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Published in:
Culture and Computing

DOI:
10.1007/978-3-030-50267-6_24

Publication date:
2020

Document version:
Accepted manuscript

Citation for pulished version (APA):
Vlachos, E., Faber, A., & Holck, J. P. (2020). A Robot in the Library. In M. Rauterberg (Ed.), *Culture and Computing: Proceedings of the 8th International Conference, C&C 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020* (pp. 312-322). Springer. https://doi.org/10.1007/978-3-030-50267-6_24

A Robot in the Library

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Abstract. If robots are to be beneficial and appealing within an international library setting, useful to patrons and cooperative with library personnel, then library culture becomes an important issue. Human-robot interaction designers need to consider technological factors, the library culture, as well as expectations from users to develop a solution that could withstand the fall of time and not atone when enthusiasm is lost. We reviewed the recent literature and performed qualitative analyses of our findings to explore the tasks that are proven to have been robotized in a library, and to investigate current cultural and technological barriers that would decrease acceptance rates of robots in a library. Search of Scopus, Web of Science, IEEEXplore, and LISTA databases was conducted complemented with Google searches. Articles with scientific content were included if they described the use of a robot in a library setting, were written in English, and were published within 2016-2018. We identified 1037 references and after title, abstract and full-text screening according to the eligibility criteria we included 18 records in our analysis. We summarize the main roles of library robots as: robots for navigation, book location and placement; robots as information desks; and robots in education. Barriers towards robotic acceptance was found to be: anxiety and fear among librarians of being replaced by robots; the lack of resources (time, money, space) for maintaining a robot and the cost of organizational restructuring; maintaining the enthusiasm around it over time; and the patrons' need for human contact.

Keywords: Robot, Library, Literature search, Technological benefits, Cultural barriers.

1 Introduction

In many parts of society, robots have been found to be able to replace physically demanding, dangerous, or repetitious human routines. The development within the field of Artificial Intelligence (AI) seems to hold the potential for more and more complex robotic task solutions which may not only mimic human, or "natural" movement, but also human decision making. In the library field, we are not quite there yet.

Some of the larger libraries around the world already have automated storage and retrieval systems (ASRS). This, for instance, applies to the Joe and Rika Mansueto Library at the University of Chicago [1] that introduced an ASRS capable of shelving 3.5 million volumes underground by size rather than classification, and the Bodleian Libraries' book storage facility at the University of Oxford [2] using an ASRS holding 8 million items. In a world that produces 2.5 quintillion bytes of data every day according to IBM consumer Products[1], vast amounts of information – and consequently huge quantities of printed material – are produced every single day. Automated library systems come in handy as part of manageable logistics solutions at larger libraries, whether the materials to be handled are books, or collections. Naturally, the ASRS facilities are an example of a controlled environment where the library users are completely absent and where only maintenance personnel will come close to the moving parts of the system. Smaller libraries don't have the need for ASRS but could -in theory- have other tasks robotized. Perhaps, a socially assistive robot (SAR) [3-5] designed to move autonomously among humans and capable of socially interacting with them could potentially have the skills to respond to the dynamic environment of a library.

To find out whether a robot could provide valuable assistance at any given library, one would have to initially look at the different routines and tasks at the library in question – and break every library task down into simple movements, or operations that a robot with the current technology would be expected to be able to execute. The handling and circulation of materials is one thing. But there are many other traditional librarian tasks to consider like the acquisition of materials that are to be cataloged, classification of materials, replacement of materials to more modern ones as part of the overall maintenance, and bibliographical support of researchers and students to name a few. Some academic libraries also provide bibliometric analyses at multiple levels and guidance on how to achieve scientific impact, anti-plagiarism support as well as information on research data management.

According to the rankings Frey and Osborne[6] have developed showcasing the job occupations and their probability of computerization, the profession of the librarian has a probability of 65% of being automated. The increasing technicalization of libraries is leading to a wide cultural diversification of patrons, library personnel and services. If a robot is to be usable, useful, and appealing to such a wide range of users, culture becomes an important issue.

The aim of this work is twofold. We explore the recent literature and perform qualitative analyses of our findings *to examine in practice the task areas that are proven to have been robotized in a library setting, and to investigate current cultural and technological barriers that would decrease acceptance rates of robots in the library of the future.* In the following sections we will describe our method and search strategy, present our results and discuss our findings.

[1] IBM Consumer Products Industry Blog, https://www.ibm.com/blogs/insights-on-business/consumer-products/2-5-quintillion-bytes-of-data-created-every-day-how-does-cpg-retail-manage-it/, last accessed 2020/01/21.

2 Method

2.1 Search strategy

A systematic literature search was performed [7], including the following bibliographical databases in order to maximize inclusion and to represent both robotic and information science literature: Scopus, Web of Science (WoS), IEEE Xplore Digital Library (IEEE) and Library, Information Science & Technology Abstracts (LISTA). The search query was composed of two components: the intervention (robot) and the context (library) taking into consideration of course the defined keywords as described in specific for each of the chosen databases. Free-text terms for the intervention search included: "robot*", "social* robot*", "personalis* robot*", "assistive robot*", and "artificial intelligence", while for the context search terms like "information specialist*", "librar*"and "librarian*" were included. The search was conducted in January 2019.

2.2 Study selection and inclusion criteria

Three reviewers independently screened the articles in a three-step process: first the title, then the abstract, and finally the full-text. An article was considered eligible if it described the use of a robot in a library setting. The studies were grouped together depending on the purpose the robot served in the library, and the grouping was done retrospectively and independently of the original articles. In particular, articles were included if they had scientific content; were published within 2016, 2017 and 2018; and if they were written in English.

3 Results

The initial search resulted in 1037 references: 571 from IEEE, 171 from LISTA, 99 from Scopus, 195 from WoS, and 1 from individual Google searches. After removal of duplicates, articles with no scientific content or irrelevant content, and after screening on title and abstract level 58 publications remained to be assessed for eligibility. A schematic flowchart of included references is shown in figure 1. A tricky part in the screening of articles was that many studies were referring to "software libraries", which are collections of data and programming code used to develop programs and applications. Hence, the high number of articles with no content. Articles with no scientific content, essays, debate articles, newspaper articles, or with irrelevant contents were excluded from the final search result, leaving 18 articles for the analysis. Table 1 below outlines the purpose the robot served, the benefits of the library by implementing a robotic solution, and the cultural and technological barriers reported.

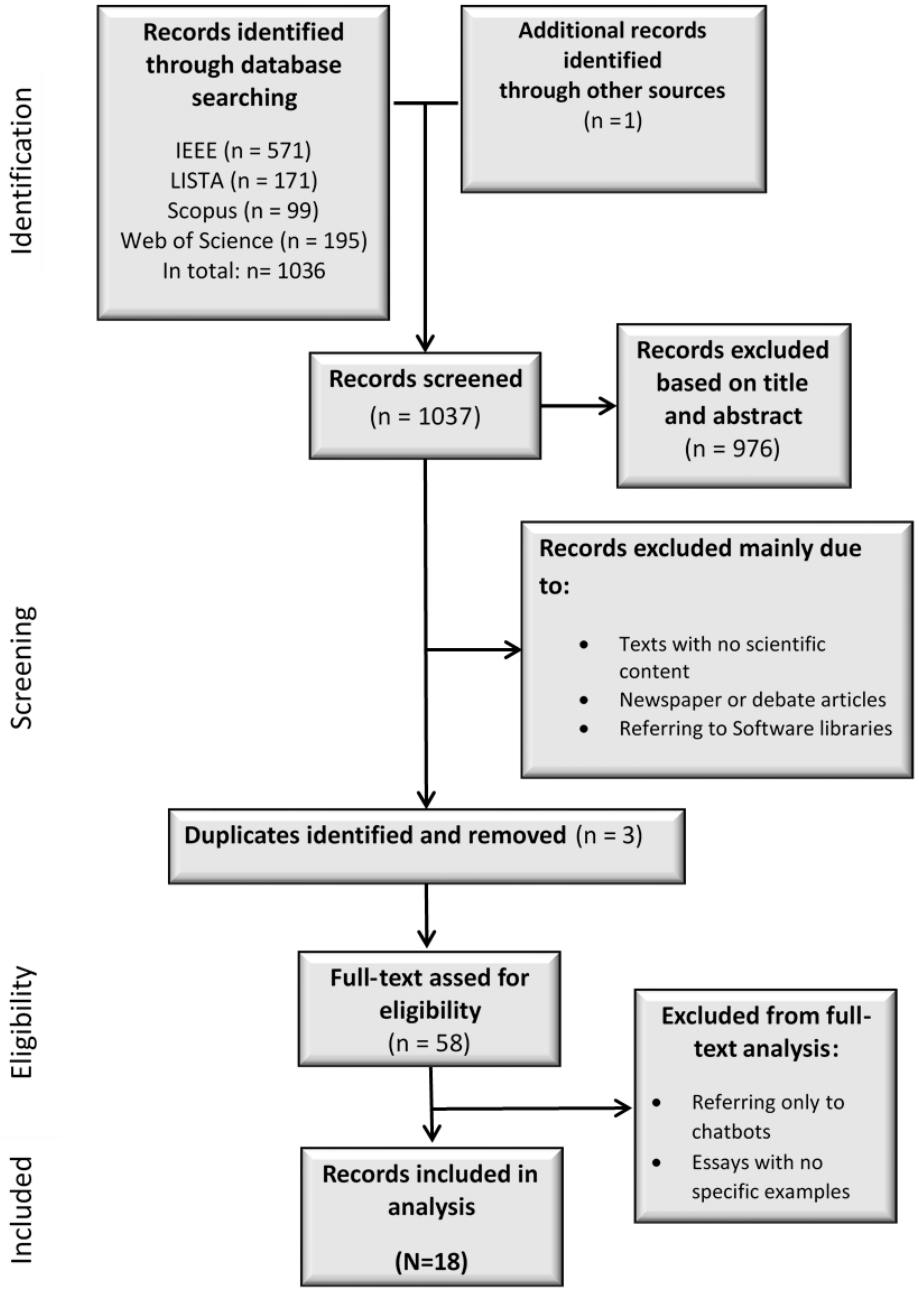

Fig. 1. Schematic flowchart of the review process, search method and results.

Table 1. Purpose, benefits and barriers on the use of robots in libraries.

Ref.	*Purpose*	*Benefits*	*Barriers*
[8]	Pick-and-place intelligent robot using an arm connected to the library database.	Avoid tedious and time-consuming tasks.	None mentioned.
[9]	Self-navigating book finder robot.	Finding books autonomously, saving time, and ideal for libraries with not enough personnel.	None mentioned.
[10]	Library management robotic system – pick-and-place.	Lessen curator inconvenience.	None mentioned.
[11]	Robotic assistance for children in book locating.	High efficiency, shorter time of book locating, user friendly, providing interesting navigation experience in the library.	Patron's unfamiliarity with robots. Robotic "strong guidance" could "limit children's opportunities of wondering and free browsing". The child users projected their expectations of human librarians onto the robots and expected them to have the same intelligence and professional skills.
[12]	Makerspace: robotics.	Library events – building, inventing, sharing and learning.	Coding and programming vs. building a robot? Funding and staff time?
[13]	Guiding robot, mascot of the university.	Interactive guidance at the university library, acceptance of robots.	None mentioned.
[14]	Intelligent agents to assist librarians and enable users' better access to their information.	Free librarian time and enable increased reference support or even off-hours support for users	Understanding what intelligent agents are, and their uses, is important for libraries for keeping up with the ever-changing technology landscape.
[15]	To gain insight into the information-seeking behaviors of patrons and to understand their perception of the library via affective computing.	Increased patron engagement and learning. Software senses the emotions of a user and provides appropriate response. To combine with for example an android robot acting as a team-mate in a learning situation.	Ethical, privacy, and cost effectiveness issues are at the top in a list of concerns.
[16]	Autonomous Book Location Management in big libraries. Robot on wheels.	Monitor book locations throughout the library, automatically detect book misplacements, and by camera help the loaner to locate the book.	None mentioned.
[17]	Mobile humanoid library assistant.	Interactive guidance and support at the library.	How to maintain the enthusiasm?

[18]	Mobile library assistant to search, locate and notify the user to collect the book.	With the increasing number of books, magazines and journals, running of library manually is a laborious and time-consuming task. Also, some books might get overlooked by the human eye. Good substitute for the manual work done by the users.	None mentioned.
[19]	Automatic shelf-scanning and self-navigating book finder robot.	Finding miss-shelved and lying-down books, liberating librarians from intensively manual labor.	Potential threat to replacing the librarian.
[20]	Telepresence robot for remote navigation and meetings.	Library tours, and online conversations with encounters, fostering communication within the libraries.	Potential threat to the librarians' job situation. People's fear of the robots turning evil. Technophobia, a sense of being monitored, or unfamiliarity with the intended purpose of the robot.
[21]	Recognize and manipulate books, localize itself and navigate using RFID tags.	Guide library users to a reference suitable source when a librarian is not available.	The state of library development in the use of AI in the field of public, technical, and management services.
[22]	Enhance library services and help improve students' information literacy skills.	Complement librarians' work and alleviate some of the burdens placed on librarians that will allow them to focus on more complex and time-consuming obligations.	Should academic law librarians consider using agent systems with the ever-changing legal environment and budgetary constraints that plague many of our libraries?
[23]	Placement of an AI lab in the library.	Students majoring in different fields, from philosophy to computer science and biomedical engineering, will visit the lab and use it to brainstorm about important social and ethical issues today and create cutting edge projects.	The very disruptive nature of any new technology could be viewed as a threat to many institutions, including the mission of the library.
[24]	Introduce young children to programming logic with the help of robots.	Libraries hold a unique position in our communities as informal learning platforms, and are perfectly positioned to bring our communities together. Robots are a great visual expression of writing a set of code to perform a task and make for a very interactive coding experience.	None mentioned.
[25]	Help bring technology fluency by coding with LEGO robotics courses to residents through digital literacy trainings.	The TechMobile is a fully-equipped computer lab on wheels, offered as a mobile outreach service of the library to people of all ages and abilities throughout the City of San Francisco for their recreational, educational and lifelong learning needs. Mobile Outreach brings the library to you!	None mentioned.

4 Discussion

4.1 Task areas and benefits

The articles collected constitute different approaches to – and views on – the use of robots in a library setting and have the potential of revealing world trends in the adaptation of robot technologies in libraries. Reading through our results in Table 1, we could identify three major task areas which will be further discussed in the subsections below:

- robots for navigation, book location and placement [8, 9, 10, 11, 16, 19, 21];
- robots serving as an information desk [13, 14, 17, 18, 20]; and
- robots in education [12, 22, 23, 24, 25].

Article [15] describes many adoption cases of robots in the libraries and does not fit into these areas, as it examines mainly artificial agents analyzing the information-seeking behavior of patrons for law libraries.

Robots for navigation, book location and placement
The automation aspect clearly plays an important part: If librarians/library staff can avoid tedious and time-consuming tasks – like detecting book displacements, putting books back on their shelves, finding lying-down books, or helping the loaners to locate their books – then they can spend their time doing more complex assignments [8, 9, 13, 16, 19, 21]. This is recommended for small libraries or libraries short of personnel and especially with a focus on high-volume repeatable assignments [10] while offering an "interesting navigation experience" [11].

Robots serving as an information desk
With the use of robots as information providers, the notion of high efficiency in a busy environment is stressed, complimented with the very modern experience *per se* of having robot technology in the library. The latter is described with buzz phrases like "interactive guidance" [13], or "a robot using intelligent agent-based software" [14]. These phrases imply, generally speaking, that robots are a futuristic experience and – depending on their type and functions of course – that they will engage the patrons in a welcoming, intelligent and creative way, adding value to the library activities as a whole [17]. Robots in this task area could act as telepresence robots for remote navigation and virtual meetings [20], as assistants to search, locate and notify the user to collect a book [18], or even as a university mascot [13].

Robots in education
Many libraries today host creative, interdisciplinary, informal makerspaces [12], artificial intelligent and robotic labs [23, 24], or even have computer labs on wheels [25] with the purpose of educating and bringing robotic fluency to the public they serve. There is a plethora of benefits in having an AI or robotic lab in the library [12, 23, 24, 25]: it offers students of various levels the opportunity to learn robotics through tutorials and workshops; students majoring in different fields can brainstorm together;

librarians can benefit as AI can make library collections FAIR (findable, accessible, interoperable and reusable) in new ways; and introduce young children to programming logic and coding with robotics. Intelligent personalized courses [22] with the assistance of intelligent agents can also help students improve their information literacy skills by making them more active participants in the learning process.

4.2 Cultural and technological barriers

By "cultural barriers" we understand ideas, customs and behavior among both library staff and patrons that may complicate, or even prevent the adaptation of a new mindset and, subsequently, a new way of doing things, a culture shift – in this case concerning the integration and use of robots in the library.

Depending on the perspective of library management and on the library resources at hand, one could speculate that tedious and time-consuming tasks would always be best handled by a robot. Nevertheless, we need to be reminded that the authors of the reviewed articles are mainly engineers who have come up with a robot solution to a library problem without necessarily considering the robot's impact on both the library patrons and the library services. Also, one would not expect the engineers to include harsh criticism of their own solution in their own publication – especially not, if the presented robot technology is supposed to be introduced to the market for library supplies and equipment. Therefore, *author bias* affected eight articles [8, 9, 10, 13, 16, 18, 24, 25] which had neither barrier nor limitation mentioned. The remaining ten articles from Table 1 indicate several cultural barriers for such an endeavor.

Most likely, some of the library's patrons will be quite *stressed or afraid when interacting with robots*. As reported in [11], robots caused anxiety and fear to children users as children were unsure of how to communicate within this unfamiliar environment. Children at a certain age could expect a robot to act as a human librarian and would possibly be very disappointed by a lesser performance [11, 22]. Also, it could be uncomfortable for patrons as well as library staff to be monitored by a robot [20] that may store personal data concerning human emotions and behavior [15].

Another cultural barrier reported is the library staff's need to *familiarize itself with the robots* in order to gain the best out of them [12] and be able to keep-up with such disruptive technologies [12, 14]. The many choices upon creating a makerspace and having to deal with coding, programming, and even building robots, may end up being a turnoff for library personnel. In many cases, and depending on the robot type and model, gaining the necessary robotics' skills [21] will be time-consuming. *Technophobia* [20] could in this case be seen as an example of a nonreceptive culture among librarians who may, or may not, have been part of the decision-making concerning acquiring a robot. In addition, the robot would demand working hours for its' operation, maintenance and administration that could act as a cultural barrier, if the library staff is unfamiliar with such technology, and economical barrier in case the library struggles with budgetary constraints [22]. Another barrier reported is the *maintenance of patron's enthusiasm* with the same robot after a couple of years [17], meaning that library personnel should come up with new ideas and tasks perfectly executed to maintain interest.

As shown in the articles [11, 15], robots and their corresponding computing technologies may come with severe limitations when compared to the capacity of a librarian. If a robot must work among the library patrons and employees, the robot must be completely safe with no risk of inflicting damage to humans, or to the library interior. *Maintenance and development costs* should be at a minimum and transparent for the library management [15].

Without any doubt, there is another important human factor to consider: In many libraries around the world, you will see shelving and book picking routines as tasks that are providing job opportunities for students and young people, modified duty work or flexible positions for people with disabilities and are engaging senior citizens at libraries in volunteer work. It goes without saying that a robot for shelving and shelf scans [19] would *deprive the opportunity of creating job positions* that are proven to be beneficial to society. As stated in [18], robots will "prove as a very good substitute for the manual work", and such statements is natural to invoke emotions of fear for librarians. *Fear*, of course, can generate resistance [20]. From a union perspective, one should consider whether the introduction of a robot would de facto lead to unemployment for members of the library staff, or disrupt employment contracts, and current work descriptions [20]. The library management should consider whether personnel to be replaced by a robot could easily be transferred to other duties, or retrained – and if not, what would be the consequences. From a psychological perspective, depending on the employee(s) in question, all sorts of negative emotional reactions could occur, possibly inflecting on the work environment in general [20, 23].

Another issue to be of some concern is – in addition to the arguments listed above – that especially students who gain work experience at a university library may, later, choose educational pathways that would eventually lead them back to the library world, even to a position at the very same library. From a recruiting perspective, this is of great importance to both the library management, and to the young employee. If student workers at the library were to be replaced by robots it would destroy the potential of this type of future recruitment. However, we should be reminded that "we do not have libraries just to create jobs for librarians" [26]. Furthermore, people with positive experiences from library work as mentioned above will tend to act as ambassadors for the library in question. At the present stage of robot technology, this is not likely to occur. Robots cannot speak fondly of libraries, unless they are programmed to do so, or are in fact operated by a human (telepresence robotics).

Robots could definitely assist librarians in their tasks, but librarians' tasks could never be automatized to the fullest degree [24, 27]. Librarians, first and foremost, are considered as intermediaries of communities as well as trustworthy, and humane advisers, they have to put up with people who are rude, or angry – even with people who are crying. Lastly, some patrons still prefer the "traditional" face-to-face-talk [20].

5 Conclusion

The adaptation of robot technology in a library may be furthered by inherent library needs, local/national and international trends, patron demands, and staff/management

demands. Currently, libraries with positive attitudes to new technologies and even prior experience with robotics seem to be inclined to invest in robots that could: autonomously navigate, locate and place books; serve as information desks; assist in the education of students and the patrons. Obstacles towards a robotic adaptation proved to be stress and fear among the library staff of being gradually replaced by robots, an unsatisfying level of robotic functionality and/or a simple reluctance to implement new and advanced library task solutions that, in turn, would demand retraining the library staff and perhaps even an organizational restructuring. The general lack of resources (staff time, money, space) would of course present an obstacle, as well as the cost of maintaining the patron's enthusiasm with robots in the long term. Finally, the smartness of robots has to be weighed up against the need for human contact – especially, regarding elderly people and young children.

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