

Chapter I

Survey and History of Digital Library Development in the Asia Pacific

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Abstract

Over the past decade the development of digital library activities within Asia Pacific has been steadily increasing. Through a meta-analysis of the publications and content within ICADL and other major regional digital library conferences over the past few years, we see an increase in the level of activity in Asian digital library research. This reflects high continuous interest among digital library researchers and practitioners internationally. Digital library research in the Asia Pacific is uniquely positioned to help develop digital libraries of significant cultural heritage and indigenous knowledge and advance cross-cultural and cross-lingual digital library research.

Introduction

The location and provision of information services have dramatically changed over the last 10 years. There is no need to leave the home or office to locate and access information now readily available online via digital gateways furnished by a wide variety of information providers, for example, libraries, electronic publishers, businesses, organizations, and individuals. Information access is no longer restricted to what is physically available in the nearest library. It is electronically accessible from a wide variety of globally distributed information repositories.

Digital libraries represent a form of information technology in which social impact matters as much as technological advancement. It is hard to evaluate a new technology in the absence of real users and large collections. The best way to develop effective new technology is in multi-year large-scale research and development projects that use real-world electronic test-beds for actual users and aim at developing new, comprehensive, and user-friendly technologies for

Table 1. Major (Asian) digital library research and development milestones

1994	• NSF Digital Library Initiative Phase 1 (DLI-1) • The First Annual Conference on the Theory and Practice of Digital Libraries, College Station, Texas
1995	• First IEEE Advances in Digital Libraries Conference, McClean, Virginia
1996	• First ACM Conference on Digital Libraries, Bethesda, Maryland
1997	• First European Conference on Research and Advanced Technology for Digital Libraries (ECDL), Pisa, Italy
1998	• The First International Conference on Asian Digital Libraries (ICADL 1998), Hong Kong, China
1999	• President's Information Technology Advisory Committee (PITAC) Report • NSF Digital Library Initiative Phase 2 (DLI-2) • Institute of Museum and Library Services (IMLS) Program • NSF National Science, Mathematics, Engineering, and Technology Digital Library (NSDL) Program • ICADL 1999, Taipei, Taiwan
2000	• ICADL 2000, Seoul, Korea
2001	• ICADL 2001, Bangalore, India • First ACM/IEEE-CS Joint Conference on Digital Libraries (JCDL 2001), Roanoke, Virginia
2002	• ICADL 2002, Singapore
2003	• ICADL 2003, Kuala Lumpur, Malaysia
2004	• JCDL 2004, Tucson, Arizona

digital libraries. Typically, these test-bed projects also examine the broad social, economic, legal, ethical, and cross-cultural contexts and impacts of digital library research.

The NSF DLI-1, DLI-2 and NSDL Programs DLI-1, 1994-1998

The original Digital Library Initiative (DLI or DLI-1), sponsored by the NSF, DARPA, and NASA, was started in 1994. The original program announcement stated:

“The Initiative’s focus is to dramatically advance the means to collect, store, and make it available for searching, retrieval, and processing via communication networks – all in user-friendly ways. Digital libraries basically store materials in electronic format and manipulate large collections of those materials effectively. Research into digital libraries is research into network information systems, concentrating on how to develop the necessary infrastructure to effectively mass-manipulate the information on the Net. The key technical issues are how to search and display desired selections from and across large collections.”

After a competitive proposal solicitation and review process, six large-scale projects (\$4 million per project on average) were selected. Most projects were more technical in nature and led by reputable computer scientists. Each project consisted of a strong team of computer, information and library science researchers, sociologists, and content specialists (<http://www.dli2.nsf.gov/dlione/>). The DLI projects were extremely successfully and had helped build an international digital library community.

DLI-2, ITR, IMLS, and NSDL, 1999-Present

The excitement of Internet-enabled IT developments and e-commerce opportunities in the 1990s prompted the U.S. Government to examine the role of IT

research for long-term U.S. interest. A President's Information Technology Advisory Committee (PITAC) was formed, which included many leading U.S. IT researchers and practitioners. Digital library research was identified as one of the successful federal research programs and a target research area.

The success of the original DLI program and the continued IT research interest as stated in the PITAC report allowed the NSF to continue to spearhead the development of the DLI Phase 2 (DLI-2) research program:

(<http://www.dli2.nsf.gov/>).

DLI-2 funded 29 research projects, with an additional nine projects with an undergraduate emphasis:

(<http://www.dli2.nsf.gov/projects.html>).

An additional 15 projects have been funded since 1999 under the Information Technology Research (ITR) program (<http://www.dli2.nsf.gov/itrprojects.html>). Some address language (e.g., CMU's AVENUE project for adaptive voice translation for minority languages) and 3D modeling topics (e.g., Columbia's project for modeling, visualizing, and analyzing historical and archaeological sites), others research topics in law enforcement information sharing and knowledge management (e.g., University of Arizona's COPLINK agent project) and multilingual access to large spoken archives (e.g., Survivors of the Shoah Visual History Foundation, a \$7.5 million project, 2001-2006).

In addition to the core DLI-2 and related ITR projects, DLI-2 also sponsors 12 international digital library projects (<http://www.dli2.nsf.gov/intl.html>) involving partners from the U.K. (University of Liverpool, Southampton University, King's College London), Germany (University Library of Gottingen, University of Trier), China (Tsinghua University, National Taiwan University), Japan (National Institute for Informatics), and Africa (West African Research Center). Most international projects face unique logistics and collaboration challenges.

Several U.S. agencies also began to develop digital library projects that are uniquely tailored to their institution's function. For example, the Institute of Museum and Library Services (IMLS, <http://www.ims.gov/about/index.htm>), which is an independent federal agency that fosters leadership, innovation, and lifetime learning, supports a series of 130+ smaller-scale digital project grants to libraries and museums for research, digitization, and management of digital resources (http://www.ims.gov/closer/cls_po.asp), from the Brooklyn's Children's Museum to the Chicago Academy of Sciences, and from Duke University's Library to the Georgia Department of Archives and History.

Another significant digital library research program was developed concurrently under the NSF National Science, Mathematics, Engineering, and Technology Digital Library Program (NSDL, <http://www.nsdl.nsf.gov/indexx.html>). The NSDL will offer, via the Internet, high-quality materials for science, mathematics, engineering, and technology education. It will strongly affect education at all levels, including preK-12, undergraduate, graduate, and life-long learning, by providing anytime, anywhere access to a rich array of authoritative and reliable interactive materials and learning environments. More than 60 projects have been funded since 1998 in three areas: the collection track for offering contents (e.g., National Biology Digital Library, Digital Mathematics Library; Experimental Economics Digital Library); the service track for providing technologies and services (e.g., University of Arizona's GetSmart e-learning concept map system); and the core integration track for linking all contents and services under a unified framework.

JCDL, ECDL, and ICADL: Building an International Digital Library Community JCDL, ECDL, and ICADL, 1995-Present

Digital libraries have become far more important nationally and internationally in 2003 than they were in 1996. Many new and significant national digital library initiatives have emerged. In addition, international conferences in digital library have proliferated from their roots of ACM and IEEE Digital Conferences (and then the Joint Conference on Digital Libraries, JCDL) to the European version of ECDL (European Conference on Digital Libraries) and the Asian version of ICADL (International Conference of Asian Digital Libraries).

The ICADL has evolved from its modest inception of about 80 participants in Hong Kong in 1998, to 150+ participants in Taipei, Taiwan in 1999, 300+ participants in Seoul, Korea in 2000, 600+ participants from 12 countries in Bangalore, India in 2001, 400+ participants from 20 countries in Singapore in 2002, and 350+ participants from 16 countries in Malaysia in 2003. Even regional digital library conferences, such as the recent First China Digital Library Conference, hosted by the National Library of China and held in Beijing on July 9-11, 2002, drew 450 participants from 18 countries and 125 exhibitors. Such a high level of activity is due to the continuous interest among digital library researchers and practitioners internationally. This is also partially due to the exponential growth of information content on the Web around the globe, which

Web searchers are rapidly failing to handle successfully. The next ICADL 2004 is scheduled to be held in Shanghai, China in December 2004.

Digital Library Development in Asia Pacific: Analysis through ICADL

Over the past decade the development of digital library activities within Asia Pacific has been steadily increasing. Through a meta-analysis of the publications and content within ICADL over the past six years, the countries that have contributed and participated in digital library research can be determined. In addition, the various disciplines involved and the research focus of each region can be ascertained. Other major regional digital library conferences held in the past few years are also discussed, following the ICADL analysis.

Country and Institution Analysis

In August of 1998 the first ICADL was held at the University of Hong Kong. The theme of the conference, "East Meets West," emphasized to the participants the ongoing exchange of ideas between researchers located in the Western and Eastern parts of the globe. Researchers in seven countries/regions of the world presented 23 papers. Of those papers, 18 were from Asian Pacific countries such as mainland China, Hong Kong, Taiwan, Singapore, Korea, and New Zealand.

The following year the National Taiwan University in Taipei, Taiwan, hosted ICADL 1999. Eighteen papers were from five Asian and two Western countries, 14 being directly from Asia. In 2000, ICADL was held in Seoul, Korea, where 37 papers from 14 countries were presented at the conference. This conference saw an increase in interest by countries that were not originally associated with the conference. The number of Asian countries involved in this conference increased from five to seven. The fourth ICADL in 2001, held in Bangalore, India, hosted 14 countries: nine from Asia Pacific; four from Europe; and 1 from North America; and a total of 35 papers. Two newcomers from Asia, India and Thailand, were present at the conference. The fifth ICADL conference was held in Singapore in 2002. ICADL 2002 saw a dramatic increase in paper presentations, from 35 in the previous year to 54. In addition to the papers, 16 poster presentations were added to the conference's schedule. The number of countries being represented also increased from 14 to 20: 12 from Asia Pacific, seven from Europe, and one from North America; Malaysia and Nepal

were two of the new Asian Pacific country additions. The most recent ICADL conference was held in Malaysia in 2003. Despite the fact that the Iraq war and SARS affected world travel, ICADL 2003 still recorded six invited talks, 68 research paper presentations, and 15 poster presentations from 16 countries: 11 from Asia Pacific, four from Europe, and one from North America. Iran was the newest country that attended the conference.

Table 2 summarizes the previous six ICADL conferences: the number of papers accepted and the number of participating countries; institutions; and departments. *Figures 1-3* illustrate the increased number of papers presented at the conferences, as well as the number of countries and institutions attending the conferences.

Table 2. Participation summary of ICADL conferences

	ICADL 1998	ICADL 1999	ICADL 2000	ICADL 2001	ICADL 2002
# of Papers	23	18	37	34	54
# of Papers from Asia	18	14	26	25+	31+
# of Countries	7	7	12	12	20
# of Countries from Asia	6	5	7	9	12
# of Institutions	17+	14+	31+	33+	55+
# of Institutions from Asia	12+	10+	21+	22+	23+
# of Academic Departments/Disciplines	6+	6+	8+	8+	11+

Figure 1. Number of papers accepted in ICADL

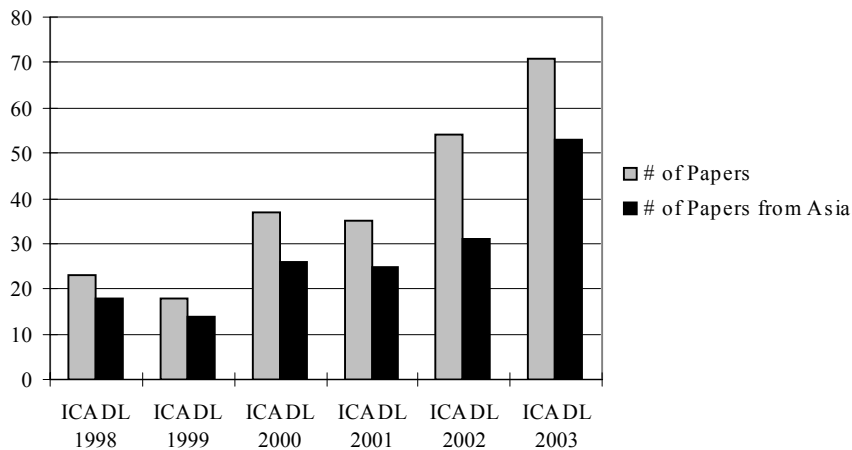
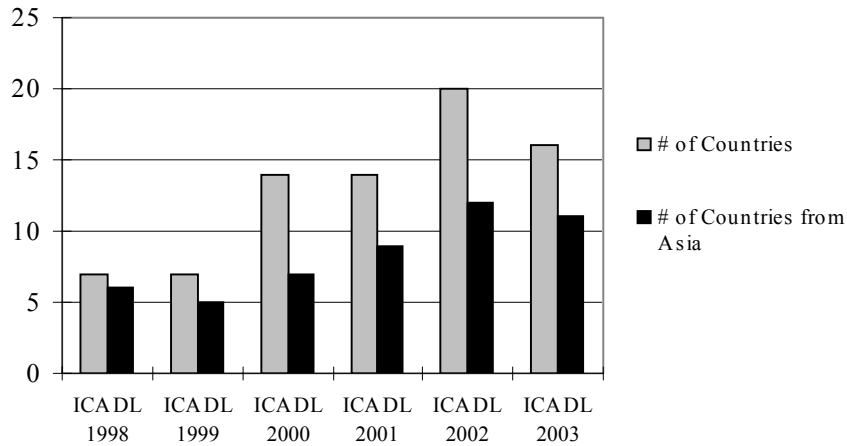
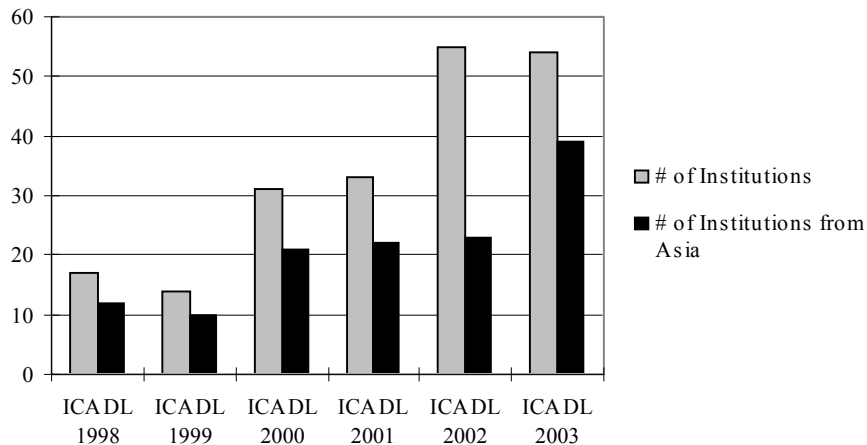
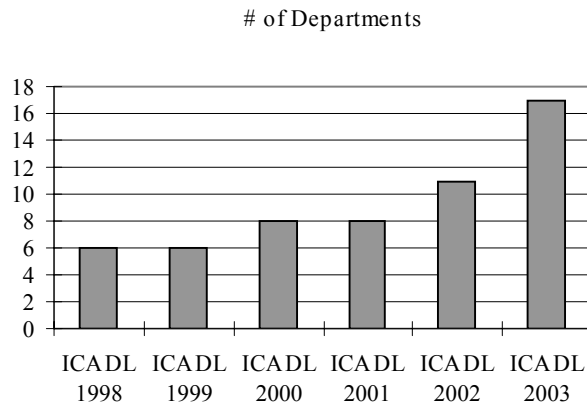


Figure 2. Number of countries represented in ICADL*Figure 3: Number of institutions represented in ICADL*

Academic Department (Discipline) Analysis

The digital library research and development being conducted within Asian Pacific countries spans many different academic departments and disciplines. Over the past six ICADL conferences, there was an increase from 6+ academic departments to over 17 academic departments being accounted for in technical sciences, such as computer science and engineering, as well as within the social

Figure 4. Number of departments (disciplines) in ICADL

science domains. The overwhelming majority of participants came from disciplines such as Information Science (Studies), Library Science, Management Information Systems, Computer Science, Information Engineering, System Engineering, Electrical Engineering, Communication and Information, Education, Anthropology, Geography, Mathematics, Linguistics, and Medical Informatics. *Figure 4* shows the growth in the number of departments (disciplines) that have participated in ICADL.

Aside from popular belief, digital library research is not restricted to those researchers involved in the technical aspects and components of the system; research within digital libraries involves social aspects as well. From a technological standpoint, digital libraries are a set of electronic resources that are built to help create, search, and use information. From a sociological perspective, digital libraries are constructed by a community of users who use the system to better support their informational needs and applications (Borgman, 1998). In the following sections we analyze the research presented at the ICADL conferences according to these two aspects.

Topical Analysis: Technical Aspect

Several major technical research areas, including content building and management, text indexing and retrieval, document summarization and categorization, personalization and visualization, interoperability, and multimedia information retrieval, have been reported in the ICADL proceedings over the past six years.

- **Content Building and Management:** Digital libraries consist of the collections of digitized resources as well as the links or pointers to other digital sources. Oftentimes they are based on library collections that have been selected by existing library collections or development/archival criteria (Smith, 1998). The Internet has also been classified as a (somewhat chaotic) digital library by some, where spidering or crawling techniques are needed in order to navigate and create unique content. For example, HelpfulMed, developed at the University of Arizona, provides medical information not only from Web pages but also from a variety of online medical databases (Chen, 2001). A medical spider was designed specifically to collect relevant medical Web pages. As a collection building tool, the Greenstone Digital Library Software produced by the New Zealand Digital Library Project has been used to build many digital library collections all over the world (Witten, 2002).
- **Text Indexing and Retrieval:** Indexing is another rapidly growing topic of interest in digital libraries. Indexing is an important task for retrieval. However, while indexing research is on the rise, the ability to correctly index Asian languages such as Chinese and Japanese becomes challenging due to the lack of explicit word boundaries inherent in the language (Yang et al., 1998). New research techniques involving the use of n-gram indexing and phrase-extraction algorithms within the Asian digital library community have been used in many research works in order to transcend the word boundary problem. Yang et al. (1998) compared n-gram and mutual information-based indexing approaches for the Chinese language and found that a mutual information algorithm could extract more correct Chinese phrases for indexing and retrieval. Ong & Chen (1999) presented a Chinese phrase extraction algorithm using an updateable PAT-tree and obtained a precision level of 70%.
- **Document Summarization and Categorization:** Summarization offers a concise representation of a document and reduces its overall size and complexity. In order to automate the summarization of documents, text extraction research has found ways to take sentences from the original document and use them to form coherent summaries (McDonald and Chen, 2002). In ICADL, summarization techniques have been developed for Asian languages such as Chinese (Yeh et al., 2002; Tang et al., 2000). Additionally, in order to help users identify relevant documents from databases containing thousands of pieces of information, categorization and clustering are often used. Text categorization is the process of assigning documents to one or more predefined categories based on their content (Chan et al., 2001). Various categorization techniques have been presented in previous ICADL conferences. Heß & Drobniak (1999) proposed a clustering algorithm, which analyzed hyperlinks of Web pages;

Jones & Mahoui (2000) described a key phrase-based hierarchical categorization approach; Chan et al. (2001) applied a Support Vector Machine algorithm to document categorization.

- **Personalization and Visualization:** End users of a system want to be able to organize the information space according to their own subjective perspectives (Renda & Straccia, 2002). Personalization provides the ability for users to create their own profiles based on their interests, behaviors, and activities. Chan et al. (2001) described a personalized categorization system in which a user could define his/her own category names and refine the categories by providing feedback to the system. Renda & Straccia (2002) presented a personalized collaborative digital library system where users could organize the information according to their own interests as well as exchange information with each other. Information visualization is also necessary when designing a human-computer interface to effectively explore information (Yang & Kao, 1999). Several visualization techniques have been studied in ICADL conferences to visualize queries or documents. Yang & Kao (1999) considered a 2D presentation of hierarchical information structure called Core Trees. Anderson et al. (2000) designed a system, which visualizes the frequency of query terms within a document using pie charts, and found the pie charts view was preferred by users over a normal text view.
- **Interoperability:** Interoperability in digital library concerns the need for and benefits of integrating distributed collections and systems (Paepcke et al., 1998). Research in this area includes Metadata Encoding and Transmission Standard (METS), Open Archival Information System (OAIS), and Open Archives Initiative (OAI) (Borgman, 2002).

Digital libraries typically include content and associated metadata. These metadata provide a description of content, format, ownership, and security as well as links to other versions, source codes, viewers, and related materials (Borgman, 1998). Many different metadata proposals have been presented in ICADL conferences. Existing common metadata schemas such as Dublin Core and Resource Discovery Framework (RDF) were widely adopted in Asian digital library projects (Yang et al., 1998; Lo & Chen, 1999; Chen et al., 2001). The Open Archives Initiative (OAI) and Open Archival Information System (OAIS) are designed to provide a low barrier for interoperability and are beneficial to collaboration between communities and service providers. Several prototype systems based on OAI protocol were presented in past ICADL conferences (Boone & Pennington, 2001; Chen & Chen, 2002). Multimedia data descriptions based on the MPEG-7 standard and other XML-based representations have also been described in various projects (Joung et al., 2000; Yen, 2000).

- **Multimedia Digital Libraries:** The contents of a digital library can contain text files, images, audio, and video representations. Because digital libraries are capable of containing multimedia collections, research areas involving the searching and browsing techniques of these content collections have increased. In the ICADL proceedings, Cha & Chung (2000) introduced a system for lecture (audio) databases; whereas Rowe et al. (2001) described a 3D retrieval system for American ceramic vessels. Ying & Heng (2002) introduced the Digital Media Gallery (DMG), a Web-based system that was designed for audio, video, image, and clipart retrieval. It is worth mentioning that digital music libraries have attracted significant interest recently. Bainbridge et al. (2002) evaluated different symbolic music matching strategies and explored the effectiveness and efficiency of those strategies under different conditions.

Topical Analysis: Social Aspect

The social aspect of digital libraries emphasizes the activities people engage in when they create, seek, and use information resources. Research within this area focuses on user studies, usage log analysis, multicultural issues, and language-specific issues (Borgman, 1998).

- **User Studies:** How end users use and respond to digital libraries is always an important concern of system designers and researchers. User studies provide a glimpse into understanding the users' behavioral patterns when seeking information. Liew et al. (2000) conducted an empirical evaluation to study the design of e-journals and how users interacted with them. Their findings showed valuable insights for the designing of e-journals, such as the need for advanced interactivity as compared with their print antecedents.
- **Usage Log Analysis:** Usage log analysis is one of the latest additions to digital library research. This technique analyzes the use of terms, operators, and number of queries per search from usage logs in order to provide a better understanding of digital library usage, user information needs, and system effectiveness (Cunningham & Mahoui, 2000). Wolfram & Xie (2001) reported on their experience analyzing usage logs and Web-based surveys for end users of the BadgerLink system and drew some conclusions about the behavioral differences between searching and browsing. Cunningham & Mahoui (2000) collected usage logs for two digital library systems and compared different searching behaviors in terms of query length, query refinement, and so on when using the two systems. Fu et al. (2003) investigated a hybrid method to cluster user queries by utilizing both

the query terms and the results returned to queries. By determining and clustering similar queries in query logs, their system could augment the information seeking process by recommending related queries to users.

- **Multicultural Issues:** Digital libraries can help ensure the preservation of collective history and cultural memorabilia (Witten, 2001). In Asian digital library applications, there are countless scenarios that involve creating and distributing locally produced information collections. ICADL publications have included local digital libraries ranging from teachers preparing educational material to medicinal knowledge based on local plants and herbs. For example, the INFLIBNT project aimed at creating a digital library of theses and dissertations from India (Vijayakumar & Murthy, 2001). SNDT Women's University Library in India developed content for a digital library on Women and Health in South Asia (Parekh, 2001). The Tsinghua University Architecture Digital Library developed a prototype system to provide rich, valuable resources for traditional Chinese architecture research and education (Xing et al., 2002). Vaidya & Shrestha (2002) produced a study on rural digital library development in Nepal and provided suggestions on technical aspects and cost-effective solutions for digital library development in rural Nepal.
- **Asian Languages and Cross-lingual Issues:** A crucial feature of Asian digital libraries is the ability to work in various local languages (Witten, 2001). The Chinese language has been widely studied for information retrieval and extraction techniques. In ICADL 1998, Wong & Li (1998) and Yang et al. (1998) both studied Chinese information retrieval and discussed issues related to Chinese language indexing techniques. In ICADL 1999, Wong et al. (1999) presented their method for Chinese news event detection and tracking, where Chinese segmentation was discussed. Ong & Chen (1999) studied an updateable PAT-Tree approach to Chinese key phrase extraction. Other Asian languages studied include Japanese, Korean, and Thai. A dictionary-based morphological analysis approach for the Japanese language was proposed by Ando et al. (2000). Theeramunkong et al. (2002) investigated using n-gram and HMM approaches for Thai OCR application.

Cross-lingual information retrieval between English and Asian languages has been more widely studied in ICADL conferences than in other Western digital library conferences. Choi et al. (2000) proposed a dictionary-based method of Korean-English query translation. Yang & Luk (2000) constructed a Chinese-English cross-lingual concept space by utilizing a Hopfield network. In ICADL 2001, Sugimoto (2001) presented a multilin-

gual document browsing tool and its metadata creation carried out at ULIS. The application was designed for Japanese, Chinese, Korean, and Arabic languages. Although no query translation was involved in the project, it was the first project of its kind to address the multilingual applications of digital libraries. Recently, in ICADL 2003, Qin et al. (2003) presented an English-Chinese cross-lingual Web retrieval system in the business domain. Their system adopted a dictionary-based approach that combines phrasal translation, co-occurrence analysis, and pre- and post-translation query expansion. Sembok et al. (2003) implemented a Malay-English scientific terms retrieving software. Several stemming algorithms for the Malay language were discussed and evaluated.

Many papers have focused on language specific applications in digital libraries. In addition to the ones discussed, several projects and papers were dedicated to looking at collections contained within local languages. For example, Adachi (2000) presented NACSIS-ELS, a digital library system of Japanese academic journals. Although the language issue was not the focus in those projects, the experiences were valuable for applying digital library technologies in a multilingual world. Zhou et al. (2003) developed a Chinese medical portal, CMedPort, which integrates various techniques such as meta-search, cross-regional search, summarization, and categorization. Their experience provides a good example of adopting information retrieval techniques to non-English languages.

Other Related Conferences in Asia Pacific

Several other conferences have been gaining worldwide attention for their efforts within the digital library research domain. Chaired by Ching-chih Chen, the 12th International Conference on New Information Technology was held at Tsinghua University, Beijing, in May 2001 (Chen, 2001). She organized twelve International Conferences on New Information Technology (NIT) in various places, including Asian countries such as Thailand, Singapore, Hong Kong, Vietnam, and Taiwan. This series of conferences has helped to encourage international collaboration among information and library professionals.

The International Conference of Digital Library—Opportunities and Challenges in the New Millennium, hosted by the National Library of China, was held in Beijing in July 2002 (Sun, 2002). The gathering promoted the development of digital libraries in China as well as other countries. More than 100 papers were published in the proceedings with participants from more than 140 digital libraries

and information institutions. The meeting also featured 125 exhibitors ranging from provincial libraries and museums to digital library hardware and software vendors. In addition, the International Symposium on Digital Libraries (ISDL) was held in Japan in 1995, 1997, and 1999 (Tabata & Sugimoto, 1995, 1997, 1999). The symposium was hosted by the University of Library and Information Science (ULIS) in Japan and attracted significant Asian and international participation.

Conclusion

Digital library researchers in Asia Pacific are facing some challenges in common with researchers in the U.S., Europe, and other parts of the world. However, they are also uniquely positioned to help develop digital libraries of significant cultural heritage and indigenous knowledge and advance cross-cultural and cross-lingual digital library research.

Digital library collections have the widest range of content and media types, ranging from 3D chemical structures to tornado simulation models, from the statue of David to paintings by Van Gogh. A mix of text, audio, and video is common among digital library applications. Collection, organization, indexing, searching, and analysis of such diverse information content continue to create unique technical challenges.

Unlike digital government or e-commerce applications that often generate their own content, digital libraries provide content management and retrieval services to many other content owners. The intellectual property issues (rights and fee collection) surrounding such diverse collections need to be carefully addressed.

Many patrons often would like library services to be “free” or at least extremely affordable. Compounding the issue further is the notion of “free” Internet content. However, for high-quality, credible content to be accessible through digital libraries, cost and sustainability problems needed to be resolved. Different digital library pricing models would need to be developed for different contents and services.

The long history and diversity of the different cultures and peoples in the Asian Pacific region has created a fertile environment for developing digital libraries of cultural heritage and indigenous knowledge. Such content and knowledge could help promote global understanding and collaboration.

Digital library content is often of interest to people all over the world, not just in one region. Many content creation and development processes also require collaboration among researchers and librarians in different parts of the world. Digital library researchers are facing the unique challenge of creating a global

service to bridge cultural and language barriers. Researchers in Asia Pacific could significantly contribute to research advancement in cultural and language issues of relevance to the region and to the digital library community as well.

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