Preface

Different aspects of context are essential for the understanding of information seeking and retrieving (Cool & Spink, 2002). The emergence of the Internet has created a variety of digital environments, permitting millions of users to search for information by themselves from anywhere in the world and at any time of day or night. On the one hand, users have diverse backgrounds with different levels of knowledge and skills; they also have different tasks at hand when they are searching for information. On the other hand, different types of online IR systems are designed with different interfaces that focus on different collections. In digital environments, therefore, it can be a challenge for users to effectively find the information they need in order to accomplish their tasks. This preface offers background information about information seeking and retrieving in digital environments and explains why this book is needed.

Information Retrieval (IR) Systems and Different Digital Environments

Information retrieval is never an easy task. The problem with IR is that document representation, either by index terms or texts, cannot satisfy user need representation, which is dynamic and complicated. Moreover, traditional IR systems are designed

to support only one type of information-seeking strategy that users engage in: query formulation. The new digital environments redefine online IR systems in terms of their design and retrieval.

IR and IR Systems

What is information retrieval? According to Meadow, Boyce, and Kraft (1999), information retrieval has been defined as "finding some desired information in a store of information or a database" (p. 2). Selectivity is the key for information retrieval. IR is not just a system activity; instead, it is a communication process between users and the system. The central problem of information retrieval is how to match, compare, or relate users' requests for information to the information that is stored in databases. Information retrieval can also be labeled as information-seeking, information searching, and information accessing. These terms can be considered as synonyms for information retrieval although their focus might be different (Chu, 2003). Wilson (2000) defined the differences between information seeking behavior and informaiton searching behavior. *Information-seeking* refers to purposive behavior involving users' interactions with manual information systems or computer-based systems in order to satisfy their information goals. *Information-searching* behaviors refers to the mirco level of behavior when interacting with a variety of information systems. However, in the literature on IR, researchers have used these terms to represent similar concepts. In this book, information-seeking and information-searching are used interchangeably with information retrieval, following Wilson's definition as well as other researchers' expressions when their works are cited.

Information retrieval can be mainly classified into the following types:

- Subject search: look for items with common characteristics.
- Known item search: find an item when a user knows particular information about that item, such as author, title, and so forth.
- Specific information search: look for exact data or fact.
- Update information: browse to enhance the existing knowledge structure of a subject area.

What is an information retrieval system? IR systems have been developed to enable users to find relevant information stored in a database(s). The typical components of an IR system include:

- User query input mechanism
- User query analysis mechanism

- Document selection/updating mechanism
- Document analysis mechanism
- Document storage mechanism
- Matching mechanism for documents and queries
- Interface for user input and system output

Why is it so difficult to find desired information? The main problem in the field of information retrieval is that the representation of documents in a database does not match the representation of user needs. Users' anomalous state of knowledge (ASK) creates cognitive uncertainty that prohibits users from adequately expressing their information needs, and their levels of need require that they can only gradually have more focused ideas about what information they need (Belkin, 1977, 1978, 1980; Taylor, 1968). Users' information needs can only be clarified in the process of interacting with IR systems along with interacting with information stored in the systems. The dynamic process of representation of information need cannot be compared with the static representation of documents.

Online IR Systems and Different Digital Environments

The development of the Internet has brought changes to existing online IR systems, such as online public access catalogs (OPACs) and online databases; at the same time, the Internet has also given birth to new online IR systems, such as Web search engines and digital libraries. How, then, to define online IR systems? Online IR systems differ from nononline systems and have their own characteristics. Walker and Janes (1999) identified the uniqueness of online IR systems: First, online searches are conducted in real time. Users can search and obtain results almost immediately. Second, online IR systems offer remote access. Users can search at any location as long as the there is an Internet connection. The typical online IR systems can be classified into the following four types: (1) online public access catalogs (OPACs), (2) online databases, (3) World Wide Web search engines, and (4) digital libraries. What are the characteristics of these online IR systems?

OPACs contain interrelated bibliographic data of collections of a library; more importantly, they can be searched by end users. OPACs were implemented in the mid1980s when they began to replace card catalogues. OPACs became the first type of IR system built for end users, and online costs are no longer an issue (Armstrong & Large, 2001; Chu, 2003). The first generation of OPACs followed either online card catalog models, emulating the familiar card catalog, or Boolean searching models, emulating online databases, such as DIALOG or MEDLINE. Second-generation OPACs integrated these two design models and added advanced features for searching and browsing, as well as display options. Third-generation OPACs enhanced advanced search features and offered ranked retrieved results (Borgman,

1996; Hildreth, 1985, 1997). The new generation of Web OPACs allows users to access resources of libraries, publishers, and online vendors (Guha & Saraf, 2005). Today, users can access an OPAC from anywhere in the world, even from the palm of their hand. The new generation of OPACs also incorporates advanced search features and new designs from other types of IR systems, such as allowing users searching OPAC and online databases via Web OPAC interface.

Online databases began to develop in the 1960s. The first major online dial-up service was MEDLINE in 1968, and the online version of MEDLARS. In 1972, DIALOG (Lockheed) and ORBIT (SDC) offered commercial online services (Walker & Janes, 1999). The first commercial system that allows searching for full-text documents was developed in 1972 by the Data Central Corporation, the ancestor of the present LEXIS/NEXIS system (Meadow, Boyce, & Kraft, 1999). Traditional online searchers are information professionals who serve as intermediaries between users and online databases. In the 1990s, online vendors began to move their services to the World Wide Web, and as a result, end users became searchers of online databases. For the past 30 years, the online industry has experienced considerable change. The number of databases, publishers, producers, vendors, and, more important, searchers has increased dramatically. An increase of full-text databases in text databases and an increase of multimedia-oriented databases are two characteristics in recent years (Williams, 2006). New online database services pay more attention to customization, interactivity, and offering expert systems of online database services.

The creation of World Wide Web in 1991 by using a hypertext model brought millions of users to search for online information. Web search engines are the crucial tools that help users navigate on the Web. According to Nielsen//NetRatings (Sullivan, 2006), by October 2005, search queries reached more than 5.1 million. Four types of search engines have been developed to enable users to accomplish different types of tasks:

- Web directories with hierarchically organized indexes that facilitate users' browsing for information,
- Search engines with a database of sites assisting users' searching for information,
- Meta-search engines permitting users to search multiple search engines simultaneously, and
- Specialized search engines creating a database of sites for specific topic searching.

One unique aspect of Web search engines is their ranking capability for presenting the search results, which is based on the properties of term frequency, location of terms, link analysis, popularity, date of population, length, proximity of query terms, and proper nouns (Liddy, 2001). The new design of Web search engines takes into

consideration interactivity, personalization, and visualization. New "community" search engines have been developed for users to share search results among themselves. Many of the Web search engines extend their services from Web search to desktop and other types of search applications.

The emergence of digital libraries provides more opportunities for users to access a variety of information resources. There are different definitions in terms of what constitutes a digital library available in the literature. Chowdhury and Chowdhury (2003) place them into two major categories based on Borgman's (1999) discussion of competing visions of digital libraries. One approach focuses on access and retrieval of digital content; the other focuses on the collection, organization, and service aspects of digital resources. Digital libraries incorporate information retrieval systems, although they are not equivalent insofar as digital libraries provide additional services such as preservation, community building, and learning centers. It has been argued that some approaches that have been taken in IR system design and evaluation are valid for digital libraries as well (Saracevic, 2000). Pre-Web digital library efforts began at the end of the 1980s and beginning of the 1990s (Fox & Urs, 2002). The Digital Library Initiative 1 & 2, funded by the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), the National Aeronautics and Space Administration (NASA), and other agencies, play a leading role in U.S. research and development on digital libraries in terms of both their technical and their social and behavioral aspects. Digital libraries can be hosted by a variety of organizations and agencies, either for the general public or for a specific user group. Interactivity, personalization, visualization, and designing for different types of user groups are the new trends in the development of digital libraries.

Different types of IR systems in digital environments are interrelated. Online databases are named "original search engines," and current search engines are influenced by online databases (Garman, 1999). At the same time, Web search engines offer more than Web pages (Hock, 2002). Wolfram and Xie (2002) identified two IR contexts that are related to online database systems and Web search engines: traditional IR and popular IR. Traditional IR is characterized by selective content inclusion from published and unpublished sources and by more sophisticated search features. In addition, it is generally used for search topics of a nonpersonal nature. In contract, popular IR creates a context that permits easy user access to and use of a variety of full-text information resources. The popular IR context has been criticized for lacking credibility in its content and sophistication in its resource organization and retrieval. Digital libraries represent a hybrid of both traditional IR, using primarily collections similar to those provided in online databases, and popular IR, exemplified by Web search engines. Information retrieval in digital environments is strongly affected by the IR system, the user, the information, and the environments.

In addition, information retrieval experimentation is an ongoing research activity. In recent years, the Text REtrieval Conferences (TREC), sponsored by the U.S. National Institute of Standards and Technology (NIST), the U.S. Department of

Defense, the Advanced Research Projects Agency (DARPA), and the U.S. intelligence community's Advanced Research and Development Activity (ARDA) and other agencies, held every year since 1992, is a major joint effort to evaluate participants' own experiments with IR systems. More than 15 tracks had been created by 2005. Among them, the Interactive Track investigates how users interact with IR systems and how to evaluate interactive IR systems. The TREC Interactive Track creates a general framework for the investigation of interactive information retrieval, and for the evaluation and comparison of the performance of interactive IR systems (Dumais & Belkin, 2005). However, the restrictions of the setting, assigned tasks, convenience sample, data collection methods, TREC assessors, and short cycle contribute to the limitation of TREC results.

The Impact of Digital Environments and the Challenges of IR

In the past, searching for information is a privilege of information professionals. Now ordinary people become end-users. The emergence of the digital environments brings changes on IR systems, on users, information, and the environments that users interact with systems. That also poses challenges for users to effectively retrieve information to accomplish their tasks/goals.

Impact on IR Systems and the Challenges for Users

In digital environments, users have to face a variety of online IR systems. However, they are not all designed by taking into consideration of users, which hinders the effectiveness of user-system interactions (Dillon, 2004). From the system side, traditional IR is supported by the two core processes: representation and comparison. The core of information retrieval is the comparison between the representation of documents and the representation of user need (Salton & McGill, 1983; van Rijsbergen, 1979). In that sense, only one search strategy is supported: query formulation. In digital environments, term match—rather than concept match or problem match—is still a critical issue even though the search mechanism has been enhanced. IR systems in digital environments do provide a variety of browsing mechanisms for users to explore information, but the query box is still the main channel for users to express their information needs. Users are limited by the search box, and most of the searches contain only one or two terms (Jansen & Pooch, 2001). While users engage in multiple information-seeking strategies in digital environments (Fidel et al., 1999; Marchionini, 1995; Vakkari, Pennanen, & Serola, 2003; Wang, Hawk, & Tenopir, 2000), online IR systems still focus on support searching-related strategies while offering some help with browsing.

Interactivity is a fundamental characteristic of searching in digital environments. Users are able to interact with online IR systems, as well as their collection via multiple avenues. The inherent interactive nature of Web-based IR systems poses a challenge for users. While users praise the ease-of-use of interfaces of online IR systems, they are also concerned with the lack of control in interacting with these systems. The simplified design of Web search engines has been transferred to other types of IR system design. Researchers have paid more attention to ease-of-use of interface design and far less to user control. The existing online IR systems do not support both ease-of-use and user control (Xie & Cool, 2000; Xie, 2003). Accordingly, the design of online IR systems needs to be clear about user involvement and system role to facilitate user-system interaction (Bates, 1990; White & Ruthven, 2006; Xie, 2003)

All types of online IR systems have some commonalities in their design, such as a search box. However, there is no standard in the design of online IR systems. Different types of IR systems have different interface designs and different search mechanisms. Even within one type of IR system, interface design and search mechanism are not same. To make things worse, the commands for search are different in different IR systems. This has limited users' abilities to interact with these systems and their collections. In the past, users searched for information in libraries or information centers. Digital environments provide opportunities for users to search for information in their own environments, such as at home and in the work place. Their institutional/organizational work tasks or their home settings might affect their information retrieval process (Cool & Spink, 2002). Most important, while users enjoy the convenience of looking for information at any time they need, they also lose the benefits of getting help from intermediaries when they encounter problems.

Moreover, digital environments have shortened the distance between the system and user. At the same time, they also make it difficult or impossible for users to get any training. Users can only seek help from the Help function of each system. However, users rarely access Help because of the inadequate design of implicit as well as explicit Help in IR systems. In addition, users need help in every stage of their information retrieval process, but they cannot always specify their help-seeking situations or needs (Cool & Xie, 2004; Trenner, 1989; Xie & Cool, 2006). Finally, as noted by Jansen (2005), for the most part, Help mechanisms have been construed only as assistants in the query formulation process rather than as ongoing partners during the information retrieval process.

Impact on Users and the Challenges for Users

In digital environments, any human being is potentially an end user. For any given IR system in the digital environment, universal access is an objective. Users could represent diverse user groups with diverse backgrounds. They could be heterogeneous in terms of their age, language, culture, subject knowledge, system knowledge,

and information-seeking skills. One user could have no knowledge of the IR system or even have computer phobia; another could construct a complicated query and customize the system. One user could have no knowledge about what he or she is going to search while another is the expert in the area. Users could also have different types of search tasks, for example, look for fact information, look for items with common characteristics, update information, and so forth. Even though they might look for the same information, different search problems might lead them to retrieve information that requires different results to solve their problems. Users might also exhibit different types of search strategies and behaviors, for example, search, browse, and so forth. The question is how to support end users of online IR systems who have different familiarity with the system environment, different information-seeking skills, different domain knowledge, different search tasks/goals, and different information-seeking strategies. In sum, how an online IR system be designed to support the diverse needs of diverse user groups?

In digital environments, users are able to access OPACs, Web search engines, and digital libraries for different types of information. Their past experience and background affect the way they interact with different types of IR systems. They might be expert users of one type of IR system but novice users of another. They bring their individual mental models and search strategies for one type of IR system to another one (Wang, Hawk, & Tenopir, 2000). Further, the new generation of Web users expects OPACs and other types of IR systems to have the same design and features as Web search engines (Novotny, 2004; Yu & Young, 2004). Simultaneously, experienced online searchers are accustomed to traditional online databases with a certain level of search sophistication, and they are unsatisfied with the inefficiency of Web-based IR systems (van Brakel, 1997; Bates, 1997).

Another change for users has to do with their expectations. The emergence of the Internet creates an illusion that users can find all the information they need within a short time. People lose patience when searching for information. Researchers have begun to compare the similarities and differences between Web searching and traditional information retrieval. These studies have found that while Web search engines follow the basic principles of IR systems, Web users show very different patterns of searching from those found in traditional IR systems, such as online databases and OPACs. For example, most Web users did not have many queries per search session, and each query tended to be short. Boolean operators were seldom used. Many users submitted only one query and did not follow up with successive queries (Jansen & Pooch, 2001; Silverstein, Henzinger, Marais, & Moricz, 1999; Spink, Wolfram, Jansen, & Saracevic, 2001).

Impact on Information and the Challenges for Users

Traditionally, relevance has been the main concern for users when they evaluate retrieved information. Before the emergence of Internet, users had no doubt about

the authority and quality of the information retrieved from traditional IR systems. In digital environments, interaction with results has become a major component of information retrieval interaction. Users interact with results to find information to solve their problems; these results lead them to search for needed information or to find new ideas to reformulate their queries if the results fail to provide relevant information.

However, in digital environments, anyone can be a publisher of information on the Web by simply uploading documents. There is no one to review and approve the content of the information on the Web. As a result, users have to make judgments for themselves about the quality and authority of Web information. Moreover, the Web offers a different searching environment for users; it contains a variety of information in content, format, and organization (Fidel et al., 1999; Jansen, Spink, & Saracevic, 2000; Wang, Hawk, & Tenopir, 2000). When users interact with the retrieved results, they not only have to make relevance judgments but also have to make authority and quality judgments. However, users are only willing to devote a small amount of time to evaluate results. In Xie's (2006) study of users' evaluation of digital libraries and Rieh's (2002) evaluation study of the Web, most users think it is a challenge for them to make judgments about quality and authority because there is generally no quality control mechanism for the Web. Even though some IR systems do have authority control systems, users want to have a way to make their own judgments.

Another challenge for users is the overwhelming amount of information available in digital environments, which causes cognitive overload (Bilal, 2000). The problem is two-fold: on the one hand, although most IR systems try to increase the size of their collections, they only index a small portion of the available information; on the other hand, the IR algorithms were created for small and coherent collections, but the digital collections of Web-based IR systems are dynamic and diverse (Arasu, Cho, Garcia-Molina, Paepcke, & Raghavan, 2001). To make things worse, many of the electronic materials are multimedia and in different languages. The uncertainty and complexity of multimedia and cross-language IR pose more challenges for users to effectively retrieve multimedia and foreign language information, in particular in evaluating and interpreting information during their interactions with IR systems (De Vries, 2001; Downie, 2003; Gey, Kando, & Peters, 2005; Goodrum & Spink, 2001; Oard, 2001; Peters, 2005; Smeaton, 2004). In addition, electronic materials have been converted from their printed or physical formats. In the conversion process, these artifacts' content and context might be missing (Mi & Nesta, 2005).

The Need for an Interactive IR Framework

One way to deal with the challenges of IR in digital environments is to develop an interactive IR framework. According to Marchionini (1995), human existence is a

series of interactions with the environment. Interactivity is a basic human characteristic, and the complexity of modern society forces people to interact increasingly with institutions and systems. However, electronic systems are beginning to replace human as the interactants. The evolving interactions in digital environments pose more challenges and problems.

Nature of IR as Interaction

Because IR is an interactive process, uncertainty and interactiveness are the two major characteristics of information retrieval. Taylor's (1968) classic work on question negotiation proposes four levels of information need that users go through in accomplishing their information-seeking tasks. The need comes from an unformulated question based on a user's uncertainty. The significance of Taylor's work is that it postulates a particular psychological state of mind of the user that may lead to an expressed request. Wersig (1979) uses the concept of problematic situation in which knowledge and experience may be sufficient to resolve the doubt. He identifies an explicit account of precursors to information-seeking behavior based on an individual's knowledge, beliefs, and situation. Belkin's "anomalous state of knowledge" (ASK) hypothesis (1977, 1978, 1980) is an extension of Taylor's model. ASK is similar to Taylor's "visceral need" and Wersig's "problematic situation," which indicates that the user's knowledge is insufficient for dealing with a specific situation. ASK provides a framework in which the reasons that users seek information could be explicitly represented and used for information retrieval. According to Taylor's "visceral need," Wersig's "problematic situation," and Belkin's "ASK," if users are not capable of recognizing their state of knowledge/problem space, they may end up in a state of uncertainty. They need to interact with information, systems, and the environment to clarify their information problems.

Ingwersen's (1992, 1996) cognitive model, Belkin's (1996) episode model of interaction with text ,and Saracevic's (1997) stratified model are the most-cited interactive IR models; all three describe general interactive information retrieval and its major components. While Ingwersen's model focuses more on the cognitive aspect of interactive information retrieval, Belkin's model emphasizes users' interaction with text (the information-seeking process); Saracevic's model concentrates on understanding the interplay among different levels of users and systems. All three models agree: 1) information problem/need is dynamic, and it changes during the information-seeking and retrieving process; and 2) information problem/need can be clarified by interactions.

The Need for an Interactive IR Framework

These three interactive IR models create a foundation for interactive IR research in digital environments. Ingwersen and Järvelin (2005) further proposed an integrated

IS&R research framework with the model of interactive information-seeking, retrieval, and behavioral processes. However, these models only illustrate interactive IR at the macrolevel, and they cannot account for the specific process or issues that emerge in the interactive IR process, nor can they connect factors influencing IR interaction with users' information-seeking strategies or behaviors in digital environments. Most important, an interactive IR framework needs to be derived from empirical studies of different users with a variety of tasks interacting with different IR systems in digital environments. As Saracevic (1996) points out, "IR interaction is a complex process that is very much situation or context dependent: it starts from and relates to users, their tasks or problems, competencies, knowledge states and intents on the one hand, but it also involves characteristics and capabilities of the system, the information resources, and the interface, on the other hand" (p. 5). Mantovani (1996) further claims that understanding interaction is difficult, because what keeps changing in interaction are not just things in the world or things in the actor, but the very structure of their connection. In order to develop an interactive IR framework in digital environments, we need to explore user-centered approaches, characteristics of different IR digital environments, and empirical studies of interactive IR in digital environments as well as existing interactive IR models and approaches.

Overview of the Book

Objective of the Book

The objective of this book is to develop a theoretical framework for information retrieval (IR) interaction and to further discuss its implications in the design and evaluation of IR systems in the digital age. This book builds on the author's award-winning dissertation titled *Planned and Situated Aspects in Interactive IR: Patterns of User Interactive Intentions and Information Seeking Strategies* awarded by the Association for Library and Information Science Education (ALISE) in 1999. It provides an opportunity for the author to synthesize her 10 years of research and other researchers' work in this important and unique area.

Structure of the Book

This book can be divided into four sections. The first provides an overview and foundation for the book. The preface provides the background for the book and answers the question why this book is needed. Chapter I starts with the discussion of the divide between system-oriented and user-oriented approaches, and further presents a variety of user-oriented approaches that are essential for understanding interactive IR.

The second section offers an overview of various IR environments and a comprehensive review of empirical studies of interactive IR in these environments. Chapter II through Chapter V focus on interactive IR in OPAC, online database, Web search engine, and digital library environments. The overview of the IR environment presents history and background of IR systems, definitions and types of the IR systems, current developments on each type of IR systems, and the challenges to users. The review of empirical studies on interactive IR is classified by the key issues derived from empirical studies, including tasks/goals and their impact, levels of information-seeking strategies, users' knowledge structure, online Help, usability studies, evaluation of interactive IR systems, and so forth. In addition, Chapter VI summarizes the Interactive Track of TREC environment and different types of Interactive Track studies, in particular the contributions and limitations of the Interactive Track. This chapter also discusses relevant works on interactive cross-language information retrieval research mainly in the interactive track of Cross-Language Evaluation Forum (iCLEF).

The third section highlights the development of the interactive IR framework. Chapter VII reviews the macro- and micro-levels of interactive IR models developed in the field, and further discusses the strengths and limitation of these models. Chapter VIII is the heart of the book, in which the author's interactive IR framework—the planned-situational interactive IR model—is presented. The discussion of the model consists of an overview of the model, a discussion of the levels of user goals and tasks and their representations, relationships between levels of user goals and tasks, dimensions of work and search tasks, users' personal information infrastructure, the social-organizational context, IR systems, dimensions of information-seeking strategies, shifts in current search goals and information-seeking strategies, and factors affecting those shifts. Chapter IX illustrates and validates the planned-situational interactive IR model by reporting and discussing the results of a pilot of a large-scale study that focuses on the investigation of how people seek and retrieve information in their research proposal writing process.

The fourth section discusses the implications of the interactive IR framework for the design and evaluation of interactive IR systems. Chapter X discusses the theoretical and practical implications of the framework for designing and evaluating interactive IR systems, especially making suggestions for how to support multiple types of information-seeking strategies, how to balance ease-of-use and user control in terms of system role and user involvement, how to create interactive Help mechanisms, and how to develop a multidimensional evaluation framework to evaluate interactive IR systems. Finally, Chapter XI summarizes the contributions of the book, discusses future research directions, and raises questions for further research on interactive IR.

Targeted Audiences

This book is intended for researchers, designers, teachers, graduate and undergraduate students, and professionals who are interested in interactive information retrieval, IR system design, and IR system evaluation in digital environments. The theoretical framework and the comprehensive literature review on theory and practice will provide a foundation for new research on interactive information retrieval and can also serve as part of the curriculum for courses related to information retrieval and IR system design. The discussion of implications will offer guidance for designers and other professionals to design and evaluate new interactive IR systems for the general public as well as for specific user groups.

Members of the following associations would be the primary readers for the proposed book: (1) American Society for Information Science and Technology (ASIST), (2) Association for Computing Machinery (ACM), (3) Institute of Electrical and Electronics Engineers, Inc. (IEEE) Computer Society, (4) Association for Library and Information Science Education (ALISE), and (5) a variety of library associations, such as the American Library Association (ALA), Special Library Association (SLA), and so forth. The secondary audience could be researchers and practitioners from other related disciplines (e.g., psychology, communication, computer science, engineering, health, education, etc.) who are interested in interactive IR, IR system design and evaluation.

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