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Current Status and Reflections on Augmented Reality Research and Practice in Libraries at Home and Abroad (Postprint)

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Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] This study systematically reviews the current state of research and practice on augmented reality in libraries both domestically and internationally to provide references for related research and practice in domestic libraries. [Method/Process] Literature on augmented reality in libraries was collected through domestic and international literature databases, academic search engines, and citation tracing, followed by content analysis and synthesis. [Results/Conclusions] The paper analyzes the current state of augmented reality research and practice both domestically and internationally, and proposes issues and considerations for the application of augmented reality in domestic libraries, including the rational introduction of AR technology, effective utilization of existing AR platforms, emphasis on evaluating user attitudes and usage effects, and emphasis on personnel training.

Full Text

Research and Practice Status of Library Augmented Reality at Home and Abroad

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Abstract:

[Purpose/Significance] This study systematically reviews the research and practical status of augmented reality (AR) in libraries both domestically and internationally, providing references for AR-related research and practice in Chinese libraries. [Method/Process] Literature on library AR applications was collected through Chinese and foreign databases, academic search engines, and

citation tracing. Irrelevant literature was excluded, and further searches were conducted on references from relevant studies, yielding 25 foreign documents and 39 domestic documents (including 6 from Taiwan, of which 3 were English papers published abroad by Taiwanese authors). **[Result/Conclusion]** The paper analyzes the current state of AR research and practice at home and abroad, and proposes issues and considerations for domestic libraries applying AR, including rational introduction of AR technology, effective utilization of existing AR platforms, emphasis on evaluating user attitudes and usage effects, and attention to personnel training.

Keywords: library; augmented reality; AR technology

Classification Number: G250.7

DOI: 10.13266/j.issn.0252-3116.2019.20.016

Augmented reality (AR) is a technology that “seamlessly” integrates real-world and virtual-world information by incorporating digital information—such as digital images, sounds, graphics, GPS data, and even smells—into the physical world, thereby providing users with enhanced sensory experiences that transcend reality. Although AR technology emerged in the 1990s, the rapid development of mobile technology has provided a powerful and convenient platform for its application. AR can be used on mobile devices without requiring additional wearable equipment like glasses. Because AR focuses on connecting the virtual and real to enhance the user experience rather than creating a completely computer-generated virtual world, this represents its greatest difference from virtual reality. Currently, AR technology is widely applied in navigation (automotive, aviation), military (target tracking, planning), hydrology and geological research (3D mapping, terrain analysis), architecture (reconstructing damaged building exteriors, simulation projects), medicine (simulation procedures), entertainment (interactive exhibitions, conferences), and education, gradually integrating into people’s daily lives. The year 2016 was considered the first year of explosive growth for AR technology, with the AR game Pokémon GO becoming a global sensation. In March 2017, Samsung released its new Galaxy S8 phone, which included AR and virtual reality functions as standard features. In Samsung’s S8 camera interface (Bixby), users can employ AR technology to identify landmarks, translate foreign signs, and purchase products seen through the camera on shopping websites like Amazon. The application of AR in libraries will no longer be distant; therefore, how to integrate this technology into library services is a question the library community must currently consider. Based on this thinking, this study deeply analyzes the research and application practice status of AR in the library field both at home and abroad, aiming to provide reference for domestic libraries introducing AR into their services.

1 Literature Collection and Statistics

In July 2018, the author conducted searches in Web of Science, EBSCOhost, ProQuest, CNKI, Wanfang Data, Taiwan’s Airiti Library, and other databases, as well as academic search engines, using the search queries “SU=libr*"

AND SU=Augment reality,” “SU=library AND SU=augmented reality,” and “SU=library AND SU=augmented reality.” After excluding irrelevant literature and using the backtracking method to search references from relevant papers, 25 foreign documents and 39 domestic documents were obtained (including 6 from Taiwan, of which 3 were English papers published abroad by Taiwanese authors). As shown in Figure 1 [Figure 1: see original paper], foreign research on AR began earlier. In 1993, G. Fitzmaurice first proposed the concept of a computer-augmented library, and although his Chameleon system could not overlay virtual objects onto the real environment—differing from current AR concepts—it still opened the precedent for library AR application research. Until 2012, related research grew slowly; in 2013, the number of studies began to increase gradually, possibly related to the growth of mobile handheld devices. Domestic research literature began in 2012, with the highest number between 2015 and 2016, indicating that domestic scholars have increasingly recognized the importance of AR applications in libraries in recent years.

2 Foreign Library AR Research and Practice

2.1 Research Status of Foreign Library AR

2.1.1 Basic Theoretical Research Basic theoretical research mainly includes concepts, characteristics, types, and user relationships driving library AR. Currently, the most recognized AR definition in foreign libraries comes from R. Azuma’s 1997 review and the reality-virtual continuum system proposed by P. Milgram and F.A. Kishino. Azuma defined AR as technology that dynamically presents virtual information in real environments in real time, which must contain three elements: physical entities and virtual environments, real-time interactive modes, and virtual objects that must interact with users in three-dimensional space. Milgram and Kishino’s reality-virtual continuum system positions real and virtual environments at opposite ends of a connected system, with the middle called mixed reality—closer to reality is augmented reality, while closer to virtual is augmented virtuality. T.R. Meredith categorized AR systems into two forms: location-aware (GPS or target-based) and vision-based. E. Zak discussed AR concepts in library information systems (LIS) and users’ roles in AR applications from a user perspective in 2014. Through analysis of AR literature in the LISTA database, Zak proposed that existing literature descriptions of AR concepts can be divided into three types: (1) AR as a new direction, where scholars believe AR can deliver information and enhance user interaction experiences, representing a new direction in technology; (2) AR as informatization, emphasizing AR’s ability to quickly transmit, collect, present, and superimpose information; and (3) AR as reality enhancement, where AR is described as enhancing reality, communication, experience, and learning. E. Zak argued that users are crucial to implementing AR functions and proposed using E.T. Dresang’s RCT theory (interaction, connection, and access principles) as a theoretical framework to better understand information behavior and representation in digital information environments.

2.1.2 AR Technology Exploration AR technology research primarily focuses on methods, technical details, and optimization measures for applying AR in libraries. A. Shatte, J. Holdsworth, and I. Lee studied mobile AR and agent programs that can provide context-aware library management solutions, implementing a prototype mobile AR library management system called Libagent and detailing its technical framework. A.G. Alex et al. introduced AR's involvement in sensors, image recognition, computer vision, human-computer interaction, virtual reality, and many other fields, proposing a SaaS security framework for library AR applications that includes AR SDK (ARToolKit), image processing (accord.net, AForge.Net, ImageResizer), optical character recognition (tesseract-ocr, Google Drive API), book metadata search (Google Books API), and C#.Net, ASP.Net, and Java. D. Chen et al. noted that low-latency, robust AR applications typically combine server-side search with client-side visual tracking, introducing a mobile AR system that recognizes book spines and discussing its implementation methods and technologies. A. Mahadik et al. introduced two tracking algorithms for context-aware library systems—marker-based technology and feature-based tracking—comparing the advantages and disadvantages of marker-based tracking (e.g., bookmarks on shelves) versus feature-based tracking (e.g., book spines).

2.1.3 AR Application Scope in Libraries As an emerging technology still developing and improving, the application scope of AR in libraries is a frequently discussed topic in foreign research. J. Hahn summarized AR application examples in higher education, museums, and libraries, such as physical bookshelf browsing, library navigation, optical character recognition, facial recognition, and building recognition. T.R. Meredith studied using AR applications to stimulate elementary school students' reading interest, demonstrating through cases how AR can provide book recommendations based on reader habits, reader consultation, environmental positioning, and proposed AR's role alongside artificial intelligence in assessing user satisfaction through facial expressions. J.W. Feltz launched a mobile learning platform in libraries, showing increased library usage and discussing AR application in mobile learning environments to bridge the gap between physical and online resources. S. Avila explored current AR applications in academic libraries, proposing that AR can attract more users to physical libraries and has unique roles in service expansion, marketing, and technical programming, suggesting that subject librarians can use free or low-cost tools to expose users to emerging technologies and generate greater interest in libraries. B. Parhizkar and H.B. Zaman explored AR applications for rare books and manuscripts in library special collections, noting that valuable manuscripts and rare books can be simulated through AR, enabling users to read them. M. Wójcik proposed AR's role in library and information science education, noting that AR helps students obtain information from physical objects in new ways.

2.1.4 AR Application Effectiveness Research in Libraries Foreign studies have also examined the effectiveness of AR technology in libraries. B.

Brinkman et al. studied the effectiveness of using ShelvAR, having users without library experience perform tasks alongside experienced librarians, with results showing equal speed and accuracy. A. Shatte conducted empirical research on Libagent's effectiveness in library sorting, retrieval, and shelf information lookup, proving the system could accurately provide context-sensitive information about shelf status and display the number of missing or borrowed books and book metadata. Shatte argued that librarians' short-term memory is limited, and Libagent could identify large numbers of missing books faster than manual methods, helping overcome cognitive limitations in basic library work. However, the system still had limitations: in experimental environments, signs guided users to correct shelves, and users could only view a small number of books within given timeframes, whereas real libraries have thousands of books and multiple shelves, requiring users to first locate the correct shelf—thus necessitating additional AR wayfinding functionality. In A.A. Cervera-Uribe's research, most participating users indicated they would reuse the AR bookshelf search system, with all participants believing the system simplified information and facilitated quick book location. M. Wójcik found in an empirical study analyzing a Polish academic center's LIS training program that AR was a useful teaching tool helping students understand skills required by librarians. K. Rush discussed AR's role in helping reluctant readers find reading interest, with experiments arranging for such students to watch book trailers via AR to guide them to interesting books. Results showed AR cannot replace teachers or school librarians but can be a beneficial tool for stimulating reluctant readers' interest.

2.1.5 Advantages and Challenges of AR in Libraries Regarding advantages and challenges, J. Hahn believed mobile AR applications can increase usage of print and digital resources. J.F. Santos et al. noted advantages and challenges of library AR orientation systems, with advantages including low-cost implementation, ease of learning and use, ability to attach information to physical objects like library manuals and posters, making libraries more interactive, and being fun to implement and use. Challenges include most AR platforms being proprietary, no single AR application being able to read all AR digital information, requiring good mobile devices, and the developing AR technology still facing potential failure.

2.2 AR Practice in Foreign Libraries

Through content analysis of literature and search engine investigations, this paper comprehensively reviews practical achievements of AR services in foreign libraries. In practice, AR has been successfully applied in foreign libraries with extensive scope, which this paper categorizes into three types: AR library application development, commercial AR platform utilization, and AR book resource construction.

2.2.1 AR Library Application Development Foreign libraries' self-developed AR projects and applications mainly focus on library tours, smart

shelves, AR books, and optical character recognition, as shown in Table 1 .

(1) Library Tour Applications. Library AR tours primarily use positioning technology and building recognition to connect real scenes users see with virtual introductions, providing more vivid and in-depth tour information. For example, North Carolina State University developed WolfWalk, a campus tour application based on library historical resources and geolocation technology, collecting historical stories of campus attractions displayed through positioning. Oregon State University Library and Archives developed BeaverTracks, allowing users to see photos and introductions of library and archive buildings after positioning and scanning the library exterior. The Bavarian State Library’s innovative service implemented Ludwig II, an AR application providing unique multimedia information about the famous Bavarian “Fairy Tale King” Ludwig II. ArchiveLAPL is a collaboration between USC Annenberg and the Los Angeles Public Library Historical Center, aiming to enhance libraries’ visual, video, and 3D experiences, designing and producing AR content around library displays, statues, and rare books. GreatStoriesatPlace, developed by Virginia Beach Public Library in cooperation with Tagwhat, is a library attraction navigation application where users can view attractions on their phones, seeing different attractions from different angles.

(2) Smart Shelf Applications. Smart shelves are mainly used for librarian shelving and user book navigation. In 2002, Vienna University of Technology developed AR-Lib, a laptop-based AR application to help users find book locations on shelves—an early library AR implementation. In 2004, Oulu University Library’s SmartLibrary project used RFID and WiFi for user book navigation. Miami University Library developed ShelvAR, an AR application helping librarians quickly organize books by recognizing icon labels on book spines to automatically indicate correct arrangement. James Cook University Library developed Libagent, a similar shelving application marking incorrectly sorted books.

(3) AR Books. AR is also applied in books to enhance reading experiences. The University of Manchester’s Mimas Academic Data Center developed SCARLET to promote research and teaching of special collections. Binghamton University Library’s ARMagicbook projects precious ancient manuscript content onto blank book pages, updating content as users turn pages.

(4) Optical Character Recognition Applications. A representative OCR case is the University of Illinois at Urbana-Champaign’s mobile application allowing students to scan text documents using OCR technology to learn about relevant library resources. Students can scan course syllabi, citations, bibliographies, book content pages, and library shelves, after which the application provides resource recommendations. The application is available from GitHub (<https://github.com/minrva>).

2.2.2 Commercial AR Platform Utilization In addition to developing their own applications, libraries also fully utilize commercial AR platforms, enabling libraries with insufficient funding and technical resources to provide AR services. Typical applications include Aurasma, Blippar, and Layar. By establishing institutional accounts on Aurasma or Blippar, librarians can create AR services using provided functions. Among foreign library application cases, Aurasma is most commonly used. Aurasma uses smartphones or tablets to recognize real scenes or objects, then precisely matches them with server databases to display rich AR animations, videos, web pages, and other information on real scenes. In libraries, Aurasma is applied in subject librarian introductions, marketing promotion, treasure hunts, exhibitions, reading incentive programs, and library tour posters or brochures. For example, UC Berkeley Library creatively designed a campus detective game using the library's virtual reference system to automatically reply with clues for Aurasma AR content locations on campus. In 2016, the library added AR clues to flyers and announcements, requiring students to participate in AR treasure hunts. Roanoke Public Library, holding many early historical photos, used Aurasma to create AR applications telling stories about Roanoke buildings in the photos.

2.2.3 AR Book Resource Construction Besides using existing AR applications, AR book resource construction is another method. AR books combine text, images, animations, sounds, videos, games, and other information types, providing richer carriers for digital publishing. The University of Texas at San Antonio (UTSA) College of Education and Human Development's Office of Teacher Education Services and UTSA Library jointly purchased AR children's books and provided handheld devices for viewing them, hoping teachers would use these books in classrooms.

3 Domestic Library AR Research and Practice Status

3.1 Domestic Library AR Research Status

Domestic AR research covers theoretical foundations, related technologies, application scope in libraries, application effects, and deficiencies and countermeasures for Chinese library AR applications.

3.1.1 Basic Theoretical Research Domestic basic theoretical research involves AR concepts, characteristics, functions, and significance. Domestic libraries' understanding of AR concepts and characteristics is largely similar to foreign research, still widely using definitions from R. Azuma and the reality-virtual continuum system proposed by P. Milgram et al. Hu Guoqiang et al. distinguished between virtual reality and AR technology. Wang Shanshan et al. analyzed AR's significance and role in libraries, believing AR enables multi-dimensional interaction and value-added services across literature, space, reading, experience, and exhibitions, integrating with user service systems to enhance library service capabilities. Yu Lili elaborated on the necessity of ap-

plying AR technology in digital library reference services, including diversified, proactive, and cross-spatiotemporal shared reference services, and proposed AR applications in digital reference.

3.1.2 AR-Related Technologies Regarding AR technologies, Wang Binying proposed key technologies for mobile libraries, including research processes for AR systems in practical use and marker recognition matters, covering marker recognition, fixed-point extraction, 3D registration, and camera fusion, with steps for implementing AR-based systems. Zhou Wei et al. explained technologies related to library navigation systems, including QR-based book ID recording, osgART-based registration tracking, and RSS-based WiFi indoor positioning, providing system design schemes. Zeng Xiangman and Yang Qiang introduced technologies and principles for AR library personalized service platforms, such as QR code and data mining technologies, discussing sensor-based camera orientation and attitude calculation methods. In Taiwan, T.C. Huang et al. introduced a priori association rule algorithms and WiFi-based indoor positioning systems for their AR applications, detailing system architecture.

3.1.3 AR Application Scope in Libraries Domestic research on AR application scope mainly involves introducing foreign application cases and analyzing application prospects, showing considerable overlap with foreign research, such as smart library tours, book shelving, and book resources mentioned above. Compared with foreign library research, Chinese scholars have also proposed some distinctive applications: (1) AR digital teaching course resource databases; (2) AR application in library cultural creative product development; (3) Virtual 3D experiments; (4) Work evaluation; (5) Knowledge sharing; (6) Personalized services; (7) AR maker space laboratories.

3.1.4 AR Application Effects Mainland China has no research on library AR application effects, while in Taiwan, C.M. Chen and Y.N. Tsai used AR in a school library to teach elementary students how to use the library correctly through AR interaction. Based on the ARLIS system, they taught how to find books and learn in physical libraries, finding that AR significantly improved student learning outcomes, with advantages in applying and understanding library skills compared to traditional librarian instruction. Lin Lijuan et al. surveyed parents in AR children's picture book development activities, with most parents holding positive attitudes toward AR picture books and highly affirming their effects on children's reading interest, curiosity, concentration, participation, and satisfaction.

3.1.5 Deficiencies, Risks, and Countermeasures for Chinese Library AR Domestic scholars fully recognize deficiencies and risks in Chinese library AR applications and propose countermeasures. Xiao Yue identified problems including low attention to AR technology, single application types, difficult development, and high costs, proposing increased attention, phased application de-

velopment models, and combined purchase-cooperation development methods. Xu Jun believed AR in libraries faces risks including unclear technical positioning and usage scenarios, technology and cost limitations, and user acceptance issues. Liao Yufeng considered obstacles including high technical thresholds, expensive costs, low user attention, and need for smartphone/tablet support, proposing solutions such as cooperating with AR companies, actively following AR technology, enhancing AR attention and librarian training, and using wearable devices to promote AR resource utilization.

3.2 Domestic Library AR Practice Status

Domestic AR application practice includes library AR application development, commercial AR platform utilization, AR books, and AR library cultural creative products and services.

3.2.1 AR Application Development In 2014, Zhou Wei, Chen Lilong, and Song Jianwen from China Academy of Art implemented an AR-based library navigation system for their library, combining marker recognition tracking with RSSI-based WiFi indoor positioning to overlay navigation symbols onto real scenes. Beijing University of Posts and Telecommunications Library developed an AR library navigation application through the “Personalized Knowledge Service Platform for Students Based on Library Business Data” project.

3.2.2 Commercial AR Platform Utilization Mainland Chinese libraries have few cases of using commercial AR platforms. Taiwan University Library uses ZAPPAR AR to provide AR tours for models, record sections, and special collections. Lin Lijuan et al. also used Aurasma as the AR picture book image recognition platform.

3.2.3 AR Book Resource Construction Chinese libraries have also introduced AR books to enhance reading experiences. Guangdong Provincial Sun Yat-sen Library purchased “Prehistoric Kings” AR popular science children’s books from Heilongjiang Children’s Publishing House in 2015, and Hubei Provincial Library purchased “AR Coloring” series AR game children’s books from Dolphin Press. In Taiwan, the National Taichung Library used AR cards combining virtual images with the real world to provide children with novel and enriching learning experiences.

3.2.4 AR Library Cultural Creative Products and Services In 2018, Binhai New Area Library held the “AR to the Future” cultural experience activity, where on-site readers scanning Chinese poetry, surnames, and herbal medicine theme patterns could see traditional cultural content come alive with 3D effects on mobile screens. Alibaba’s AR content open platform has cooperated with the National Library, launching the first customized AR intelligent calligraphy teaching product “Hanmo Shuxiang” calligraphy stationery box.

4 Analysis of Domestic and Foreign Library AR Research and Application

Many libraries and researchers at home and abroad are actively engaged in AR research and practice, attempting to use AR to solve existing problems and expand library services. AR contributes significantly to enhancing user experience, improving service levels, and interacting with users, and its future library applications will become more extensive.

4.1 AR's Role in Libraries

4.1.1 Tighter Connections Among Library Elements AR technology can promote integration among library elements, making connections tighter between physical and virtual resources, users and librarians, and contexts and information. Applying AR to virtual reference consultation and library tours helps eliminate gaps between physical and virtual information, facilitating resource discovery, extended reading, and interaction with librarians, providing users with unprecedented service experiences.

4.1.2 Changing Library Work Methods As a new technology, AR provides possibilities for improving traditional work methods. AR can be applied to shelf organization and book positioning, reducing librarians' workload and improving efficiency.

4.1.3 Enhancing Library Service Value AR provides users with novel sensory experiences in new ways, thereby enhancing library service value. For example, AR in information literacy teaching can significantly improve user learning interest, promote knowledge understanding, and enhance learning effects. AR in library marketing promotion can generate greater user interest and participation, achieving better promotion effects. AR for ancient book reading allows users to fully access original documents without damaging them, promoting research on ancient books.

4.2 Deficiencies in Library AR Applications

4.2.1 Insufficient Theoretical Research In terms of research content, there are few theoretical research results on AR at home and abroad, with several research gaps remaining. Comparatively, foreign AR research started earlier with broader scope and more practical cases, such as studies on user satisfaction, usage, and empirical effects. Domestic research, except for some empirical studies in Taiwan, mainly focuses on AR concepts and application scope in libraries, mostly summarizing foreign applications and cases.

4.2.2 Low Practical Application of Self-Developed Projects Self-developed applications mainly include library navigation, AR books, and smart shelves. These applications consume high development costs but are not

widely applied in practice, showing insufficient sustainability. For example, ArchiveLAPL has only an iOS version without Android, and ShelvAR was forced to stop service due to lack of commercialization. Mainland Chinese library AR practice cases, except for cultural creative products, remain in the research stage without large-scale real-scenario application. Therefore, domestic AR applications started late and mostly remain in the experience stage, with a long way to go before real library environment application.

4.3 Future Development Directions

4.3.1 Broader Application of Commercial AR and AR Books Time-line analysis shows self-developed applications concentrated in 2010-2014, after which libraries mostly began using commercial applications for AR services. Cases using Aurasma mainly concentrated in 2013-2017. Commercial applications, requiring no large development costs, being easy to use with good user experience, will have broader application scope and become the main method for library AR application.

4.3.2 Integration Development of Library AR Applications Past self-developed AR applications had single functions, mostly limited to a few features without deep services. Future AR applications will develop toward multi-functional integration. For example, the University of Illinois' Minrva application initially had simple functions but now has multiple modules and plugins, including library catalog search, citation modules, collection modules, anonymous Q&A, and map navigation. Future library AR applications will integrate with other functions to provide deeper services, such as recommending resources based on user interests, providing information based on environmental positioning, and even assessing satisfaction based on user expressions with artificial intelligence.

5 Reflections on Domestic Library AR Application

5.1 Rational Introduction of AR Technology

For libraries, introducing AR involves user hardware devices, application software, AR resources and usage methods, as well as overall planning, collection policies, staff training, and service effect evaluation. If any link in this systematic project is not well executed, service effects will be greatly reduced or even cause user 反感. Meanwhile, introducing AR requires high costs. Although many foreign libraries use free platforms, these often have usage limitations, and expanding scope requires payment—still a considerable expense. Some librarians note these free applications have disadvantages in practicality and quality. Therefore, libraries should consider whether to incorporate AR into their service systems based on their own conditions, user needs, technology maturity, and their own perspectives.

5.2 Effective Utilization of Existing AR Platforms

Foreign library practice shows that mature AR platforms allow low-cost or even free AR services to increase reader participation. Domestic libraries can learn from this experience. Although domestic AR platforms are not yet mature, excellent content and developer platforms have emerged. For example, the Vision+ platform supports users in creating AR content easily through template tools, Web editors, and SunTool tools based on difficulty and flexibility. In November 2017, Tencent officially opened its QQ-AR platform, allowing users to upload a photo, video, and URL link to realize AR creativity on QQ, viewable directly through QQ's scan function. In October 2017, Alibaba released its AR open platform, providing core functions like 2D/3D recognition tracking, content production platforms, and high-quality rendering engines. Developers can quickly create AR content by accessing kits without worrying about algorithms, sensors, or GPU optimization. Domestic library professionals should track these platforms and fully apply them when appropriate.

5.3 Emphasis on Evaluating User Attitudes and Usage Effects

Current library AR research mostly focuses on application scope, with few studies analyzing user attitudes and usage to determine which methods help achieve library goals. AR is not just simple technology but a channel librarians can use to disseminate information and promote user research. If properly implemented, AR can be a powerful tool. Librarians can initially build usage prototypes and test them with small seed user groups to evaluate attitudes toward AR, operational difficulty, and effects, while considering special circumstances like poor networks, low device performance, complex application operations, and insufficient user AR awareness. These research results can help libraries apply AR correctly.

5.4 Emphasis on Personnel Training

AR can be applied in various library service scenarios, including resource navigation, service promotion, reference consultation, and AR books. For better application across these scenarios, librarians must enhance their learning capabilities, understand and effectively use AR tools, and use them to improve services to meet challenges from this emerging technology. Besides commercial platforms, libraries also need personnel with development capabilities to participate in AR application development, such as shelving and navigation applications, for more profound AR technology development in libraries.

Currently, library AR applications at home and abroad remain in the exploration stage, with limited research, insufficiently broad application, and difficult-to-measure effects. Domestic research and practice still lag behind foreign developments. With increasingly common mobile handheld devices, AR has become part of daily life. Scholars generally believe introducing AR into libraries will become a future trend, significantly meaningful for expanding library services

and solving practical problems. Therefore, domestic libraries need to follow AR technology development, attempt to apply AR to existing library service systems, and promote library career development.

References

- [1] FITZMAURICE G. Situated information spaces: spatially aware palmtop computers[J]. *Communications of the ACM*, 1993, 36(7): 39-49.
- [2] AZUMA R. A survey of augmented reality[EB/OL]. [2018-05-15]. <http://www.cs.unc.edu/~azuma/ARpresence.pdf>.
- [3] MILGRAM P, KISHINO FA. Taxonomy of mixed reality visual displays[J]. *IEICE transactions on information systems*, 1994, 77(12): 1321-1329.
- [4] MEREDITH TR. Using augmented reality tools to enhance children's library services[J]. *Technology, knowledge and learning*, 2015, 20(1): 71-77.
- [5] ZAK E. Do you believe in magic? Exploring the conceptualization of augmented reality and its implications for the user in the field of library and information science[J]. *Information technology & libraries*, 2014, 33(4): 23-50.
- [6] SHATTE A, HOLDSWORTH J, LEE I. Mobile augmented reality based context-aware library management system[J]. *Expert systems with applications*, 2014, 41(5): 2174-2185.
- [7] ALEX AG, JEGATHAS S, JAYANTHIAJG, et al. SaaS framework for library augmented reality application[C]//2014 world congress on computing and communication technologies. Trichirappalli: IEEE, 2014: 8-12.
- [8] CHEN D, TSAI S, HSU C, et al. Mobile augmented reality for books on a shelf[C]//2011 IEEE international conference on multimedia and expo. Barcelona: IEEE, 2011: 1-6.
- [9] MAHADIK A, KATTAY, NAIK R, et al. A review of augmented reality and its application in context aware library system[C]//2016 international conference on ICT in business industry & government (ICTBIG). Indore: IEEE, 2017: 1-6.
- [10] HAHN J. Mobile augmented reality applications for library services[J]. *New library world*, 2012, 113(9/10): 429-438.
- [11] FELTZ JW. Enhancing mobility: integrating new services into your library's mobile platform to increase traffic[J]. *Journal of library & information services in distance learning*, 2014, 8(3/4): 263-274.
- [12] AVILA S. Implementing augmented reality in academic libraries[J]. *Public services quarterly*, 2017, 13(3): 190-199.
- [13] PARHIZKAR B, ZAMAN HB. Development of an augmented reality rare book and manuscript for special library collection (AR Rare-BM)[C]//International visual informatics conference on visual informatics: bridging research and practice. Berlin: Springer, 2009: 343-355.
- [14] WÓJCIK M. The latest information and communication technologies in LIS education[J]. *The European proceedings of social & behavioural sciences*, 2017, 31: 43-47.
- [15] BRINKMAN B, BRINKMAN S. AR in the library: a pilot study of multi-target acquisition usability[C]//2013 IEEE international symposium on

mixed and augmented reality. New York: IEEE, 2013: 241-242.

[16] CERVERA-URIBE AA. The augmented library: an approach for improving user awareness in a campus library[C]//2017 IEEE international symposium on mixed and augmented reality adjunct proceedings. New York: IEEE, 2017: 15-19.

[17] WÓJCIK M. Potential use of augmented reality in LIS education[J]. Education and information technologies, 2016, 21(6): 1555-1569.

[18] RUSH K. Augmented reality (AR): a school library app to engage high school reluctant readers to read for pleasure[D]. Illinois: Northern Illinois University, 2017.

[19] SANTOS JF, ESPOSO-BETANS M. Advantages and challenges of using augmented reality for library orientations in an academic/research library setting[EB/OL]. [2018-12-30]. <https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2199&context=iatul>.

[20] Beavertracks[EB/OL]. [2018-07-19]. <https://osulibrary.oregonstate.edu/beavertracks>.

[21] CEYNOWA K. Mobile applications, augmented reality, gesture-based computing and more-innovative information services for the internet of the future: the case of the Bavarian State Library[EB/OL]. [2018-07-09]. <https://www.ifla.org/past-wlic/2011/122-ceynowa-en.pdf>.

[22] USC students create augmented reality app for LA public library[EB/OL]. [2018-08-09]. <http://www.neontommy.com/news/2014/01/usc-students-create-augmented-reality-app-la-public-library>.

[23] UMLAUF EJ, PIRINGER H. ARLib: the augmented library[EB/OL]. [2017-11-02]. <http://www.infotoday.eu/Articles/Editorial/Feature-Articles/Augmented-Reality-in-the-library-gaming-Welcome-Week-121498.aspx>.

[24] Augmented reality in the library-gaming welcome week[EB/OL]. [2018-08-09]. <http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=5625962996D8B6CBF1EBA5543315A4425?doi=>

[25] DEPTULA M. Augmented reality: practical applications for libraries[EB/OL]. [2018-08-09]. <https://library.ifla.org/1893/>.

[26] HAWKINS D. Augmented reality and next generation libraries[EB/OL]. [2017-04-09]. <http://www.libconf.com/2013/04/09/augmented-reality-and-next-generation-libraries/>.

[27] JONES JA. Augmented reality books come to UTSA libraries[EB/OL]. [2018-08-10]. <https://lib.utsa.edu/news/augmented-reality-books-come-utsa-libraries>.

[28] HU Guoqiang, MAI Laihong. Application of virtual reality and augmented reality in smart libraries[J]. Library work and study, 2017(9): 50-54.

[29] WANG Shanshan, FANG Xiangming. Significance and role of augmented reality technology for libraries[J]. Library and information service, 2015, 59(3): 90-94.

[30] YU Lili. Research on AR augmented reality technology in digital library reference services[J]. Henan library science journal, 2016, 36(8): 127-129.

[31] WANG Binying. Research on application of augmented reality technology in library mobile information services[J]. Information research, 2015(6): 78-81.

[32] ZHOU Wei, CHEN Lilong, SONG Jianwen. Research on library navigation system based on augmented reality technology[J]. Journal of system simulation, 2015, 27(4): 810-815.

- [33] ZENG Xiangman. Research on application of augmented reality technology in library personalized service platform[D]. Beijing: Beijing University of Posts and Telecommunications, 2013.
- [34] YANG Qiang. Research and implementation of augmented reality technology in library personalized service system[D]. Beijing: Beijing University of Posts and Telecommunications, 2014.
- [35] HUANG TC, SHU Y, YEH TC, et al. Get lost in the library? An innovative application of augmented reality and indoor positioning technologies[J]. The electronic library, 2016, 34(1): 99-122.
- [36] XIAO Yue. Innovative application and development countermeasures of augmented reality technology in libraries[J]. Library work and study, 2018(2): 48-53.
- [37] WANG Lu. Application of augmented reality technology in children's library service innovation[J]. Liaoning economy, 2017(10): 94-96.
- [38] LIAO Yufeng. Research on application of augmented reality (AR) technology in libraries[J]. Information and documentation services, 2017, 38(1): 62-66.
- [39] LIANG Ya. Discussion on library experience services based on mobile augmented reality technology[J]. Hebei library science and technology garden, 2016, 29(1): 19-22.
- [40] WANG Pu. Research on application of mobile augmented reality technology in libraries[J]. Library and information, 2014(1): 96-100.
- [41] CHEN CM, TSAI YN. Interactive augmented reality system for enhancing library instruction in elementary schools[J]. Computers & education, 2012, 59(2): 638-652.
- [42] LIN Lijuan, LI Zhengji, LAI Yanming. Construction and application of augmented reality picture book database[J]. National central library bulletin, 2017(6): 83-105.
- [43] XU Jun. Application prospects and risk analysis of augmented reality (AR) technology in public libraries[J]. University library and information science journal, 2018(2): 106-109.
- [44] YU Chenglong. Design and implementation of library literature push system based on mobile augmented reality technology[J]. Agricultural library and information science journal, 2017, 29(2): 65-68.
- [45] ZHANG Fuxiong, LAI Guancheng, ZHENG Zhiyuan, et al. Library book-finding guidance system on smartphones[C]//2010 Library and Information Science Seminar. Taipei: Taiwan Library Association, 2010: 98-108.
- [46] ZHANG Jia, ZHANG Guo. Integration and construction of AR library using augmented reality technology to enhance e-books[C]//2010 Cross-Strait Library and Information Science Academic Seminar Proceedings B. Taipei: Chinese Library and Information Science Education Society, 2010: 234-236.
- [47] AR augmented reality: a journey to explore NTU library[EB/OL]. [2018-06-20]. <http://cvweb.lib.ntu.edu.tw/main/AR/index.html>.
- [48] Binhai New Area Library "AR to the Future" triggers new reading fun[EB/OL]. [2018-03-12]. http://news.ifeng.com/a/20180312/56656636_0.shtml.
- [49] ArchiveLAPL App[EB/OL]. [2018-10-12]. <https://www.lapl.org/archive-lapl-app>.

[50] ShelvAR[EB/OL]. [2018-10-12]. <http://shelvar.com/index>.

[51] Minrva | subscribe[EB/OL]. [2018-10-12]. <http://www.minrvaproject.org/subscribe.php>.

[52] GREENE D, GROENEN GYK M. Virtual and augmented reality as library services[EB/OL]. [2018-03-12]. <https://www.thefreelibrary.com/Virtual+and+Augmented+Reality+as+Libra+a0522758858>.

Research and Practice Status of Library Augmented Reality at Home and Abroad

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Abstract: [Purpose/significance] This paper systematically reviews the research and practical status of library augmented reality (AR) at home and abroad, providing references for AR research and practice in Chinese libraries. [Method/process] Literature was collected through Chinese and foreign databases, academic search engines, and citation tracing, with content analysis performed on the collected documents. [Result/conclusion] The paper analyzes the current state of AR research and practice in libraries domestically and internationally, and proposes issues requiring attention for domestic library AR application, including rational AR technology introduction, effective use of existing AR platforms, emphasis on user attitude and effectiveness evaluation, and personnel training.

Keywords: library; augmented reality; AR technology

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Library and Information Service Magazine
December 2018

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