities and resources create many different interaction points, making it necessary to address multiple challenges. The following section present several projects that address some of these challenges by designing, building and evaluating custom-made interactive surfaces and handheld applications for digital libraries.

3. INTERACTIVE SURFACES

The Interaction Group Laboratory (IGLoo) in the School of Information at The University of Texas at Austin is investigating how people interact with and use information purposely and intensively. IGLoo researchers are conducting several projects focusing on supporting people who need to interact with digital libraries in situ at specific physical locations.

Promoting student involvement and participation is a key objective of the IGLoo. IGLoo researchers include both faculty and graduate students. Some projects include grant-funded, independent research, and course projects. Students in the course worked intensively in the IGLoo for one semester, reading and discussing relevant literature, designing and testing alternative prototypes, building custom-made interactive walls, kiosks, and tables and evaluating the final systems.

The following subsections discussed a selected set of projects designed to support activities such as browsing aggregated social media about social events, discussing and analyzing making group decisions, and teaching cooperative play and sharing skills. The final subsection discusses a research project external the IGLoo about improving the mobile interfaces for digital libraries.¹

3.1 On Location Access to Aggregate Event Information

The prevalence of social media in the modern facilitates the creation and aggregation of large corpora of information. For example, people attending social events like musical festivals or public protests read and create many entries in formats that vary from tweets, to comments, to emails, to reports and stories. The relevance of these materials is time-dependent and location-dependent. Supporting the access and presentation to such collections is the focus of Timeline Interactive Multimedia Experience (TIME) [11].

¹ While the project was external to the IGLoo activities, the researchers included members of the IGLoo. This type of collaboration has been very valuable and influential for the research activities in the IGLoo.
While journalists and historians might be interested to access the information about a musical festival remotely and after a long time, many attendants will be more interested in having in-situ access. Crow et al. explore this by designing and building a multitouch information kiosk that allows users to access and manipulate the tweet, videos or articles about a music festival. Figure 1 shows the TIME kiosk.

NHS was designed based on the concept of food deserts, which represent geographic areas that lack healthy eating choices. The system was designed as a large multitouch interactive table with a gestural interface. It uses Google maps in order to retrieve relevant environmental factors like grocery stores, fast food restaurants, convenience stores, liquor stores, and parks/green spaces, etc. It computes a health index based on the frequency and distance of the environmental facts to a user-defined location. Figure 2 shows Neighborhood Health Score.

This work required considering aspects ranging from the actual design of the kiosk, to the type of interactions and number of users, to the gesture vocabulary, to the actual software interface. The project identified several requirements for browsing aggregated social media and for on-location digital library systems including:

- Browsing aggregated social media information requires providing clear representation of the flow of the information.
- On-location (in-situ) digital library systems need to support contextualized interactions and activities (for example making plans and navigating crowded surrounding).

3.2 Urban Planning and Community Health Information Visualization

The Neighborhood Health Score (NHS) project studied the effectiveness of using large interactive tables for supporting collaborative work with geographic information in the context of urban planning and public health. It was conducted by Natalie Hill, Misha Sra and Yi Xu under the advisement to the author. NHS helps urban planners and community leaders to: assess the healthiness of neighborhoods, identify relevant factors that affect it, contemplate alternatives, and make plans and decisions.

NHS faced some of the same challenges that researchers must address when designing tabletop applications. NHS is designed such that users gather around the table and had face-to-face discussions. However, Google maps have an implicit top and down. As a result one side of the table always has an upside-down view of the text. This highlights the need to consider proper proxemics and design omni-directional interfaces.

3.3 Computer Supported Collaborative Play

The Shared Storytelling Spaces (STORYTELLING) is a project that investigates how to support early childhood education and development. It was conducted by Daniel Hill, Daniel Acevedo, Ana Carmona, and Bhavna Verma under the advisement to the author. STORYTELLING focuses on teaching and supporting cooperative play and sharing skills.

STORYTELLING portrays a fairytale scenario where two children needed to collaborate, negotiate and share the virtual space to complete a set of tasks. STORYTELLING is designed to promote and develop cooperation skills. It proposes the use of two interactive surfaces, one horizontal and one vertical. The two surfaces have different affordances and constraints both physically and software-wise. The vertical surface is multitouch and the table uses fiducials. The surfaces are placed apart but in
the same room and within talking distance. This setup and the application design induce the players communicate in order to accomplish their task. Figure 3 shows STORYTELLING (the monitor is placed for demonstration purposes only as the system is actually designed to use a 6 by 3.5 feet interactive wall).

In-situ interactions with digital libraries often rely on augmenting the environment where these activities are carried on. This includes devising specialized ubiquitous information technologies (such as interactive surfaces) that support contextualized activities. Custom-built ubiquitous information technologies based on interactive surfaces provide an excellent platform for supporting in-situ collaborative work with small groups.

The design space for in-situ digital libraries is very large. Designers must consider many variables including number, size and position of the screens, support for different interactions methods (e.g., multitouch, tangible, or keyboard), configuration, shape and size of the augmented space, etc. Furthermore, the design of augmented library environments must consider that people will configure (and reconfigure) their space and tools according to their specific (and changing) situation [4].

4.1 Persisting Challenges
Research fields such as digital libraries, human-computer interaction, ubiquitous computing, and computer-supported cooperative work (among others) provide very valuable insights for developing integrated digital libraries. At the same time, a review of the previous research reveals a number of significant challenges, including:

- Using physical objects in order to interact with digital objects
- Creating and managing the links between physical objects and their digital representations

Furthermore, by reflecting and summarizing the lessons learned from the multiple projects conducted in the IGLoo, it is evident that the field needs to address several major challenges including the following:

4.1.1 Support Individual and Group Interactions and Transitions
An intrinsic mission of libraries is to support their users. Increasingly this implies extending their ability to support individual interactions (such as searching and reading) and group activities (such as discussing and analyzing). Furthermore, this also implies supporting the transitions between individual and group interactions. Furthermore, it is important to identify and study the set of interaction patterns that most libraries need to support.

4.1.2 Contextualized Activities Specific to Libraries
What is it that people try to accomplish in a digital library? Often, the answer is “many things”. As a result, it is necessary to keep expanding the support for multiple contexts and goals. At the same time, it is important to identify and study the set of contextualized activities that most libraries need to support. Furthermore, it is important to investigate how to integrate all of them into a coherent whole.

4.1.3 Standardize Specialized Interfaces
This is a difficult goal. The integration of digital and physical libraries demands a great diversity of interfaces that match the varying contexts of use (such as individual, group, or alternating) and also match the affordances of constraints of the resources (such as large-format materials like maps and works of art). This increasing diversity is challenging (for example, even today there
is not a well-standardized vocabulary for multitouch gesture interactions). It is important to devise a way for supporting the increasing variety of interfaces and custom-built information technologies without taxing users by making them learn to use each of them independently.

4.1.4 Standardize Evaluation Metrics
Digital libraries have often been evaluated as Web systems using metrics such as session length [23]. As physical and digital libraries get increasingly more integrated, these evaluation metrics become less meaningful as they leave unanswered many significant aspects. This is particularly clear in the case of in-situ digital libraries. It is critical to develop new metrics.

5. CONCLUSIONS
Digital and physical libraries can have a complementary and synergistic relationship. This often requires designing and building specialized systems that support users to use digital libraries in-situ. An important area that in-situ digital libraries must support is small group collaborative work. However, different activities require different interaction support (such as tables, walls, or combinations). Libraries can benefit users different activities require different interaction support (such as tables, walls, or combinations). Libraries can benefit users significantly by providing them with specialized solutions and custom-built information technologies that match the affordances and constraints of the resources and provide better task support.

Several challenges remain, including: enhancing the support for individual and group interactions and the transitions in between, identifying the most significant set of contextualized activities specific to libraries and determining their most important characteristics; developing standards for specialized interfaces, and evaluation metrics.

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7. REFERENCES


