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Evaluating Children's Performance and Perception of Robotic Assistance in Library Book Locating

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***Abstract*— This study explored the possibility of service robot in assisting children's book locating activities in libraries. A comprehensive review of children's experiences of library resources locating was made to develop the library robot and the corresponding criteria for evaluation. With a working prototype of library robot, this study examined effective and appropriate interface and information design to assist children in book locating activities by empirically collecting their performance and perception with robotic assistance in a genuine library setting. The result suggested that robot guidance effectively led children to find the assigned book in library while received high appraisal in its efficiency in guiding children to find the book. Children participants regarded the library robot as a favorable and friendly agent to provide interesting navigation experience in the library.**

I. Introduction

For many public libraries, children aged from toddlers, schoolchildren to young adults are major users of the library space and services [1, 24], and they regard library space as familiar and favorable place to access information. Child patrons come to libraries for a variety of activities that involved library collections and services, a user survey from public library in Taiwan showed that schoolchildren of 7 to 12 years old are the major users of library resources with a rapidly growing book lending rate and averagely 2 times of visits every week [2]. In school libraries, accompanied with the teaching and library instruction activities, children visit libraries more frequently, but the significant population of children has not gained equal attention in academic research as it is in library practices [3, 23].

Meanwhile, difficulties are often encountered by children when accessing materials in libraries due to their limited spatial skill and knowledge of library information organization rules [4, 5]. According to Eaton's study [4], elementary children averagely spent much more time to complete book locating tasks than older patrons. Traditional methods to cope with book-locating problems include design of library space and signage system, such as map and directory in library space [6]. A systematic and consistent organization of spaces is essential to help both the novice and experienced patrons to effectively locate the desired resource [4, 7, 8]. From the perspective of software, library instruction was conducted to enable users with library knowledge to be referenced between bookshelves. There also exist library practices of improved graphical catalog and interface to cope with the difficulties children had when searching in typical keyword OPAC systems [9, 10, 11].

However, related studies and surveys suggested that children actually preferred direct and social search strategies such as going directly to the shelves to find books, or to ask a friend or a librarian for help [12, 24]. Facilities such as redesigned bookshelves and color guidance in the space often failed to help patrons to locate resource in libraries due to inappropriate environmental setting or insufficient spatial guidance that were often physically fixed to certain spots of the libraries [7]. Additionally, these time-consuming interventions are contrarily interrupting the overall resource discovery and locating experiences that children enjoyed in libraries, and the inconvenience to access the desired resource may result in lower motivation and unfulfilled information needs [6, 13, 14]. It is also worthy of notice that children compete for the limited human librarians' help on getting actually basic and routine information like the location, title and call number of a book not only because they prefer human help [15], but the fragmental spatial design fails to guide them through the book locating tasks [16]. Given the challenges imposed by the signage system, mobile and automated service providing with book searching and locating for children patrons to augment the gap between the catalog and desired materials is necessary to be developed.

II. Literature Review

Previous studies in robotic guidance design put emphases on the appearance and guidance patterns [17, 18, 19, 20]. Robotic arms, robotic services with combination of ubiquitous environment and robot provided direct guidance to their patrons have been explored. For example, the UJI library robot, equipped with three-fingered robotic arms, was capable of retrieving certain book on the shelf in public library space on users' request [21]. Mikawa, Morimoto and Tanaka [18] developed a librarian robot that can guide patrons through laser pointer, gestures and voice according to the distance between the patron and destination bookshelf. In the short distance, the robot made movement toward the direction of the bookshelf; when there was longer distance between the robot and the shelf, it turned on the laser pointer to show direction of the shelf and simultaneously instructed the patrons with verbal message. Researchers further investigated patrons' preference of different interaction modes and the result indicated that in a short distance, verbal guidance seems sufficient for patrons, while in longer distance, visual presentation of the direction was clearer for patrons to understand the destination. Nevertheless, for those who are not skilled at navigation in space, such as elderly and

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child patrons, extra care and service might be delivered according to their needs. Behan and O'Keeffe [22] proposed the librarian robot "LUCAS" to move between stacks, locating books for patrons. Systems were designed and tested, and the result indicated that users anticipated locating the book with the robot but the interaction process and appearance of the robot still need further refinement. This result supported that patrons looked forward to the guidance robot to locate books with them and more fluent service process need to be developed.

Motivated by the aforementioned issues, this study aims to explore the phenomena of children's library experiences with the focus on issues and problems of book locating in physical library settings, and assist in the book locating in library to children by means of robotic guidance. To understand the possibilities and insufficiency of robotic assistance on book locating for children to access library services, a prototype of library robot was developed and evaluated by children in a real library setting. Children's performance and perception toward the robotic assistance were collected to gain insights for robotic interface design in details.

III. Methodology

To validate the effect of robotics guidance methods and the presentation styles of interfaces, a designated usability experiment was conducted to extract insight from child patrons' actual behaviors in libraries. A quasi-experiment research design incorporated with qualitative techniques including observations and interviews were adopted. Child participants were asked to complete a book locating task in the assigned library accompanied by a library robot. Their performance and perception of the robot were collected and analyzed.

A. Subjects and Procedures

The laboratory setting for the usability experiment was special collection area of children books inside a school library. Considering the spatial and physical requirements to conduct usability experiments, a purposive sampling was adopted to recruit and choose 12 elementary school children in their third to fifth grades to participate in the study. These participants were all experienced library patrons who has visited school libraries recently. Library savvy users were selected in order to avoid anxiety and fear for unfamiliar environment. Participants were asked to locate an assigned illustration book with the robot guidance, this newly published book was only present when the experiment was conducting and all participants had no idea where the book was in advance. In order to perform the guidance, the library robot BookSmile implement actions and tasks as shown in Table I.

These 12 participants were first given a brief introduction of the experiment and a questionnaire of background survey. As participants completed the questionnaire, each of them was randomly assigned to complete the book locating task with the robot which was initially located at the entrance of the library. The robot greeted participants by saying "Hello" and called the name of the participant. After the greeting, the robot recommended the assigned book as "Book Today" and asked if the participant wanted to find the book with the robot. As soon as the participant agreed to find the book by pressing the button on the screen, BookSmile began moving and simultaneously would remind the participant to follow him. When approaching the destination, BookSmile would stand in front of the bookshelf, and the map of the bookshelf that indicated the location of the assigned book was shown on the screen.

During the experiment, participants' book-locating performance was measured by the accuracy, the time spent on the tasks, and their self-reported efficiency with the robotic assistance. Additionally, qualitative behavior characteristics such as facial expression, speed of movement and physical movement toward the agent was videotaped during the book locating tasks. After the experiment, objective measurement by usability assessment was adopted to collect participants' perceived effectiveness, efficiency and extended satisfaction toward the library robot.

TABLE I. Robot Actions and Corresponding Reactions

Actions	Tasks
Greeting	1. Introducing itself near the entrance , says hello to participants by calling their names 2. Informing them of how to activate the book locating service
Guidance	1. Moving to the bookshelf, simultaneously showing the map of the library and telling the participants the location of the bookshelf 2. Arriving the bookshelf, simultaneously showing the book location on the shelf and telling the participant to pick up the book 3. Telling the participant to put the book on the face and confirm
Return	Moving toward the entrance

B. Instruments

Library robot BookSmile: A working prototype of library robot developed in-house by the researcher called BookSmile [23] was used to provide robotic assistance in book locating. This working prototype equipped with functional hardware and software that was perceived to be suitable for helping children locate resources public libraries.

The appearance of BookSmile is a Z-shaped, toy-like mobile robot with the height of 130cm. The skeleton of the robot is made of steel but covered by cushions to ensure its weight-carrying capacity and safety for use. BookSmile was equipped with laser and image sensors and a localization system. One 8.9-inches panel for system monitoring and one 12-inches panel with a touch interface were mounted on the robot as an interface for child users. The specifications of BookSmile was shown in Table 2 and Fig. 1. BookSmile was capable of human sensing and context aware navigation. It displayed a map of the library and bookshelves to guide patrons, spoke in a human voice, and scanned barcodes for book borrowing.

By learning library map in advance, the localization system planned the path and drives the wheels of the robot; simultaneously, the laser sensors installed in front of the robot measured the distance between itself and the destination. The robot was able to recognize its location in time and knew which direction and position it should visit

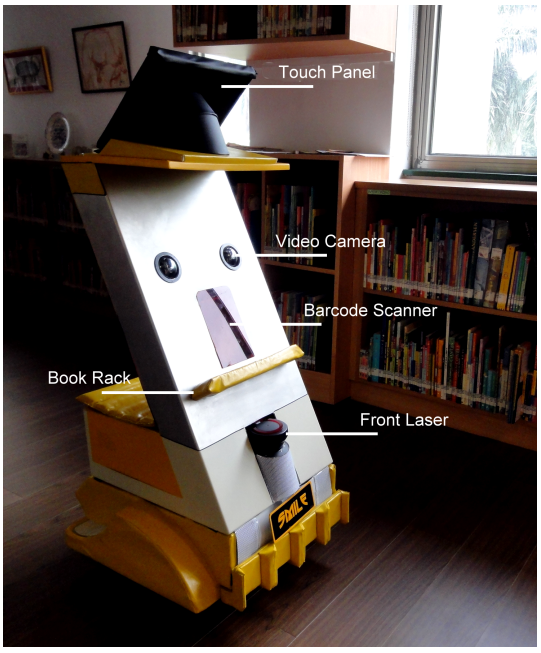
after receiving users' request. The laser was also serving to avoid obstacle along the path to prevent from colliding in bookshelves and readers. The second laser sensor with human sensitive field was installed in the back of the robot to recognize the patron standing nearby and his/her walking pace. The map of the library learned by the robot in real time was synchronously interpreted and transformed into speech and visual guidance that shown on the top display. Human voice was articulated as the speech interface, and the children patrons could activate the guidance by simply touching the screen on the top of the robot.

TABLE II. THE SPECIFICATIONS OF BOOKSMILE

Size	50cm x 70cm x 130cm
Weight	60kg
Skeleton	Aluminum
Driving Type	Two-wheel differential type
Driving motor	DC servo motor
Max. speed	1m/s
Batteries	16V Li-ion battery
Computers	Industry computer and Mac mini
Display	8.9" panel and 12" touch panel
Camera	Monocular camera and stereo
Laser	SICK and Hokuyo
Continuous operation time	0.5-2 hours

Source: Yueh, H.-P., Lin, W., Fu, L.-C., & Sung, T.-J. (2011). Project Report: Advanced Concept and Innovative Design of Intelligent Navigation Service Robot in Children's Library (NSC99-2218-E-002-035). Taipei: National Science Council.

Figure 1. Library Robot BookSmile [23]



To understand children's perception and attitude toward the robotic assistance, perception and attitude assessment was developed. The questionnaire was consisted of seven questions in Likert 4-scale (Cronbach's alpha=.561 >.50). Three items enquiry children's perception of guidance performance concerning task effectiveness and efficiency; other 3 items explore children's attitudes toward guidance agent, including perceived friendliness, extent of favorable and interesting; the remaining 1 item investigates children's overall satisfaction of the guidance.

IV. PRELIMINARY FINDINGS

In this study, all the 12 participants completed the book locating tasks with the robotic assistance. Gender distribution of the participants was balanced, with 6 boys and 6 girls. These participants visited library on the regular basis, with over a half of them had visited library in the past month. For the library using experiences, 50% of the participants adapted browsing strategy (58.5%) when deciding which books to borrow, following by searching the Internet (8.3%) and recommendation (8.3%). For the robot using experiences, all the 12 participants had no experience with robot.

A. Book locating task performance with Robot Guidance

The book locating task performance was measured by time from starting guidance to grasping successfully the correct book. All participants successfully find the assigned book with guidance of robot. Half of children participants completed the book locating time between 1 to 2 minutes, and there is one third of them finding the book within 1 minute.

Children participants on average spent 1.18 minute (70.91 seconds) to successfully retrieve the book from the shelf, with the quickest one only spent 45 second to finish the task while the slowest one took 2.75 minutes (165 seconds) to find the book. With reference to the related empirical studies [4, 7], albeit careful consideration of environment and task should be taken, the time children spent to locate a book with the robotic assistance was relatively shorter than the time without robotic assistance. Furthermore, while all participants were library savvy, it was their first time to visit the library of this experiment. And they performed quicker in locating books not only compared to the same age, but also encompassed the patrons who were also visiting the library for the first time. The findings supported that the robot guidance could enhance the book locating performance of children patrons, and for those who have limited experience with library, the robot guidance might be a quicker solution for them.

B. Children's book locating behavior during guidance

As the robot led participants towards the bookshelf, half of participants walked closer after the robot and focused their attention on the touch screen interface; while some participants looked around the environment and compared it to the library map; still other 2 participants walked slowly and often fell out of the detectable realm of the robot, resulting in robot's calling "please follow me." When the robot approached the bookshelf, most children compared the library and bookshelf map to the real space to locate the book. All participants successfully retrieved the book after comparing the bibliographic information on the interface to the real bookshelf.

The result supported that the library robot effectively led their participants to the accurate location of the bookshelf and assist participants in finding the assigned book successfully. Nevertheless, some participants showed hesitance along the path to the bookshelf. This behavior might due to children's unfamiliarity with the robot and thus they were unsure of how to interact with it. This indicated that clearer hint of interaction mode might be added to make the robot service more fluently.

C. Perception of robot guidance

According to the result of perception and attitude assessment, children participants rated the book locating service function with high appraisal. They agreed that the robot provided accurate navigation *(M=3.92/4)*, useful information *(M=3.83/4)* and easy-to-understand content *(M=3.92/4)*. On average, children regarded the robot as easy-to-use *(M=3.58/4)*, quicker *(M=3.58/4)*, friendly *(M=3.58/4)* and interesting *(M=3.83/4)* assistant for them. Although the robot was not perceived very novel *(M=3.17/4)*, participants still favored the robot *(M=3.67/4)* and the overall experience interacting with it *(M=3.75/4)*. Some children reported in the interview that BookSmile was not like the typical robot as seen in cartoon, but quite fit in the libraries.

According to the result, children were satisfied with the overall experience with the robot guidance. Accurate navigation, useful information and easy-to-understand content were most appreciated by the children patrons. This indicates that the robot meet the need of its users in functional aspects. In comparison to the existing computer interfaces common in libraries for resource locating, the findings of the study suggested that robotic interfaces were more feasible because child participants perceived the library robot as a service provider instead of an information system or companion. The child users projected their expectations of human librarians onto the robots and expected them to have the intelligence and professional skills to help people.

Nevertheless, when asking if the robot found the book quicker, children patrons reported slightly lower rating despite the book locating time was short. 2 participants rated the question with lowest score and some other participants stared at the wheel or imitated the robot's pace during the navigation and reflected that the robot walked too slowly after the task. It was also found that some participants showed both excited and anxious about the library robot, which led to the avoidance behavior, such as staying in distance or avoiding touching the robot. For instance, some children hesitant to walk with the robot often fell out of the detectable realm of 30cm radius, and thus caused the robot to slow down, waiting for participants to follow up. While the encouraging words and gestures of the robot significantly improve the attention and motivation of interaction, succeeding refinement such as enlarging the detective realm would be considered.

V. Conclusion

This study investigated how children patrons interact with robot guidance in a genuine library setting. The result shows that robot guidance effectively led children to find the assigned book in library. The library robot Booksmile received high appraisal in its efficiency in guiding children to find the book and is also a favorable and friendly agent to provide interesting navigation experience in library. According to the findings, robotic assistance assured precision in locating a resource in the library, and it allowed individualized and adaptive services. The library robot connected the library resources with the child patrons, who were thus motivated to explore and enjoy the library. Despite of the shorter time of book locating with the robotic assistance, it was also necessary to consider the possible and complex factors that interfered with children's library experiences. Although in this study, having the robotic guidance improved the efficiency and effectiveness of book locating, the strong guidance could also limit children's opportunities of wondering and free browsing. Providing children with multiple and intelligent modes of guidance were considered in our future studies.

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References

[1] Walter, V.A., Public library service to children and teens: A research agenda. *Library Trends*, vol 51(4), 2003, pp. 571-589.

[2] Taipei Public Library, *Taipei citizen's reading behaviors and favorable reading materials ranking chart*. 2011 January.

[3] Walter, V.A., *Children & libraries: Getting it right*. 2001: ALA Editions.

[4] Eaton, G., Wayfinding in the library: book searches and route uncertainty. *Reference Quarterly*, 30(4), pp. 519-527. July 1991.

[5] Harris, P. and P.J. McKenzie, What it means to be "in between": A focus group analysis of barriers faced by children aged 7 to 11 using public libraries. *The Canadian Journal of Information and Library Science*, 28(4), pp. 3-23, 2004

[6] Beneicke, A., J. Biesek, and K. Brandon, Wayfinding and Signage in Library Design, Libris Design Project. 2003.

[7] Li, R. and A. Klippel, Explorations of wayfinding problems in libraries: A multi-disciplinary approach. *Journal of Map and Geography Libraries*, 8(1), pp. 21-38, 2012.

[8] Mandel, L.H., Lost in the labyrinth: Wayfinding behavior in a public library—predictable? Maybe not. *Proceedings of the Association for Information Science and Technology*, 48(1), pp. 1-3, 2011.

[9] Bilal, D. and I. Bachir, Children's interaction with cross-cultural and multilingual digital libraries: Understanding interface design representations. *Information Processing & Management*, 43(1): pp. 47-64, 2007.

[10] Druin, A., et al., The International Children's Digital Library: Description and analysis of first use. January, 2003.

[11] Hutchinson, H.B., A. Druin, and B.B. Bederson, Supporting elementary-age children's searching and browsing: Design and evaluation using the international children's digital library. *Journal of the Association for Information Science and Technology*, 58(11), pp. 1618-1630, 2007.

[12] Borgman, C., V. Walter, and S. Hirsh, The science library catalog: A springboard for information literacy. *School Library Media Quarterly*, 24(2), pp. 105-110, 1996.

[13] Beck, G. S., Wayfinding in libraries. *Library hi tech*, 14(1), pp. 27-36, 1996.

[14] Bosman, E. and C. Rusinek, Creating the user-friendly library by evaluating patron perception of signage. *Reference Services Review*, 25(1), pp. 71-82, 1997.

[15] Borgman, C.L., et al., Children's searching behavior on browsing and keyword online catalogs: the Science Library Catalog project. *Journal of the American Society for information Science*, 46(9), pp. 663, 1995.

[16] Piper, D., S. Palmer, and B. Xie, Services to older adults: preliminary findings from three Maryland public libraries. *Journal of education for library and information science*, pp. 107-118, 2009.

[17] Kiesler, S. and J. Goetz, Mental models and cooperation with robotic assistants, *Proceedings on Human Factors in Computing Systems*, pp.576-577, ACM Press, Minneapolis, MN. 2002.

[18] Mikawa, M., Y. Morimoto, and K. Tanaka. Guidance method using laser pointer and gestures for librarian robot. in RO-MAN, 2010 IEEE.

[19] Saygin, A.P., et al., The thing that should not be: predictive coding and the uncanny valley in perceiving human and humanoid robot actions. Social cognitive and affective neuroscience, 7(4), pp. 413-422, 2011.

[20] Woods, S., K. Dautenhahn, and J. Schulz. The design space of robots: Investigating children's views. in Robot and Human Interactive Communication, 2004. ROMAN 2004. 13th IEEE International Workshop on. 2004. IEEE.

[21] Morales, A., et al. An experiment in the use of manipulation primitives and tactile perception for reactive grasping. in Robotics: Science and Systems, Workshop on Robot Manipulation: Sensing and Adapting to the Real World, Atlanta, USA. 2007.

[22] Behan, J. and D.T. O'Keeffe, The development of an autonomous service robot. Implementation: "Lucas"—The library assistant robot. *Intelligent Service Robotics*, 1(1), pp. 73-89, 2008.

[23] Lin, W., Yueh, H. P., Wu, H. Y., & Fu, L. C., Developing a service robot for a children's library: A design-based research approach. *Journal of the Association for Information Science and Technology*, 65(2), pp. 290-301, 2014.

[24] Campbell, C., Haines, C., Koester, A., & Stoltz, D., Media mentorship in libraries serving youth. ALSC White Paper 2015; Available from: http://www.ala.org/alsc/sites/ala.org.alsc/files/content/2015%20ALSC%20White%20Paper_FINAL.pdf.