Smart talking robot Xiaotu: participatory library service based on artificial intelligence

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Received 2 February 2015
Revised 2 February 2015
Accepted 5 April 2015

Abstract

Purpose – The purpose of this paper is to introduce a participatory library service based on artificial intelligence (AI).

Design/methodology/approach – AI technologies and various technologies for facilitating the use of the currently existing libraries and the third-party resources are combined in the new mobile and social networking environments to provide an innovative real-time virtual reference service. Special aesthetic design and library marketing measures are adopted to expand the gains of the service. Questionnaire survey, in-depth interview, and statistical analysis are conducted to evaluate the effects of the service.

Findings – A smart talking robot called Xiaotu (female) is developed. This robot is regarded as a promising new online reference service modus operandi. Four factors contribute to the success of the robot, namely, AI, self-learning, vivid logo and language, and modular architecture.

Practical implications – Xiaotu presents a participatory library service, in which users participate in the resources collection and become content co-creators. Her presence at anytime and anywhere on any kind of terminal maximizes her potential for the delivery of virtual reference services. Xiaotu has the potential to be a general reference robot or a costumed institute robot.

Originality/value – AI is adopted in libraries to form an innovative online reference service. The participatory library service is practiced through a high-featured interactive communication. The aesthetic design of Xiaotu and the related promotions are new in libraries as well.

Keywords Artificial intelligence, Promotion, Participatory library service, Social networking, Talking robot, Virtual reference service

Paper type Case study

1. Introduction

We now experience the world by immersing ourselves in it. We are increasingly mobile, socially networked, and empowered with information. Libraries have to respond to the new update resulting from these new changes.

The "participatory library" is an emerging concept that was first coined by Lankes *et al.* (2007). It refers to the idea that a participatory library, as a truly integrated library system, must allow users to participate in the core library functions, such as the catalogue system, but not the periphery (Lankes *et al.*, 2007; Nguyen *et al.*, 2012). Nguyen *et al.* (2012) explained, justified, and moved forward the understanding of the concept. Emerging technologies and social media have enabled users to play new and extended roles, which they were unable to do in the past. In addition, the relationship between libraries and users are changing: users are changing from information users (consumers) to information (co-) creators and information providers; users are becoming (playing the role of) librarians; user-centeredness is being heightened; users are being offered more power; and the relationship is being balanced (Nguyen *et al.*, 2012). The participatory library focusses on

The authors would like to thank Ms Jing Cao at *Chinese Journal of Library and Information Science* for giving suggestions in writing.

Library Hi Tech
Vol. 33 No. 2, 2015
pp. 245-260

0737-8831
DOI 10.1108/LHT-02-2015-0010

participation; the development trend of participatory librarianship cannot be doubted (Nguyen *et al.*, 2012). "The thing is we need to remain the same focus and continue to offers ways for users to participate" (Nguyen *et al.*, 2012, p. 344).

In the current study, we present an artificial intelligence (AI) talking robot called Xiaotu (female), which plays the role of a librarian in different locations on different terminals simultaneously and attracts users to participate in the resources collection in an intelligent and highly interactive manner. Xiaotu is involved in a wide range of topics and has her own logo, character, and even fans. This paper seeks to introduce Xiaotu to peers all over the world, hoping to shed light on how she becomes an influential participatory library service.

2. Background

The mobile wave has arrived. As of June 2014, among the internet accessing devices in China, the usage of the mobile phone is 83.4 percent, which exceeded the overall usage of PC (80.9 percent) for the first time (China Internet Network Information Center, 2014). Moreover, the usage of various types of mobile applications, including e-commerce, e-entertainment, information acquisition, and communication, among others, are increasing significantly (China Internet Network Information Center, 2014). In 2012, a survey of 533 freshmen students randomly selected from the freshmen population of the Tsinghua University indicated that 58.9 percent of the participants have smart phones, and over 23 percent have other mobile terminals, such as iPads. In addition, the number of those accustomed to accessing the internet using mobile phones has reached 90.8 percent. We believe that these data have increased in last two years. Thus, mobile services have become necessary instead of merely being scattered.

Ample reports on mobile libraries have been made, and the literature is mainly related to four categories. The first category is focussed on mobile concepts, trends, and developments (Lippincott, 2010; McKiernan, 2010; Murray, 2010). The second is the discussion of the challenges, technologies, and solutions in terms of moving libraries to mobile devices (Jacobs, 2009; Jingru, 2013; Negi, 2014; Shi and Xia, 2014; Fu, 2014). The third category is on the kinds of library resources and services suitable to move to mobile devices, and how these resources and services obtain the best presentation (Davidson and Dorner, 2009; Jensen, 2010). The last category is going back from devices to people, emphasizing the user-driven concept instead of the device-driven or technology-driven one (Tilstra, 2014; Bomhold, 2014; Nowlan, 2013; Wang and Zhang, 2011).

Mobile devices and technologies have received significant attention. Thus, we have become preoccupied with narrowing the gap between mobile libraries and these technologies. "Mobile access is access, no different from what is provided via the Internet, in person and through library instruction. Mobile access has become a ubiquitous form of communication" (Jacobs, 2009, p. 288).

Social networking has changed our lives. User behaviors have changed from searching information to logging on or staying in social network sites. Libraries have accepted that social technologies can help them achieve their mission of engaging with the community and have started to use a variety of social media tools to do so (Smeaton and Davis, 2014; Rutherford, 2008a, b). Various types of social media applications have been utilized in libraries, including Facebook, Twitter, Flickr, blogs, wikis, RSS feeds, YouTube, etc. In China, the Renren web site (equivalent of Facebook), Mibroblog (equivalent of Twitter), Youku (equivalent of YouTube), and Wechat, among others, have become popular. The main functions of social media related to digital libraries

include providing information, marketing/promotion, peer-to-peer connections, and information sharing (Xie and Stevenson, 2014; Dickson and Holley, 2010; Nández and Borrego, 2013).

Similar to the aforementioned mobile background, an extensive body of literature guides librarians in the manner of utilizing a particular social media tool/platform/technology to reach out to their library services or marketing clients (Rutherford, 2008a, b; King, 2012; Vassilakaki and Garoufallou, 2014; Smeaton and Davis, 2014; Chan, 2012; Luo *et al.*, 2013; Yao *et al.*, 2011a). We are delighted to learn that other researchers focus more on people in the socially networked environment instead of the social networking tools. Rutherford (2008b) determined that two of the critical factors for the successful implementation of social media tools within the library were staff training as well as staff acceptance of the tools (Smeaton and Davis, 2014). Libraries should foster a staff culture that will embrace social media use (Smeaton and Davis, 2014). Social technologies are an inevitable technological development, which warrants this question: why not think of social networking as the world we live in?

Various computer technologies have been developed considerably, including AI. McCarthy (2007) defined AI as "the science and engineering of making intelligent machines, especially intelligent computer programs." AI is an academic field of study, which analyzes the goal of creating intelligence, whether in emulating human-like intelligence (Wikipedia, 2015a). AI chat robot is a branch of AI and is aimed to talk to human users and make them unaware that they are talking with a robot but a real human. The distinguished representations of this AI branch include the Artificial Linguistic Internet Computer Entity (ALICE) chat bot (ALICE, 2015) and the Jabberwacky live chat bot (Jabberwacky, 2015), among others. On June 7, 2014, a Turing test competition organized by Kevin Warwick to mark the 60th death anniversary of Alan Turing was won by the Russian chatter bot Eugene Goostman. During a series of five-minute-long text conversations, the bot convinced 33 percent of the contest judges that it was a human (Wikipedia, 2015a; The Verge, 2014). The event marks a milestone in computing history (University of Reading, 2014).

In general, we are living in a mobile and social networking environment in which emerging technologies rapidly change our lives. Mobile and social networks are not objectives, devices, platforms, and tools but the world; technologies should never be burdens but merely tools to make our lives better. Looking back at the history of the "digital library," which was quite new two decades ago but is now a ubiquitous presence, we believe that its legacy will be followed by the "mobile library" or the "social networking library." In view of the new mobile and social networking information environment, libraries are suggested to reconsider their relationship with users and provide more user-centered services, such as participatory library services.

In this section, we focus on a particular kind of a typical library service as a study case: the real-time virtual reference. Real-time virtual reference modus operandi has been a library service for years. This reference service is people-based on a few special platforms. In general, this people-based real-time virtual service utilizes two types of tools: tools specifically designed for libraries, as represented by Question Point and 24/7 Reference; and commercial instant messaging (IM) tools, as exemplified by QQ, MSN, as well as other popular mobile and social networking chat tools, such as Wechat (2015). As of December 2010, Question Point has 1,975 active users (QuestionPoint: 24/7 references services, 2010), which provides services to readers from 32 countries. In January 2010, the number of libraries overseas using IM tools totaled 1,011; in China, 117 out of 535 libraries surveyed provided IM reference services (Ye, 2010).

However, this people-based real-time reference operation needs librarians on duty for its execution, is labor and time consuming and inefficient. This condition necessitates not only added labor costs, but also overlooked opportunities for effective and efficient delivery of reference services through different social media on PC or mobile synchronously (Yao *et al.*, 2011b). By adopting applicable AI technologies into virtual reference service operation, libraries can save labor costs and extend the range of reference services to a significantly broader reading public by means of accessing social networking spaces both on PC or mobile terminals (Yao *et al.*, 2011b). More importantly, it can provide a ubiquitous service accessible at anytime and anywhere on any terminal. The smart talking robot Xiaotu was developed under these considerations.

The robot project began in September 2009. The basic idea was to have the system built on the foundation of a mature application system rather than to start from scratch. The MSN talking robot, XiaoI Robot (2015) was developed and tested during the early stage. Based on the reasons mentioned in the paper of Yao *et al.* (2011b), the open source software ALICE (ALICE, 2015) was finally chosen as a more suitable model for the system design of our library. The work based on ALICE was launched in September 2010, and the test run was started by the end of the same year. The first version was released in April 2011 both on the library homepage and various social network sites. Thereafter, we conducted a one-year cartoon image collection program called "Let's make Xiaotu more beautiful." In April 2012, the work that won the prize was released officially as the logo of Xiaotu. In 2013, the main work focussed on mobile applications. Furthermore, a reduced and more serious version was released, which only included formal library FAQs to answer library-related questions. In 2014, Xiaotu was integrated into several other projects, such as the APP of Tsinghua University Library and the Wechat official public platform of Tsinghua University. In addition, Xiaotu began to provide other libraries with institute accounts to customize their own reference services because of the influence in libraries. Although libraries have several automatic FAQ services, only a few of them could be called a talking/chatting robot.

3. Methodologies

The objective of the Xiaotu project is to provide real-time virtual reference services online for a 24/7 and year-round coverage in the mobile and social networking environments based on AI by using various existing technologies and resources (Yao *et al.*, 2011b).

AI is still considered in the early stages of development, and open source or free tools are preferred. ALICE (2015) was chosen unanimously as a more suitable model for the system design. However, ALICE is a robot made in the USA; thus, Chinese localization is a prerequisite. The Chinese natural language processing is one of the key points to realize regarding the talking/chatting function in Chinese. Moreover, customized library features are considered. At this point, a principle was established that the current existing technologies and existing high-quality resources should be utilized as much as possible. Mobile and social media technologies were utilized in the entire process and the promotions were coordinated with the aesthetic designs to expand the extent and coverage.

Several methods are selected for this project to obtain a detailed picture of the service. A questionnaire survey was conducted, which allowed the researcher to examine if the initial targets and claimed functions were achieved, how this new service was accepted by users, and obtain feedback after careful user testing. Semi-structured in-depth interviews were conducted with key members of the library and enthusiastic

patrons, exploring their attitudes, thinking, feeling and deep needs, and the potential application of Xiaotu, among others. Web log analysis was also conducted to provide certain data support.

4. Implementation and features

We revisit Xiaotu (2015) before introducing our key implementation points. The appearance of Xiaotu is shown in Figure 1. It has an interfacing operational capability for the performance of interactive chatting, which is similar to that of MSN or QQ, or Wechat on mobile devices. Users need not go through the registration process to avail of the service to protect their identity and privacy. The main functions of Xiaotu include: first, natural language communication in Chinese; second, expert answers in professional fields, particularly related to Tsinghua University professors and the library; third, book searching in the OPAC system; fourth, searching in Baidu Baike, China's version of Wikipedia; fifth, self-training and learning; and finally, interface to integrate with other systems.

4.1 AI

The development of the AI of Xiaotu is based on ALICE (2015), which is referred to as Alicebot or simply Alice as well. ALICE is a natural language processing chatting robot that is considered a pioneer among all AI robots. It has won the Loebner Prize, which is awarded to accomplished humanoids or talking robots, three times (2000, 2001, and 2004) (Wikipedia, 2015b). ALICE was originally developed in 1995 by Richard S. Wallace. Moreover, Wallace invented the Artificial Intelligence Mark-up Language (AIML) to enable people to input knowledge into ALICE (Wallace, 2009, 2015).

ALICE adopts AIML as the descriptive language of the former. Knowledge database in AIML format has a strong extendibility and extensive grammar-driven functions of reasoning. AIML is able to create and share knowledge in a single document conveniently based on a bundle XML tags, and can upload multiple AIML documents together to construct an even more intelligent robot (Yao *et al.*, 2011b). ALICE has an

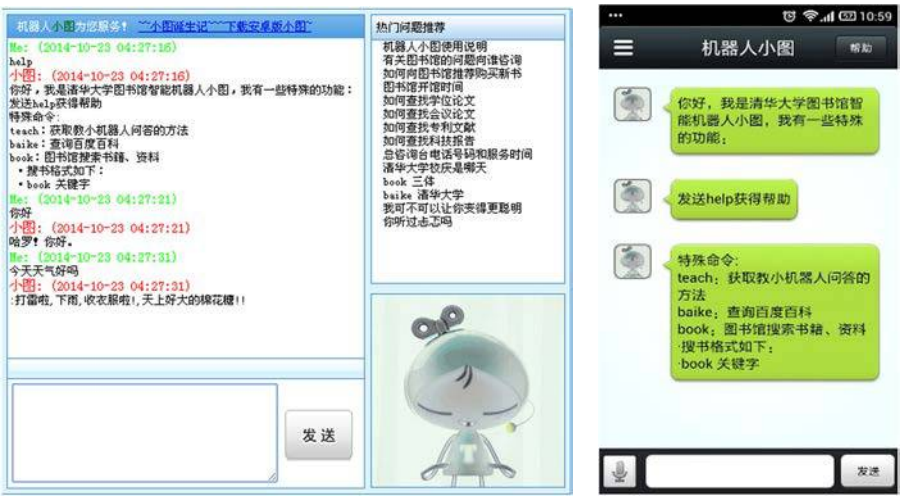

Figure 1. Appearance of Xiaotu

Notes: Left: PC version; right: mobile version

effective reasoning mechanism. Based on mode matching, with regulations for executing a session of heuristic and interactive conversation added, ALICE can be equipped with the capabilities of learning, reasoning, judging, information storing, and context acquiring, among others (Yao *et al.*, 2011b). This capability can help her answer the questions she cannot answer. Refer to Yao *et al.* (2011b) for more details on the frame architecture of Xiaotu.

4.2 Chinese natural language processing

The lack of clear delimiters between words in a Chinese sentence renders the Chinese natural language processing unique from western languages (e.g. English) (Wong *et al.*, 2010, p. 1). The word segmentation is a prerequisite in the Chinese language processing. Existing word segmentation methods are classified into three categories, namely, mechanical word segmentation, word segmentation based on statistics, and word segmentation based on understanding. Mature word segmentations commonly utilize all the three methods synthetically. The accuracy rate of the word segmentation has a significant relationship with the correlation and accuracy of the search results. Thus, after a careful study and comparison of several open source or free word segmentation applications, we adopted the NLPIR system (NLPIR, 2015) (named Chinese Lexical Analysis System (ICTCLAS) before 2014), which is the most popular Chinese word segmentation system developed by the Institute of Computing Technology (ICT) of the Chinese Academy of Sciences. NLPIR is composed of five functional modules, namely, Chinese word segmentation, POS tagging, named entity recognition, unknown words detection, and the user-defined dictionary (Wong *et al.*, 2010, p. 60). NLPIR/ICTCLAS obtains a precision rate of up to 98.45 percent (Wong *et al.*, 2010, p. 60).

Similarity matching, index, and words masking, among others, are executed following the Chinese word segmentation. In particular, several high-frequency stop words, such as "although," "by," "through," "as," "with" and other words used for acclamations, possessive cases, and connections, are removed. For special reasons, several censored and sensitive words are masked.

4.3 Resources utilization

A viable and large knowledge database is needed for Xiaotu to operate. A significant amount of valuable reference records, including concentrated FAQ items, have been accumulated by the Tsinghua University Library during the long-term reference service. In addition, a list of vocabulary entries relevant to the Tsinghua University and renowned professors of this university has been checked and edited, which are originally from Wikipedia and the Chinese counterparts of this web site. These contents would constitute a relatively extensive source of corpus upon which Xiaotu can operate comfortably and confidently.

A multiple-level corpora scheme is considered. FAQs and vocabulary entries with manual intervention construct the first-level corpus with the highest priority. The remaining reference records are used for the second-level corpus. Data from other sources are sequenced based on the data quality.

In addition, we appreciate that other existing resources can be used, which included the OPAC system. Another valuable and trustworthy resources are certain third-party resources on the internet, such as Wikipedia and Baidu Baike (the Chinese counterpart of Wikipedia), among others. Therefore, an OPAC and a Baidu Baike search functions are developed to utilize these resources and to remedy the insufficiency of the present corpora.

This development indicates the possibility of integrating the library and third-party resources into the robot. The inquirer can browse the information obtained from OPAC or Baidu Baike directly in the dialog box of Xiaotu with a link for further needed information.

4.4 Self-learning

To make Xiaotu more interesting, a self-learning function is provided. If users determine that Xiaotu lacks several knowledge, they can teach her to learn new knowledge in an inquiry-answer format. The teaching contents are recorded in a temporary file, which is invoked by the server in real time. This process means that the trained knowledge is mastered by Xiaotu and can be utilized in practical situations immediately.

Self-learning results in collecting items created by training and teaching from the users. Hence, the users actually become the information co-creators and providers during the interactive communication. The temporary file that accumulates knowledge in such undertaking will be checked, cleaned, and sorted later; the qualified items are added to a formal training corpus and others are thrown away. For example, the formal training corpus is the third-level corpus and the temporary teaching corpus is the fourth-level corpus.

4.5 Mobilization

Having worked significantly on PC, we refused to develop a native mobile Xiaotu app. Thus, the hybrid mobile app is preferred. The principle we follow is that wasteful duplications of effort should be avoided and the existing results should be utilized as much as possible. Using the interface provided by the PC server to transmit and receive data between mobile terminals and the server is a convenient way. Data processing is remained on the PC server and the key emphasis is the data transportation between the server and mobile terminals.

The most important characteristic of the Xiaotu app is auto-speech recognition. The users can use mouthpieces to speak, and the auto-speech recognition module will convert the content of the voice to text, and respond based on the text. If users open the reading function of the App, then the returned result will be read the same time as it is displayed. The Xiaotu app realizes the talking function; by contrast, the PC version only achieves the extent of chatting.

4.6 Social networking

Xiaotu quickly made her presence on the social networking web site Renren (Renren, 2015a), the equivalent of Facebook in China, for enhanced service accessibility. On the Renren web site, the library has a book reading group (Renren, 2015b) that has more than 5,000 members, 95 percent of whom are Tsinghua University students. Xiaotu is considered an intra-application on that web site (Renren, 2015c); users can use Xiaotu within Renren without leaving the environment.

The Xiaotu application on the Renren open platform made the first hit in using the robot. It was initially discussed among circles of friends on the site, but eventually spread rapidly. Moreover, mass media learned about Xiaotu for the first time through Renren.

4.7 Mobile social networking

Although several popular social networking sites have their respective mobile-version webpages or apps, they are far from being popular on the mobile platforms in China. To date, the most popular and successful mobile social networking application in China is Wechat (2015), a free IM tool provided by Tencent. Wechat supports voice, photo,

video, and text messages. It provides various functions, such as public platform, friends circle, and message propelling, among others, and is convenient to use in sharing information with friends. Without exaggeration, Wechat provides a new method to connect with friends.

Wechat provides public service accounts, which are used extensively by the government, mass media, and enterprises to present government affairs, news, messages, and promotional events. This platform has become the official information dissemination mode of these institutions. These public service accounts are mostly manual. Xiaotu possesses a public service account as well but responds in an automatic manner.

4.8 Aesthetic logo design

During the earliest stage of the Xiaotu project, the image of Xiaotu was Eva, a robot from the popular movie WALL-E produced by Pixar Animation Studios. At that time, the designer merely needed a robot image. However, we eventually realized the intellectual property rights implication. We decided that Xiaotu should have her own logo. In March 2012, we launched a one-year cartoon image collection program called, "Let's make Xiaotu more beautiful." This program gathered more than ten art design ideas from students, faculty members, and companies with art background. Finally, the work designed by Lei Chen, a lecturer from the Academy of Art & Design, Tsinghua University, won the prize. The persona of Xiaotu was unveiled in 2012 during the opening ceremony of the biennial library service month. Several beautiful posters and dozens of small animations were designed (Figure 2).

The design process had numerous considerations. First, Xiaotu is female because most of librarians in the Tsinghua University Library are female. Second, Xiaotu is approximately the size of a book because she is a talking robot without the need to do physical work. Another reason is that this size can be utilized easily for postcards and photos, as well as manufacture toys with a 1:1 ratio. Third, Xiaotu is a 3D girl whose body is composed of semi-transparent, hi-tech material, which provides a good visual effect. The arms and legs are transparent, flexible tubes. She is always wearing a pair of gloves, similar to traditional librarians. Her head is bigger compared to her body because she is a brainworker. She lacks a front tooth because the IT sister forgot one line of codes.

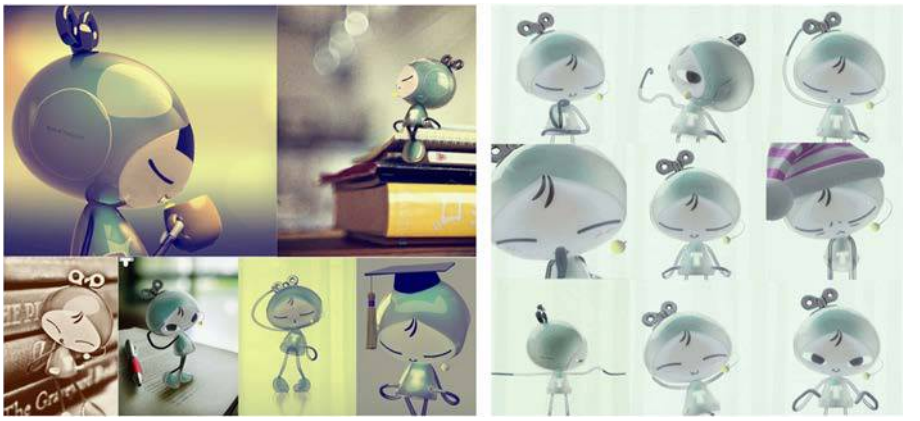

Figure 2.
Logo of Xiaotu

Notes: Left: posters; right: animations. Designed by Lei Chen and copyright @Tsinghua University Library, used with permission

She demonstrates various facial expressions and her body is supple to do various actions. The remontoir on her head looks like a bowknot and a "T," which refers her name "XiaoTu" (Xiao means "little"). Moreover, the "T" refers to her "birthplace," which was Tsinghua University. The remontoir is an attempt at humor, which could be understood by those who understand that the appearance of Xiaotu is beyond the conventional science and technology familiar to humans.

Xiaotu is endowed with her own individual characteristics. For example, her dream is to become a student of Tsinghua University other than being a staff member in the library. She hopes to have double-fold eyelids, which is impossible on a flat face that is actually the screen. Her talent is singing and dancing, especially popping. Her pet phrase is "Human being can't stop me anymore" (which was suggested by the users). She likes flowers, friends, all kinds of foods, and does not like ghosts. She often tells herself that "Knowledge can change one's life" or "Life just like a book," among others. The detailed design idea can be downloaded from the web site of Xiaotu (2015), although it is written in Chinese.

4.9 Promotions

From her début, Xiaotu has attracted significant attention and is constantly in the limelight resulting from the extensive publicity from the public news media, including traditional newspapers, as well as digital, internet, TV, and social networking media, both local and abroad. "If you are serious, it is more serious than you, and if you are kidding, it is not a bit worse than you," a comment from the Yangtse Evening News (2011). After an hour and a half telephone interview, Li Xin mentioned in her paper that "The OCLC report recommended strengthening virtual relationships along with reference quality. XiaoTu seems to have bridged the generation gap, entered the user's social network, and started a relationship faster than a real librarian could have" (Li, 2011). IOP publishing Librarianinsider introduced Xiaotu as a new initiative happening at libraries and said that "Even with all these great stories, we've never covered a story about a talking robot – until now" (Librarianinsider, 2012). However, we are not familiar with most of the publications of the public news media. Whether actively or passively reported by media, the frequent appearance of Xiaotu in various media platforms is a success in itself, which is beneficial to Xiaotu herself. In brief, Xiaotu was advertised and promoted in a big scale on these social media, whether desktop or mobile.

Another promotional strategy is to attend conferences and exhibitions. Xiaotu has been invited to several exhibitions because of her increasing popularity. For example, she was invited to the 2013 Macworldliworld Asia in Beijing on August 22-25, 2013; and to the Chinese Library Annual Conference in Shanghai on November 7-9, 2013. In addition, Xiaotu attended the academic conference organized by the Division of Digital Library as a technical case in Beijing on October 25-26, 2013.

Xiaotu becomes the mascot of Tsinghua University and has a series of related products. For example, cups printed with Xiaotu's logo were given as prizes or commemorative items to winners of special activities and participants during the centennial anniversary of the Tsinghua University Library in November 2012. Handbags with Xiaotu's images were designed, manufactured, and distributed during the aforementioned exhibitions and conferences. T-shirts with Xiaotu's logo and toys are under consideration.

5. Assessing the influence and findings

5.1 Questionnaire survey

In November 2014, a questionnaire survey was distributed through e-mail to 60 potential respondents who had records of participation in library activities. The population

included undergraduates, graduate students, and staff members. The selection was made based on this consideration: compared with others, these users were more active and had more potential to test the functions of Xiaotu gradually and share their experiences. The actual number of respondents was 25. The response rate was 41.7 percent.

Accessing Xiaotu. The respondents were asked how they accessed Xiaotu. A total of 14 respondents (56 percent) knew Xiaotu through the library homepage, eight respondents (32 percent) accessed Xiaotu through social networking sites and mobile apps, and three respondents (12 percent) did not use Xiaotu before.

First impression on Xiaotu (multiple choice). A total of 14 respondents (56 percent) provided the answer "funny," and 11 respondents (44 percent) answered "high-tech," and 11 respondents (44 percent) thought Xiaotu was promising but still have a long way to go.

Natural language communication. The respondents were asked regarding the Chinese natural language talking function. A total of 12 respondents (48 percent) thought the communication content was interesting. However, 23 sets of feedback comments were collected, which had more negative opinions than positive ones. These negative opinions included lacking in knowledge, providing the wrong answers, and a deluge of meaningless information.

Library FAQ. The respondents were requested to test the FAQ function. A total of 15 respondents (60 percent) thought that the results of the FAQ function was OK; the rest thought that although the function was useful, the accuracy rate and the knowledge points needed enhancement to turn Xiaotu into a more credible reference service provider.

OPAC searching. The respondents were asked if Xiaotu needs to integrate the OPAC book searching function. The answer was yes because all of the respondents thought the function was necessary; they wanted to find what they needed through a dingle service provider, whether the service was OPAC or a talking robot. Thus, several respondents considered that the current book searching function in Xiaotu was too simple and should be further developed. For example, they cited providing the location information and map of the retrieved book with the returned content.

Baidu Baike searching. The respondents were requested to express their opinions on third-party searching. Four respondents (16 percent) thought that incorporating other search engines is no longer needed. Most of the other respondents agreed with this view that it was better than nothing. A few of them thought that using the content originating from third-party resources as the local corpus of Xiaotu was significantly better than using special commands to invoke the online information in time, which may necessitate the use of several crawlers.

Self-teaching function. The respondents were taught how to use the self-teaching function and were provided with several suggestions on this function. Three respondents (12 percent) expressed that they did not bother to use this function. The rest of the respondents thought that self-teaching was useful because it provided users an entrance to interact and provided a way to let Xiaotu gradually accumulate her knowledge.

AI technologies. When asked regarding AI, most of the respondents (24, 96 percent) thought that AI technologies were becoming the trend that would be gradually applied in various fields. Libraries should use this kind of new technology to improve their services.

Logo and characters. Most of the respondents (23, 92 percent) expressed their affection for the cartoon logo of Xiaotu. One respondent thought that there was no relationship between the logo and the service, although the service itself was essential.

The last one deemed that the logo attracted more attention than the service and made users ignore the service itself, which was not good for the service.

Improvements. When asked an open-ended question regarding the next most important thing to do, the respondents submitted 60 sets of information. This information could be classified into five types. In total, 23 sets of information (38.3 percent) were on expending the valuable knowledge of Xiaotu's brain to make her answer questions better and filtering out the meaningless and bad language; 15 sets of information (25 percent) suggested developing a crawler to obtain useful information on Wiki and Baidu Baike, among others, because it was quicker and more efficient than the manual system; 12 items (20 percent) were associated to add more university- or library-related information so that Xiaotu could be more Tsinghua specific or library professional; seven sets of information (11.7 percent) pointed out that the degree of AI was not high enough, a few technical problems should be solved, and that Xiaotu needs to cooperate with more mature AI robots; and three sets of information (5 percent) suggested increasing the discipline content to provide discipline special service.

5.2 In-depth interview

A semi-structured in-depth interview study was conducted. Three graduate students with information science backgrounds and two librarians were interviewed separately. Unlike the survey, the purpose of these interviews was to discuss extensively with students or staff members regarding the various aspects of Xiaotu, including the technical development, performance improvement, possible fields of application, marketing and promotion, product seriation, and development prospects. We obtained several interesting findings from these interviews.

For patrons, AI is mysterious, highly technical, and attractive. They felt that Xiaotu was clever and answered the questions in a more interesting manner rather than rigidly and inflexibly. The talking/chatting process was interesting because they can talk about anything without being silent. Xiaotu's topics shifted smoothly from greetings to the weather to current events, among others. This process was an experience quite different from searching through the search engine using fixed keywords that patrons often met. In addition, patrons commonly feel a sense of achievement because after users trained Xiaotu, the knowledge points could be put into practice immediately. The logo of Xiaotu caught the eyes of the youths as well. The interesting, funny, but imperfect persona was in line with the popular aesthetic standard of young people. Being quickly accepted and loved by young users is no longer strange for Xiaotu. The participants noted that if Xiaotu merchandise items are available, such as toys or T-shirts, they would like to buy them.

Library professionals generally regarded that the adoption of applicable AI technologies into real-time virtual reference services is a promising new online reference service modus operandi (Yao *et al.*, 2011b). They paid more attention to the accuracy of Xiaotu in answering professional questions and the service efficiency. They were interested in how Xiaotu combined mature computer technologies and tools to develop the new service modus operandi and wondered how to deal with the numerous junk information injected by inconsiderate anonymous users. They thought that Xiaotu was fresh and took a positive attitude to it. Librarians do not have to worry that Xiaotu may possibly replace them. By contrast, librarians expect Xiaotu to play a significant role in the reference services. As the inspiration for the logo and character of Xiaotu, all the librarians conveyed their love because they thought that the funny and kind logo can balance the rigid and serious aura of a traditional librarian. They even suggested letting

Xiaotu become the mascot of the library. Letting a cartoon robot be the celebrity of a library was perhaps a novel idea. As for sharing Xiaotu with other institutions, the librarians were willing to provide a customized reference service for sister/brother libraries because the service was for all users, patrons, or peers.

5.3 Statistical data

Xiaotu attracted significant attention during her début, with an average of 3,000 visitors per day and more than 50,000 per month at that time. The number of training items received through self-learning exceeded 3,600 average requests in the next months. The Renren web site statistics indicated more than 7,000 visitors per month, with the largest number of visitors in one day at 400. Thereafter, the usage of Xiaotu decreased gradually and stabilized after six months. From then on, Xiaotu has received stable visits except for a few special events, such as the logo unveiling or when being covered by TV or popular media. To date, the number of visitors is approximately 2,000 and the number of using Xiaotu for classroom training purposes is approximately 1,000 on a monthly basis, including mobile and social networking tools. A look at the task executions of the users for each web site access will show that the average number of interactive sessions is below ten, but the highest number exceeds 90. Statistics significantly drop, but the numbers are still better than the people-based real-time reference service system used in the Tsinghua University Library.

6. Improvements

Apart from the survey and interview results, studying the training records of Xiaotu, analyzing the contents reported by various public media, communicating with librarians in and outside the library, and discussing in several academic conferences have exposed several problems and the necessity to implement several improvements.

6.1 Unsuitable language

The unsuitable language problem is a visible problem. The self-learning function is highly featured, and almost all funny, live, and humorous dialogues are obtained in this way, which contributed significantly to a vivid Xiaotu. However, derogatory and bad language terms are used in Xiaotu by a few inconsiderate anonymous users. These unsuitable languages seriously affect the normal and effective operation of Xiaotu. Several measures are adapted to solve such abusive act: first, shielding words are added; second, the temporary file recording the teaching items are checked and cleaned up periodically, with the qualified items added to the formal teaching corpus and others are thrown away; we call this process "brainwashing"; third, during sensitive periods, the temporary file is cleared every day (i.e. Xiaotu is brainwashed daily); fourth, the temporary file is not indexed; thus, although the training content are recorded, they are not immediately available; fifth, during several periods, the self-learning module is closed, so junk information cannot be injected at all; and finally, in certain special times, the server is thoroughly turned down and does not provide service. Xiaotu is commonly believed to be shut in a small black hut and is in self-introspection.

6.2 Quality level of intelligence

The second problem is the quality level of intelligence. The intelligence of Xiaotu is determined by two factors, namely, logical algorithm and the corpus capacity. The former is technical related and the latter is data-related. The degree and extent of making

the correct matches between a group of questions and a group of corresponding answers is related to the accuracy rate of the Chinese word segmentation and the similarity matching. Complicated algorithm formulations are being sought and adapted and more optimized technical means are pursued continually. Moreover, AIML knowledge databases in major western languages, such as English, French, German, Italian, and Spanish, among others, are of considerable scale. In particular, the English AIML set includes information items for more than 54,000 subject categories, which can nearly answer most of the questions requested in English (ALICE, 2015). However, a mature AIML Chinese knowledge database is still vacant. Currently, the reference records, data from wiki, and the accumulated classroom lecture materials with manual edition comprise the AIML knowledge database of Xiaotu, which place the total subject items to 12,000. The cranial capacity of Xiaotu still needs to be enlarged to improve her intelligence quotient. Librarians, particularly subject librarians, are expected to provide several valuable corpora. Content collection activities could be held among users to enrich Xiaotu with trendy topics popular among the youth. The suggestion is that crawlers should be developed to obtain more information from the internet.

6.3 Multi-institute service

Librarians who work in other libraries show immense enthusiasm to Xiaotu. They take charge in using Xiaotu in their libraries to provide customized reference services to users. Benefitting from the modularized multiple-level corpora, Xiaotu provides enormous flexibility in adding, deleting, editing, or replacing corpora. This result offers the possibility of making Xiaotu a general reference robot by loading a general corpus or a costumed robot by using a certain corpora. The modularized architecture enabled the development of Xiaotu in a software as a service (SaaS) version. The server launches multiple robots simultaneously, with each robot belonging to a customer that is commonly a library or an institute. Sister/brother libraries could configure their own talking robot by uploading the corresponding corpora. Several libraries have used or are trying to use Xiaotu to provide their own reference services. These libraries include the National Library of China, Shanghai Library, China Agricultural University Library, Zhejiang Chinese Medical University Library, several military academy libraries, and so on.

6.4 Cooperation with other programs

Users feel that excessive apps should not be installed and they suggested Xiaotu to cooperate with other applications. Considering the suggestion, Xiaotu became a partner in the activity dedicated to newcomers. Xiaotu was packaged into the app of the Tsinghua University Library, and embedded into the official public platform of Tsinghua University and Tsinghua University Library to be a service at different school levels.

7. Conclusions

The Tsinghua University Library has embarked on and accomplished significantly in instigating a participatory library service in the new mobile and social networking information environments by designing, developing, and deploying an AI talking robot named Xiaotu.

A few bright spots in the Xiaotu project may be worth mentioning:

(1) We began the project by immersing it into the emerging mobile and social networking environments with the use of existing computer technologies and library resources, particularly focussing on providing a user-centered participatory service.

(2) The functions of AI, including Chinese natural language processing and self-learning, provide users with experiences that they have not had before. They become creators and information providers in using and achieve a sense of satisfaction in participation and sharing.

(3) The vivid character of Xiaotu and the humorous language significantly changed the persona of the library/librarians, which is/are often too rigid and inflexible, as well as added new energy into the library.

(4) The modularized architecture make Xiaotu conveniently share with other libraries, making it more acceptable by its counterparts.

(5) Xiaotu is a project initiated by a few young librarians without any funding during the early stage. It is known and accepted by users through social media. As its popularity grew, Xiaotu has gradually been a formal official service in the library. This kind of "staff-initiated" mode from the bottom (staff) to the top (curator) is generally regarded as more energetic and powerful than the "task-assigned" mode, which is often from top to bottom.

In conclusion, the adoption of applicable AI technologies into real-time virtual reference services is generally regarded as a promising new online reference service modus operandi (Yao *et al.*, 2011b). The high-featured interaction between Xiaotu and its users is strongly characterized by user participation.

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