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Research on the application of information technology of Big Data in Chinese digital library

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Abstract

Purpose – Through the case analysis of China's digital library, the purpose of this paper is to make readers understand the development status, achievements and problems of China's digital library. At the same time, it also enables readers to understand the common application forms of these modern information technologies in digital libraries, so as to provide a reference basis for the application of new technologies in other countries' digital libraries.

Design/methodology/approach – On the basis of literature review, the authors have analyzed a conspicuous collection of related papers in order to make a comprehensive summary and elaboration on the present situation of modern information technology application in Chinese digital libraries.

Findings – This paper defines and analyses the concepts, contents and relationships of the three most important modern Big Data information technologies, and then completes the analysis of the current situation of the application of information technology in Chinese digital libraries. The block chain can achieve more accurate information collection, more secure information storage and more effective information dissemination. Artificial intelligence can improve the existing digital library service level in three aspects: resource construction, information organization and information service. Internet plus will help transform the traditional digital library business mode in order to adapt to the change of user-centered service.

Originality/value – This is among the first structured attempts of comprehensively and generally summarizing the application of modern information technology in Chinese digital libraries. It also contains an original exploration of the relationship between the main kinds of modern information technology. Based on this, a relatively complete application scenario and possible vision of modern information technology in digital library can be built.

Keywords China, Big Data, Digital library, Artificial intelligence, Block chain, Internet plus

Paper type General review

1. Introduction

For a long time, libraries have been hoping to realize the ideal of "All information for all people at all time". The emergence of information technology has finally turned it into reality. More than 6bn people in the world now own mobile phones, each of whom has more computing power than the computers used in the 1969 US lunar landing program, and can store all the collections of the Library of Alexandria in ancient Egypt. Scott Nicholson once asserted that the changes in the library industry in the past five years have indeed exceeded those in the previous 100 years, and that the changes in the next five years will make the changes in the past five years insignificant (Zhang, 2011).

Although there are still many difficulties and limitations, libraries have been following the pace of technological development. Lib2.0 will be held from the very beginning of Web 2.0. A large number of mobile library solutions have emerged soon after the mobile internet was put forward. After that, cloud computing, resource discovery, Big Data and associated data, basically all the hot words in the IT field cannot escape the pursuit of the contemporary library (Liu and Zhou, 2015).

In the era of Big Data, the technology of Big Data processing is more needed. The era of Big Data brings not only a rapid and large increase in data resource, but also a greater

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challenge to extract valuable knowledge needed by users. The difficulty of data processing is significantly increased. The traditional data processing technology has obvious shortcomings, which puts forward new requirements of providing big-data-based resource service for digital libraries (Jiang *et al.*, 2011). Therefore, digital libraries must make continuous improvement in technology application and the ability of relevant personnel to apply new technologies, such as data analysis, decision-making analysis, semantic analysis, data quality and data management and visualization presentation technology, etc. to achieve better construction and management of digital libraries.

The development of digital library is actually the product of the development of information technology, especially internet technology. Some scholars think that from the perspective of the development of information civilization, information technology has pushed the library through the traditional stage of library into library automation and digital library, and will continue to appear in a more innovative stage in the future (Wang, 2017). The existing research literature shows that the proposal of the concept of digital library can be traced back to the proposal of electronic library at the earliest stage. Christian (1975) first proposed the concept of electronic library, which was further defined in 1984 as an institution that provides access to information and uses electronic technology to increase and manage information resource (Dowlin, 1984). The digital library discussed in this paper also refers to this new form of library which utilizes modern information technology to realize the digitalization of resources and service. According to different processing stages, specific functions of digital library platform often include data resource processing, storage management and access service (Bai, 2010). Therefore, information technologies in library can also be divided into system support technology (server, cloud platform, etc.), content organization technology (linked data, semantic analysis, etc.) and user service technology (personalization, visualization, etc.) (Ye, 2017).

2. Application status of information technology in Chinese digital library

The Library and Information Technology Association (LITA) of the American Library Association published a book "The Top Technologies Every Librarian Needs to Know-A LITA Guide" in early 2014 to analyze the application of information technology in contemporary libraries (Oddone, 2014). New Media Consortia launched its research series Horizon Report in 2014, which is a special issue for academic libraries. It points out six trends in the next five years: electronic publishing and mobile application in the near future (within one year); bibliometrics, citation technology and open content in the medium term (2–3 years); and Internet of Things, Semantic Web and linked data technology in the long term (4–5 years) (NMC, 2014). The following edition of 2017 adds the latest technology content including artificial intelligence, library service platform, network identity, Big Data, digital academic technology and related library applications.

The blue book on the development of public libraries in China (2010) also introduces the application of technologies such as internet and mobile internet in the development of public libraries, including full coverage of network service, library 2.0 technology and service, bibliographic information retrieval on OPAC, interworking technology of library card, application of RFID technology, mobile library and service, etc. All of these fully reflect the achievement of contemporary digital library in China (Public Library Research Institute, 2010).

For example, the technology center of China Academic Library and Information System has developed Unified Exchange System and Data Management System based on Hadoop distributed model. The former is mainly used for collecting and exchanging resource from different sources and formats, while the latter is mainly used in Big Data processing for cleaning, validating, standardizing, format conversion, data checking and merging, data integration, data improvement and data association. Those resources of Big Data mainly include metadata, digital objects, library collection, logs and so on (Wang and Chen, 2009).

However, compared with the rapid development of internet resource providers or information technology companies, there are still obvious deficiencies in the software and hardware infrastructure of digital libraries. Especially in the face of the requirement of mass data processing in the era of Big Data, data acquisition, transmission, calculation and storage pose more challenges on powerful computing center, high-throughput network transmission equipment and large cloud storage center (Marx, 2013). In view of the overall situation, the existing technology and equipment of Chinese digital libraries still cannot meet the greater requirement of reality. For example, some scholars analyzed the data of 2012 in the database of Academic Libraries of the Ministry of Education in China. Statistical results show that the total coverage rate of wireless network in Chinese academic libraries is only 49.2 percent. On average, each library has about 12 switches with 48 ports, about 10 servers, and the total storage capacity of digital resource is about 44.3 Tb. Only 61.2 percent of these libraries can access China Education and Research Network, 50 percent of them have backbone connection with bandwidth of 500–1,000 Mb and 75 percent of desktop terminals have downstream bandwidth above 100 Mb. Meantime, the imbalance of application of information technology between those universities of Chinese 985 Project and other types is very obvious (Wu, 2013).

3. The impact of new information technology on Chinese digital library

We can illustrate the interrelationship of several main new technologies in Figure 1.

Figure 1 illustrates the content and reasons of three main technologies to be explored in this paper. For digital libraries, information technology is the basic condition to support its various services. Although there are many kinds of information technology, we can divide them into three categories: data, algorithm and application. In order to better explain, this paper needs to define these relevant concepts. Data represents the object of information system processing and is the core resource. Only data can ultimately form the source of value. Algorithms serve data, and effective algorithms can better discover the value of data. The application mainly combines business promotion and user requirement, and encapsulates the functions of underlying data and algorithms to solve practical problems.

In different times, these three technologies have different hotspots of concern. For example, 20 years ago, digital libraries focused more on data as databases and data warehouses. Algorithms focused more on data mining. At the application level, grid computing was a hot topic in that era. In the age of Big Data, especially since 2015, there is an urgent need for people to explore new and better data discovery technologies for heterogeneous, massive and rapidly growing data resource. It should be pointed out that Big Data does not mean data only. Its extensional meaning embodies a general concept including data, algorithm and application, which are indispensable. Some scholars have

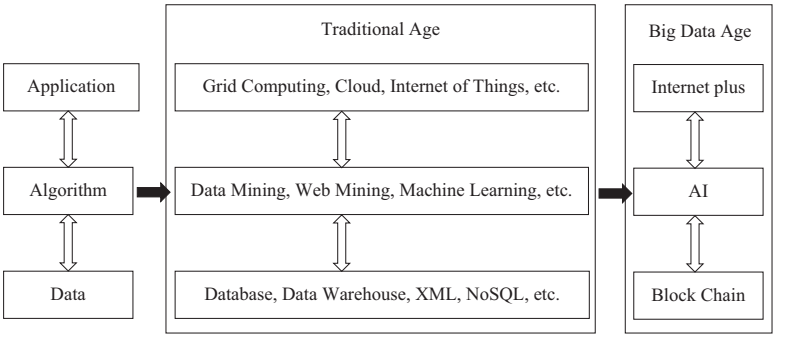

Figure 1.
Relationship between internet plus, AI and block chain technology in application system

proposed that Big Data is the information asset characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value (Mauro *et al.*, 2016). Today, at the data level, a storage method represented by block chain is formed, and the processing capability represented by AI is formed at the algorithm level. For application in China, Internet plus has become the most concerned concept in this era. Correspondingly, the development of modern digital libraries in China is also constantly practicing and verifying the application of these technologies.

3.1 Internet plus

Broadly speaking, as a revolutionary intermediary force with infinite potential and compatibility, internet can be seamlessly fused and deeply integrated with any traditional object, thus completing the revolutionary transformation of traditional industries. In China, people define a concept called Internet plus (Internet plus) to describe this phenomenon. This includes two aspects (Wang *et al.*, 2017). First, the Internet plus will emphasize six core concepts such as cross-border integration, innovation driven, reshaping structure, respect for human nature, open ecology and connecting everything (Feng, 2015). Second, internet information technologies provide the traditional industry with the ability of communication and computing at anytime, anywhere and on demand, making them more conveniently to use data resource than before, and giving full play to the value of Big Data. These can eventually generate a new economic form with many characteristics such as product-based, user-oriented, closed-loop of online and offline (Wang, 2015).

In the field of digital library, the emergence of Internet plus also provides a new opportunity for the development of libraries. With the Web 4.0 technology represented by intelligent technology and Big Data, the new generation of library service platform has begun to enter the market, resulting in the concepts of Internet plus library (Zhang and Li, 2015), Lib4.0 (Noh, 2015), intelligent library and Big Data library (Dou and Liu 2017; Jia *et al.*, 2016).

Internet plus library can be seen as realizing personalized service innovation based on user data and user resource. The user community of Online to Offline is introduced into the library. Through the organic integration of online library service and offline library service in physical space, it emphasizes the collaboration of library's overall services and user interaction.

Its four main features include:

(1) Spatial integration and extension: this extension can be seen from two aspects. First, the traditional offline service can be extended to online mode, which cannot only make full use of the network environment to improve service effectiveness and efficiency, but also greatly save unnecessary space and personnel cost. Second, the combination of online service and offline service can generate more innovation based on service integration. Libraries' physical space also needs to accept the characteristics of changes caused by internet. For example, according to the situation of library building, resource storage and user's geographical location, the existing resource of library should be allocated more effectively.

(2) User driven and autonomic service: in the environment of Internet plus, the driving importance of user requirement in the construction of library resource is increasing. For example, data-driven resource purchasing can give full play to the value of resource construction and maximize the satisfaction of user. At the same time, in all kinds of libraries, the self-service mode is widely used. Users can apply for various services by themselves, such as self-purchase, self-sharing, automatic loan and so on. We have always noticed that the traditional library-led active service mode has gradually shifted to the user-led passive service mode. According to this trend, we can boldly imagine that libraries in the future should be more modular and functional, and gradually evolve into various functional units providing

independent services. Users can actively access relevant service according to their own interests and needs. From this point of view, library can be regarded as an interconnected structure adapting to the changing environment and user requirement, which can realize the interconnection of user, institution and data, so as to obtain the more recognition of user and realize its own value (Ghosh, 2014). We do need libraries that are different from traditional libraries and moving toward new form with realizing new functions (Chu and Duan, 2018).

(3) Personalized user service: the rapid development of internet technology makes it possible for libraries to make full use of users' personalized characteristics. Each user has a different view of the library. Through Big Data analysis, libraries can formulate corresponding service content and allocation resource for different user groups to ensure that the cost of user service is proportional to the value of library.

(4) Diversity of access: as the most important characteristics of Web 4.0, ubiquity refers to the ubiquitous connection at any time and any space, identity refers to the personalized service provided by identifying user's context information and connection refers to the consistent and extensive collaboration between users (More, 2014). At this time, a large number of connections can be formed between user and space, user and resource, user and librarian, librarian and librarian and user and user, thus more opportunities and possibilities for library service innovation can be achieved. The restriction of space layout in the library can be broken through, and the ubiquity and virtualization of the library service place can be implemented.

The idea of Internet plus in library can prompt the deep integration of internet with traditional libraries, and can be helpful in building the intelligent library. The following innovation of library service can be realized (Mo, 2018):

(1) Innovative book purchasing: the traditional book purchasing modes of libraries mainly include bibliographic-based mode, MARC-based mode and live mode. With the support of internet, digital library can innovate existing purchasing modes and achieve real-time communication of information between libraries, library distributors and publishing organizations, so as to implement unimpeded online interaction between the three upstream and downstream parties. User of library can become supplier's customer and play the role of interviewer to buy his favorite books. Changsha Library in China began to cooperate with bookstores in 2010 and held several events to purchase the books chosen by users. In May 2014, Inner Mongolia Library in China also launched a similar activity, which integrates the requirement of libraries and the supply of bookstores into one platform of data cloud (Zhang, 2015). This service is also widely used in other libraries, such as Foshan Library in China (Tang, 2015). The library of Harbin Engineering University guides the collection construction and resource purchasing by using the Big Data of users' behavior. This includes two aspects. One is to use the information of books and the information of readers' borrowing to analyze the subject, publishing house, type distribution and copy guarantee of relevant books. The second is to use Scopus database to extract the published papers and reference data of key disciplines in this university, and to evaluate the quality of collection and resource guarantee ability of library by analyzing the publication and citation of these papers, so as to guide the subscription to scholar databases and foreign periodicals (Tong *et al.*, 2018).

(2) Internet plus Maker Space: for libraries with good advantages of internet information service, they should summarize and collate various information resources of innovation and entrepreneurship in the Maker Space, excavate knowledge and information materials suitable for makers' innovation, and provide

periodic or irregular training for makers, so as to further establish perfect new entrepreneurship information support system. The specific types of service include document information service, knowledge consulting service, information assessment service, etc., which also requires libraries to formulate reasonable development plan for Maker Space service, further expand the pluralistic function of Maker Space with technology of internet, emphasize the transformation of innovation and entrepreneurial achievements and enhance the cooperation of library and Maker Space in many dimensions (Li, 2018). In May 2013, the opening of "Creating New Space" of Shanghai Library marked that Maker Space formally entered the Chinese public library field. At the end of 2015, the Maker Space established by the library of Shanghai Jiao Tong University and Jingdong marked the beginning of the development of Maker Space in Chinese academic libraries (Sun *et al.*, 2016). By the end of 2016, 1,337 entrepreneurs have been certified by the Ministry of Science and Technology of China, covering e-commerce, smart hardware, finance, health care, social networking and other fields (Association of Research Libraries., 2015). The same is true abroad. According to the data from the Association of Research Libraries survey in 2015, 64 percent of North American libraries are providing Maker Space service and 17 percent began the attempt of this service (Huang and De, 2017).

(3) Digital Service Center: modern digital libraries use digital space integration and service innovation to provide data management service, virtual and real space service, virtual and real collaboration service and acquisition service of digital resource, so as to better meet the increasingly requirement of specialized data service of users (EDUCAUSE, 2012). This integration, transformation and innovation can ultimately realize the transformation and upgrading of digital libraries from data storage center and data distribution center to modern data research center and enable digital libraries to actively participate in the process of knowledge creation in user's research and work, realize the transformation from information service to knowledge innovation, and finally realize the transformation from information management service to digital research support (Li, 2012). This service is also known as Digital Academic Space, or Digital Academic Laboratory, or Digital Academic Service. The Center for Digital Scholarship (CDS) of academic libraries in North American is also a common form (Wang, 2014). CDS in North American originated from the Center for Digital Humanities (CDH). Its main function is to apply various digital media to the research in the field of humanities and social science (National Society for research management of Social Sciences, 2010). Most CDH are located in libraries or have some cooperative relationship with libraries. It mainly provides such basic research support services as digital academic research, data mining and knowledge innovation service and digital academic research project service, digital academic course service and so on(Sheng *et al.*, 2017).

3.2 Artificial intelligence

Some scholars believe that if we make the process that computer is introduced into library automation system as the first development stage of digital library, digital resource construction as the main content of information technology as the second stage and internet as the third stage, then the artificial intelligence stage can be regarded as the fourth wave of innovation stage of digital library development (Wang, 2017).

In the field of digital library, artificial intelligence also has tremendous potential for development. For example, the application of library catalogue has gone through three stages: the stage of human-readable but machine-unreadable card catalogue, the stage of

machine-readable but human-unreadable digital catalogue and the stage of machine-readable and also human-readable semantic catalogue. With the further development of ontology language and knowledge mapping, it has laid an important foundation for machine to realize cognitive intelligence, so that it is possible for artificial intelligence system to read like human being (Li, 2017). Jianzhong Wu, former director of Shanghai Library, said that library and information professionals who study Semantic Web and information retrieval should participate in and make contribution to the development of artificial intelligence (Sohu, 2014). Some scholars believe that the greatest driving force for the application of artificial intelligence in library is the potential requirement for personalized service based on Big Data mining. Library information analysis, decision support and information service can be completed when introducing artificial intelligence technology and concept into library service, combining with latest information technology to simulate connection structure similar to human brain, automatically acquiring resources of Big Data (Huang and Wu, 2017).

As early as the 1990s, library scholars have put forward the idea of improving reference service in library by means of artificial intelligence, and proposed that reference service should develop from simple bibliographic inquiry to targeted problem solving (Riddick, 1990). The application of artificial intelligence in the field of digital library can be traced back to the intelligent library proposed in 2003 when the library of University of Oulu in Finland proposed a location-aware mobile library service called Smart Library (Creative Commons, 2014). In 2010, the concept of Smart Library was introduced into China by Dong Yan, a librarian of Xiamen Campus Library of Huaqiao University in China. When the first edition of IFLA Trend Report was released in 2013, it already mentioned the application of artificial intelligence in library (Li, 2013). Nowadays, the application of artificial intelligence in Chinese libraries has made great progress in many fields such as self-service, shared service, mobile service, interactive service and personalized service (Lu, 2017). Some scholars believe that more advanced applications of artificial intelligence in library require more modern information technologies such as RFID, Internet of Things, cloud computing technology and so on (Mo, 2016). From the perspective of user service, some scholars still believe that the new generation of intelligent libraries should focus on user experience and satisfy users' needs as the main driving force (Yang *et al.*, 2017).

The application systems of artificial intelligence have begun to run formally in many Chinese libraries, which include Find+ of Nanjing University Library, the libtalk of Shanghai Library and the recommendation system of Guangzhou Library. The 24 h self-service libraries based on RFID and Internet of Things technology have been basically launched online in many cities all over China, so that the number and service radius of 24 h libraries have even been included in the fifth evaluation index of Chinese national public library (Wang, 2015). At present, the services provided by digital library based on artificial intelligence are mainly manifested in the following three aspects:

(1) To improve the traditional service of library, especially in the aspects of book circulation, reader management and document management.

For example, in the field of book circulation, the Library of Xianlin Campus of Nanjing University can count 10,000 books in 1 h with the error rate not exceeding 1 percent. At the same time, it can automatically check the whole library's collection, find whether there are wrong shelves, books and lost books and update the location information of books in real time (Wu, 2014).

In the field of reader management, Shanghai Jiao Tong University(Shanghai Jiao Tong University Library, 2014) and Zhejiang University of Technology (China News, 2017) have applied face recognition technology to libraries, enabling face-scanning service to support user entry and book borrowing with deep neural network method to reduce the error rate to one millionth in real scenes (Yu, 2017a).

In the field of document management, Nanjing University has conducted many in-depth researches on automatic classification of bibliographic and periodical articles, and has tried to apply various intelligent models (Wang *et al.*, 2010; Ye, 2013). Some scholars used Google's artificial intelligence framework to classify periodical papers automatically according to the Chinese Library Classification. The prediction accuracy of classification in social sciences, science and technology is 78.23 and 73.31 percent, respectively, and the overall prediction accuracy is 75.39 percent (Guo *et al.*, 2017).

(2) To enhance the ability of digital library to provide new knowledge services which content is mainly data driven and subjects become diversified.

For example, in recent years, although with the number of electronic resources purchased by libraries is increasing, it makes it more difficult for users to find useful content. The application of artificial intelligence technology can track the content of resources to meet the individual needs of users. The Wenjin Book Search System developed by the National Library of China has carried out preliminary practice in this area (Xu, 2018). Chongqing University Library uses machine learning to measure users' preferences dynamically and provides more accurate personalized service accordingly (Shen *et al.*, 2015). In fact, this is true in other countries as well. Aberystwyth University in 2016 (Aries Marketing, 2016), Westport Library of Connecticut in 2014 (The Westport Library, 2016) and Creative Intelligence Museum of Yamazawa Village, Minamitsuru District, Yamanashi-ken, Japan in 2015 (Current Awareness, 2014) have successively started the application of library robots based on artificial intelligence.

The speech recognition technology of artificial intelligence directly means that libraries can provide machine-based face-to-face intelligent consulting service. Now, many libraries in Tianjin (Belle8, 2018), Hangzhou (People News, 2016) and Ningbo (CNNB, 2014) have exhibited their own talking robots which can provide reference and consulting service for users according to their historical behavior. Many Chinese academic libraries have also launched their own robotic services such as Tubao in the Library of Nanjing University, Tuxiaoling in Shanghai Library, Wangbao in the Library of Ningbo University and Xiaotu in the Library of Tsinghua University. By building a knowledge base, these robots can integrate the learning, reasoning, judgment, memory and context acquisition functions of artificial intelligence into the existing consulting services in library, and realize the natural language communication with users (Sohu, 2018; Baidu Encyclopedia, 2019; Xie and Guo, 2017).

(3) To strengthen the management of the library itself.

The combination of analysis technology of artificial intelligence and resources of Big Data can provide more effective management decision support functions than traditional methods. Libraries have a large number of valuable data, such as user data, resource data, service data, etc. Using them for deep learning can provide great help for operation decision making and accurate service in library. For example, the experimental system of Big Data analysis in Chongqing University Library can accumulate, analyze and summarize the data from three dimensions of resources user and service. It can guide the operational process of library, optimize user experience and maximize the value of the original data in library (Yan and Zhong, 2016).

More related applications in digital library are shown in Table I.

However, we also notice that there are still many problems in the application and development of artificial intelligence in the field of library. Artificial intelligence is not a general method, but just one of many tools. As a technological paradigm, its development

Table I.
More application methods and areas of artificial intelligence technology in digital library

Application	Description
Virtual assistant (human–computer interaction)	Speech or character recognition based on natural language processing, video search, voice search, face recognition, virtual navigation, machine translation
Document classification	Using the deep neural network model to simulate the principle of document classification, the similarity between document vectors is calculated, and then artificial intelligence technology is applied to classification, re-classification and forward reasoning, so as to realize the automatic classification of documents
Personalized service	Personalized content recommendation application based on user portrait, fusion recommendation and personalized content generation technology
Intelligent consulting	Intelligent service based on large amount of heterogeneous data resource mining and knowledge mapping
Intelligent education	Personalized learning, automated counseling, intelligent assessment, platform for game-based teaching, educational decision making and early childhood education, preschool education robot service
User discovery	Identifying accurately user's real requirement to help library acquire more potential users based on knowledge mapping, user portrait, machine learning

process can only dominate about 10 years. There are still uncertainties in the future and prospective focus of technology (Baidu, 2018). Especially, this kind of problem is more obvious in the field of libraries. Limited training corpus in library can lead to potential problems in related artificial intelligence service. For example, Xiaotu, the consulting robot of Tsinghua University Library, was temporarily corrupted because a limited corpus could not cope with a large number of induced error messages.

At the same time, the relevant theory of artificial intelligence and user behavior analysis are seldom studied. Some people even worry that the development of artificial intelligence will bring about security problems for future human beings. Of course, more scholars still hold a positive view on this, and suggest that people should focus on how to improve the existing level of artificial intelligence services and application mode, and really make contributions to liberating human beings from the tedious work through more advanced automation (Alan, 2017).

There are many theoretical gaps in the library application of artificial intelligence, such as how to integrate the principles of technology and application with the humanistic idea of library, and how to guide the correct application of artificial intelligence technology in library. In order to form a complete theoretical system, we must absorb the traditional library theories such as library value theory and library space theory, ensure that users are always in the center of the knowledge ecological chain and the practice of intelligent analysis is always carried out correctly for users (Shan and Shao, 2018).

There are only 2m artificial intelligence professionals worldwide, and only 2 percent in China, ranking seventh (Baidu Library, 2018). Limited by the shortage of professional and technical personnel related to artificial intelligence, the development of digital library based on artificial intelligence is still in its infancy. British librarian Harrison said that even the world-class libraries cannot provide extensive and effective user service without fully exploiting their collection advantages, efficiency and well-trained staff (Pei *et al.*, 2016). At the same time, the application of artificial intelligence also needs a lot of infrastructure improvement. For example, the most common application of Internet of Things technology is only radio frequency identification in Chinese libraries. Due to the restriction of funds and technology, the total number of radio frequency identification technology is also very small, which is less than 3 percent of the total number of libraries in China. Moreover, most Chinese libraries often take a step-by-step approach to implement the intelligent management application of radio frequency identification (Chen *et al.*, 2015).

Of course, as Ray Kurzweil, who has accurately made dozens of scientific and technological predictions in the twentieth century, believes that since the human brain is a biological organ, its capacity and complexity cannot support exponential growth, there will be a "singularity" in 2045. It indicates that artificial intelligence will surpass human intelligence. Machine brain will play a role with human brain. It is this ideal that constantly inspires more people to work for it.

3.3 Block chain

2016 can be called the first year of block chain. In October of 2016, the Information and Software Service Department of the Ministry of Industry and Information Technology of China issued the white paper book on the development of block chain and its application in China, which provides many policy supports for the development of block chain technology in various industries. At the same time, relevant professional alliances and research institutions have been established in most provinces in China, such as the Industrial Alliance of Zhongguancun Block Chain of Beijing, Block Chain Research Institute of Qingdao, etc. With the further integration of block chain, Big Data, artificial intelligence and other technologies, more opportunities for industry innovation will be created.

As a basic data management of distributed storage and security mechanism, block chain technology has been widely used in many fields, from Bitcoin at the beginning to internet finance later, it has been applied in other fields such as internet energy and electronic health archive. As far as libraries are concerned, in September 2017, the first library based on block chain in China was established in Shekou Free Trade Zone, Qianhai, Shenzhen (sosoBTC, 2017).

In the field of digital library, the main functions of block chain include providing new technical means for more accurate information collection, safer information storage and more effective information dissemination, so that every organization or individual with the ability to build data resource can participate in the construction of data resource in digital libraries. These include upstream publishers, upstream circulators and downstream users, and even any third party that volunteers to donate data resources (Yu, 2017b). This design can greatly improve the traditional way and strategy of data resource providers to distribute data resource and achieve more flexible and stable open resource management, especially for some scientific data sharing with diversified and multi-level characteristics (Hao *et al.*, 2018). On the other hand, it can better manage and utilize some copyright-free data resource, so that they can become an effective source of self-built data resource in library (Gu, 2016). From a broader perspective, the block chain can effectively promote the organic integration of various service resources, service subjects and service objects in the public cultural service of digital library, promote the complementary advantages of cross-regional and cross-industry organizations, eliminate the deviation in the construction of public cultural service of digital library and bring about the synergistic effect in order to effectively decrease service cost and enhance service efficiency, improve the utilization of resource and the public's awareness of digital libraries (Wei and Dong, 2018).

At present, in the process of applying the block chain, digital library are still facing many problems, such as the lack of relevant supporting policies, the lack of unification of standards and norms, the lack of professional and technical personnel and its development is still in its infancy.

4. Summary

Of course, the progress of technology has no end, the application of technology in the field of digital library is still in a period of rapid development, and the related data service technologies are in need of progress. Through the analysis of this paper, we have witnessed the current situation of the application of modern information technology in digital library in

China, which is of great reference value to any digital libraries that want to further improve the existing library service by using modern information technology. At the same time, the paper also makes a detailed description of the characteristics and problems of relevant Chinese researches, which will help more similar researches to emerge. This paper not only illustrates the application of some technologies, but also highlights the successful cases of the Chinese government in promoting the application of internet and modern information technology, and elaborates on the significance and specific measures of implementing these policies in the field of digital library. This provides a useful case reference and also provides a basic research material for further improving the research of digital library around the world, and ultimately promotes digital library to a more brilliant future.

References

Alan, B. (2017), "Smart machines are not a threat to humanity", *Communications of the ACM*, Vol. 60 No. 2, pp. 40-42.

Aries Marketing (2016), "Artificial intelligence integration allows publishers a first look at meta-bibliometric intelligence", available at: www.ariessys.com/views-press/press-releases/artificial-intelligence-integration-allows-publishers-first-look-meta-bibliometric-intelligence/ (accessed January 20, 2019).

Association of Research Libraries (2015), "SPEC Kit 348: rapid fabrication/makerspace services", available at: https://publications.arl.org/Rapid-Fabrication-Makerspace-Services-SPEC-Kit-348/ (accessed January 20, 2019).

Bai, G.S. (2010), "Research on the construction of digital library platform", *Information Studies: Theory & Application*, Vol. 33 No. 4, pp. 102-105.

Baidu Encyclopedia (2019), "Xiaotu (Tsinghua university library robot)", available at: https://baike.baidu.com/item/小图/10524099 (accessed January 20, 2019).

Baidu Library (2018), "China artificial intelligence industry market status and development prospect analysis report", available at: https://wenku.baidu.com/view/3d27bad2760bf78a6529647d27284b73f242367c.html (accessed January 20, 2019).

Baidu, M. (2018), "Marcus criticized Le Cun and others again: fighting for deep learning, rather die than surrender", available at: https://baijiahao.baidu.com/s?id=1589640586964937517 (accessed January 20, 2019).

Belle8 (2018), "The China-Singapore friendship library of Tianjin Intelligent library opened on September 28. Scan your face, borrow books, drive back books, and the robot serve", available at: www.belle8.com/thread-6446252-1-1.html (accessed January 20, 2019).

Chen, Z.H., Wang, Y.C. and Liu, Y.Q. (2015), "Current applications of RFID technology in libraries under the environment of the Internet of things", *Journal of Intelligence*, Vol. 34 No. 5, pp. 196-201.

China News (2017), "Baidu cloud face recognition located in Zhejiang science and technology library", available at: www.chinanews.com/business/2017/04-11/8196746.shtml (accessed January 20, 2019).

Christian, R.W. (1975), "The electronic library: bibliographic data bases 1975-76", Knowledge Industry Publications, New York, NY.

Chu, J.L. and Duan, M.Z. (2018), "Smart library and smart services", *Library Development*, Vol. 41 No. 4, pp. 85-90, 95.

CNNB (2014), "Ningbo university park library has a robot administrator who can hear and say", available at: http://news.cnnb.com.cn/system/2017/12/29/008713452.shtml (accessed January 20, 2019).

Creative Commons (2014), "Wind or wave? How to grasp the direction in the information frenzy", available at: https://trends.ifla.org/files/trends/assets/ifla-trend-report_simplified-chinese.pdf (accessed January 20, 2019).

Current Awareness (2014), "E1856 – robot library staff visible from pepper's future library", 2019 available at: http://current.ndl.go.jp/e1856 (accessed January 20, 2019).

Dou, H.Q. and Liu, B.S. (2017), "Internet and library: elements, models and services", *Information and Documentation Services*, Vol. 24 No. 3, pp. 91-95.

Dowlin, K.E. (1984), "The electronic library: the promise and the process", *Library Quarterly Information Community Policy*, Vol. 54 No. 4, pp. 428-429.

EDUCAUSE (2012), "What's next for campus cyberinfrastructure? ACTI responds to the NSF ACCI Reports", available at: https://library.educause.edu/resources/2012/7/whats-next-for-campus-cyberinfrastructure-acti-responds-to-the-nsf-acci-reports (accessed January 20, 2019).

Feng, G.Q. (2015), "Study on the reform of library service based on Internet thinking", *Library and Information Service*, Vol. 59 No. 2, pp. 25-30.

Ghosh, M. (2014), "Hack the library! A first timer's look at the 29th computers in libraries conference in Washington, DC", *Library Hi Tech News*, Vol. 31 No. 5, pp. 1-4.

Gu, J. (2016), "A study on the development of library-oriented Chinese e-book under the new normal", *New Century Library*, Vol. 37 No. 1, pp. 32-35.

Guo, L.M., Liu, W. and Wu, P.J. (2017), "Machine learning and its application in library: take tensorflow as an example", *Journal of Academic Libraries*, Vol. 35 No. 6, pp. 31-40.

Hao, S.B., Xu, W.Z. and Tang, Z.Y. (2018), "Block chain model of scientific data sharing and its realization mechanism", *Information Studies: Theory & Application*, Vol. 41 No. 8, pp. 1-10.

Huang, W.B. and De, D.M. (2017), "Development needs and service positioning of the makerspace in libraries", *Library Development*, Vol. 40 No. 4, pp. 4-9.

Huang, X.B. and Wu, G. (2017), "Development opportunity and change trend of library in artificial intelligence era", *Library and Information*, Vol. 36 No. 6, pp. 19-29.

Jia, X.L., Li, S.N. and Wu, Y.M. (2016), "Next generation library service platform based on the 'Internet +library' thinking", *Library and Information*, Vol. 1, pp. 44-48.

Jiang, D.X., Yuan, X.L. and Liu, Q.X. (2011), "Exploration on university information architecture", *Experimental Technology and Management*, Vol. 28 No. 5, pp. 7-11.

Li, K.X. (2013), "Reflections on the definition of 'wisdom library' from the humanistic perspective", *Library World*, Vol. 32 No. 6, pp. 14-16.

Li, L.B. (2012), "Internet of things expedites birth of smart library", *Journal of the Library Science of Sichuan*, Vol. 34 No. 6, pp. 2-5.

Li, L.R. (2017), "Analysis on service pattern and innovation development of library-from the perspective of artificial intelligence: interpretation of the report entitled 'artificial intelligence: opportunities and impacts of future decision making'", *Library and Information*, Vol. 36 No. 6, pp. 30-36.

Li, Y.N. (2018), "Research on library service mode innovation of 'Internet+ create customer space'", *Journal of Library Science*, Vol. 40 No. 1, pp. 100-103.

Liu, W. and Zhou, D.M. (2015), "Forward-looking of the next decade library technology trends", *Library Journal*, Vol. 34 No. 1, pp. 4-12.

Lu, T.T. (2017), "From wisdom library to intelligence library: library development diversion in the artificial intelligence era", *Library and Information*, Vol. 36 No. 3, pp. 98-101.

Marx, V. (2013), "Biology: the big challenges of big data", *Nature*, Vol. 498 No. 7453, pp. 255-260.

Mauro, A.D., Greco, M. and Grimaldi, M. (2016), "A formal definition of big data based on its essential features", *Library Review*, Vol. 65 No. 3, pp. 122-135.

Mo, X.H. (2016), "Research on the innovative development of university library service oriented to the idea of smart city", *Information Studies: Theory & Application*, Vol. 39 No. 8, pp. 92-95.

Mo, X.H. (2018), "University library service and innovation under the background of 'Internet +'", *Party History*, Vol. 25 No. 5, pp. 30-31.

More, S. (2014), "Web4", available at: https://seths.blog/2007/01/web4 (accessed January 20, 2019).

National Society for research management of Social Sciences (2010), "Methodological innovation and the development of philosophy and Social Sciences", Wuhan University Press, Wuhan.

NMC (2014), "NMC horizon report > 2014 library edition", available at: http://cdn.nmc.org/media/2014-nmc-horizon-report-library-EN.pdf (accessed January 20, 2019).

Noh, Y. (2015), "Imagining library 4.0: creating a model for future libraries", *Journal of Academic Librarianship*, Vol. 41 No. 6, pp. 786-797.

Oddone, K. (2014), "The top technologies every librarian needs to know – a LITA guide", *Technical Services Quarterly*, Vol. 32 No. 2, pp. 241-243.

Pei, W.W., Lv, S.X. and Xiao, Q. (2016), "Countermeasure research on china's university library human resources management in the ubiquitous information environment: taking the Peking university library as an example", *Journal of Academic Libraries*, Vol. 34 No. 6, pp. 28-34.

People News (2016), "The library has a robot administrator who can listen and say", available at: http://zj.people.com.cn/n2/2016/1014/c228592-29144907.html (accessed January 20, 2019).

Public Library Research Institute (2010), *Blue Book on Development of China's Public Libraries*, Haitian Publishing House, ShenZheng.

Riddick, J.F. (1990), "Reference librarians and serial publications in the age of artificial intelligence", *The Reference Librarian*, Vol. 12 Nos 27–28, pp. 281-287.

Shan, Z. and Shao, B. (2018), "Evolution and current situation of 'artificial intelligence-library user behavior analysis' in China", *Researches in Library Science*, Vol. 37 No. 10, pp. 9-15.

Shanghai Jiao Tong University Library (2014), "The face recognition service of Shanghai Jiao tong university library was officially launched", available at: www.lib.sjtu.edu.cn/index.php?m=content&c=index&a=show&catid=212&id=1834 (accessed January 20, 2019).

Shen, M., Yang, X.Y. and Wang, K. (2015), "Research on user preference retrieval system of university library based on machine learning", *Library and Information Service*, Vol. 36 No. 11, pp. 143-148.

Sheng, X.J., Jie, F. and Peng, F. (2017), "Research of university library's space reform and service transformation under digital environment: a case study of brown university library", *Library Tribune*, Vol. 37 No. 5, pp. 133-143.

Sohu (2014), "Library robot comes, library robot solution", available at: www.sohu.com/a/156234754_99919020 (accessed January 20, 2019).

Sohu (2018), "Intelligent self-service upgrade – when robot walks into library", available at: www.sohu.com/a/225157215_99958728 (accessed January 20, 2019).

sosoBTC (2017), "The first block chain library in China has settled in Qianhai", available at: www.qukuaiwang.com.cn/news/3229.html (accessed January 20, 2019).

Sun, J.H., Wei, J. and Sun, J.M. (2016), "Research and practice on the construction of makerspace in Chinese university libraries", *Library Theory and Practice*, Vol. 38 No. 7, pp. 80-84.

Tang, J.S. (2015), "A review of PDA research in China", *Researches in Library Science*, Vol. 34 No. 2, pp. 22-28.

The Westport Library (2016), "Robotics at the library", available at: http://westportlibrary.org/about/news/robotics-library (accessed January 20, 2019).

Tong, X., Qu, Y.Y. and Lu, P. (2018), "Probe into the document resource construction of university library under the environment of 'Internet+': taking Harbin engineering university library as an example", *Journal of the Library Science of Sichuan*, Vol. 40 No. 2, pp. 46-49.

Wang, H., Yan, M. and Su, X.N. (2010), "Research on automatic classification of Chinese bibliography based on machine learning", *Journal of Library Science in China*, Vol. 36 No. 6, pp. 28-39.

Wang, J.F. (2015), "Library's 24-hour self-service: critiques, misunderstanding and reflections", *Library and Information*, Vol. 34 No. 6, pp. 19-25.

Wang, L. (2014), "Digital scholarship: a new trend of research service in Brown North American University Library", *Proceedings of the 2014 International Conference on Chinese Digital Publishing and Digital Libraries*, *Jinan*, pp. 1-18.

Wang, S.W. (2015), "The great trend of China in the era of internet interconnection – multidimensional observation of 'Internet +'. People's Forum", *Academic Frontier*, Vol. 4 No. 10, pp. 15-24.

Wang, S.W. (2017), "Information civilization and library development trend", *Journal of Library Science in China*, Vol. 43 No. 5, pp. 4-20.

Wang, T.L., Liang, X. and Guo, S.M. (2017), "Research on smart library based on 'Internet +' thinking", *Information Science*, Vol. 4, pp. 74-78.

Wang, W.Q. and Chen, L. (2009), "The model of calls' cloud service platform for distributed digital libraries", *Journal of Academic Libraries*, Vol. 27 No. 4, pp. 13-18.

Wei, D.W. and Dong, X.L. (2018), "Innovation and upgrading of block chain technology driven national digital library", *Library Theory and Practice*, Vol. 40 No. 5, pp. 98-103.

Wu, H.H. (2013), "Study on informatization facilities in Chinese academic libraries", *Library and Information Service*, Vol. 57 No. 22, pp. 81-86.

Wu, J.Z. (2014), "Natural language understanding is the key to breakthrough of AI", available at: http://blog.sina.com.cn/s/blog_53586b810102wqec.html (accessed January 20, 2019).

Xie, Z.M. and Guo, Q.L. (2017), "Semantic scholar: academic search engine based on deep learning", *Journal of Intelligence*, Vol. 36 No. 8, pp. 175-182.

Xu, J.H. (2018), "The interpretation and enlightenment of new media consortium horizon report: 2017 library edition", *Journal of Academic Libraries*, Vol. 36 No. 1, pp. 27-33.

Yan, X. and Zhong, J. (2016), "Research on big data application system of library based on the analysis of data source: a case study of " 'Chongqing Library big data analysis test system' ", *Journal of the Library Science of Sichuan*, Vol. 38 No. 4, pp. 2-6.

Yang, X.Y., Wei, Q.Y., Luo, L. and Xu, T.C. (2017), "The characteristics of new generation library system", *Library Tribune*, Vol. 37 No. 7, pp. 2-8.

Ye, C.L. (2017), "Study on the key technology of university library's big data based on hadoop", *Digital Library Forum*, Vol. 12 No. 5, pp. 33-38.

Ye, P. (2013), "Research on automatic classification of Chinese journal papers based on machine learning", Nanjing University, Nanjing.

Yu, Q.L. (2017a), "On the application of face recognition technology and library management", *Information & Communications*, Vol. 24 No. 11, pp. 288-289.

Yu, X.G. (2017b), "Research on library digital collection construction based on block chain technology: a case study of entire OA electronic periodicals in university libraries", *Library Science Research & Work*, Vol. 15 No. 2, pp. 40-43.

Zhang, H. (2015), "You read, I pay – inner mongolia library launches special services", *China & The World Cultural Exchange*, Vol. 24 No. 5, pp. 43-44.

Zhang, X.L. (2011), "The trend of subverting digital libraries", *Journal of Library Science in China*, Vol. 37 No. 5, pp. 4-12.

Zhang, X.W. and Li, C.H. (2015), "Study on top-level design of 'Internet+Library' ", *Library and Information*, Vol. 34 No. 5, pp. 33-40.

Further reading

Chen, M., Zhou, L. Q. and Lv, Y. E. (2014), "Research about library mobile service innovation in big data era", *Library and Information*, No. 1, pp. 117-121.

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