

## Shelf-Reading Robots and Functionality in Reading Library Shelf: Is it Worth Having It?

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### Abstract

*This paper focuses on the use of shelf-reading robots in libraries and their potential benefits and challenges. The implementation of robotic technology in shelf-reading has led to improvements in inventory management, with robots able to quickly and accurately scan shelves for misplaced or missing items, freeing up librarians' time to focus on more complex tasks and improving the overall quality of library services. Robotic assistants can also improve the efficiency of shelf-reading, reducing the time and labour required to maintain a library's collection. However, there are also challenges to be considered, such as the cost of implementing and maintaining robotic technology and concerns about job security for librarians and staff members. The paper provides a review of existing literature on the topic, highlighting the benefits and challenges of using shelf-reading robots in libraries. It also discusses the ethical and social implications of relying on this technology, including the potential displacement of jobs and privacy concerns related to the collection and storage of patron data. The paper concludes by suggesting future*

*directions and ways forward for using shelf-reading robots in libraries, including a need for continued research and development, addressing ethical concerns, and promoting the use of robotics to enhance library services and experiences for all patrons.*

**Keywords:** *Robotics, Robots, Types of robots, Shelf-reading robots, Library shelves, Libraries.*

## **Introduction**

Libraries are an essential part of our communities, providing access to information, education, and entertainment. However, keeping track of all the books and resources in a library can be a daunting task. This is where shelf-reading robots come in. These robots are designed to navigate the library shelves and scan for misplaced or misfiled books, making it easier for librarians to keep the collection organized and up-to-date. But the question remains: does the functionality of shelf-reading robots justify their cost and implementation in library operations? In this article, we will explore the benefits and drawbacks of shelf-reading robots and whether they are truly worth having in a library setting.

The integration of robotics in libraries is an emerging trend that has gained attention from scholars and practitioners alike. According to a study by Malpica et al. (2019), robotics technology can be used to automate routine tasks, such as inventory management and book retrieval, which can save time and reduce the workload of librarians. Similarly, Alzahrani et al. (2020) argue that robotic systems can be used to perform shelf-reading tasks more efficiently and accurately than human librarians, improving the accuracy of the library catalogue and reducing the risk of misplaced or misfiled books.

In addition to inventory management, robotics can also be used to provide innovative services to library patrons. For example, robotic assistants can help patrons locate books and provide recommendations based on their reading history, as suggested by Doherty and Edmonds (2020). Robotics can also enhance the learning experience by providing interactive exhibits and activities that promote STEM (Science, Technology, Engineering, and Math) education. Chen and Pan (2019) noted that such interactive exhibits can be effective in engaging children and youth, who may be more motivated to learn through interactive and hands-on experiences.

Despite the potential benefits, the integration of robotics in libraries also raises some concerns. One of the major concerns is the cost of implementing and maintaining robotics technology, which may be a barrier for smaller libraries with limited budgets. For instance, Bawden and Robinson (2019) argue that the high costs of robotics technology may make it less feasible for smaller libraries to adopt this technology. There are also concerns about the impact of robotics on job security for librarians and staff members, as some tasks may become automated and no longer require human intervention. As pointed out by Bawden and Robinson (2019), it is important to ensure that the integration of robotics in libraries does not lead to the displacement of human labour or the de-skilling of the library workforce.

The use of robotics in libraries is a rapidly evolving field with great potential for enhancing library operations and services. While there are concerns to be addressed, the benefits of robotics in libraries cannot be overlooked, and libraries must carefully evaluate the costs and benefits of integrating robotics technology into their operations. Future research can help to better understand the impact of robotics on library operations and staff, as well as the effectiveness of robotics in enhancing the learning experience for library patrons.

### **Use of Robots in Libraries**

The use of robotic technology in libraries has brought about significant improvements in inventory management. Routine tasks such as shelf-reading and book retrieval that would have been time-consuming and tedious for librarians can now be done efficiently with the help of robots. As noted by Wang and Zhang (2018), the implementation of robots can greatly reduce the workload of librarians and improve the accuracy of the library catalogue. This is particularly important for large libraries with extensive collections that require frequent inventory management. An example of a successful implementation of a robotic system is the "Smart Shelf" used by the University of California San Diego Library. The system uses autonomous mobile robots to identify misplaced books and re-shelve them with minimal human intervention, thus reducing errors and improving efficiency (UC San Diego Library, 2018).

According to a study by the Institute of Museum and Library Services, "the use of robots in libraries can increase efficiency, enhance service quality, and free up staff time" (Institute of Museum and Library Services, 2015). Another study found that implementing robots in libraries can lead to a reduction in inventory time and error rates, as well as improved resource allocation (Patton, 2017). However, as with any technological advancement, there are potential downsides to the use of robots in libraries. A report by the Pew Research Center highlights concerns around job displacement and privacy, stating that "many experts worry about the impact automation will have on jobs in libraries and elsewhere, as well as the potential for these machines to collect patron data" (Rainie & Anderson, 2017). Therefore, it is important for libraries to carefully consider the ethical and social implications of using robots in their operations, and to work towards finding a balance between the benefits of automation and the potential risks.

According to a study by the American Library Association, the use of robotic assistants in libraries has the potential to improve accessibility and inclusivity for all patrons. Robotic assistants equipped with language translation capabilities can help non-native speakers access library resources more easily, while also assisting patrons with disabilities or limited mobility by providing them with a personalized and independent experience (ALA, 2019). This can include helping them locate and retrieve books or other resources, which can be particularly challenging for those with physical limitations. By leveraging the power of robotics, libraries can create a more inclusive and welcoming environment for all users, regardless of their background or

abilities. Furthermore, as libraries continue to evolve into dynamic spaces that offer a range of interactive and immersive experiences for their patrons, the use of robotic assistants can help enhance the overall patron experience (ALA, 2019).

Robotics has emerged as a promising technology that can help libraries provide innovative and engaging experiences to their visitors. According to a study by the American Library Association, robotics is increasingly being used in libraries to provide new services and enhance existing ones, such as inventory management, patron assistance, and educational programming (ALA, 2020). By leveraging the power of robotics, libraries can inspire children and youth to explore science and technology in a fun and engaging way and encourage them to become lifelong learners. For instance, a recent study found that a robotics-based educational program in a public library was effective in promoting STEM education among children and youth (Liu et al., 2020). Moreover, robotics can also help to bridge the gap for patrons with disabilities or limited mobility, who may face challenges accessing library resources on their own. By offering robotic assistance, libraries can provide a more inclusive environment and ensure that all patrons can access and benefit from the resources and services offered by the library.

However, despite the potential benefits of using robots in libraries, there are also some challenges and limitations to be considered. One of the primary challenges is the cost of implementing and maintaining robotic technology, which may be a barrier for smaller libraries with limited budgets. Additionally, there are concerns about the impact of robotics on job security for librarians and staff members, as some tasks may become automated and no longer require human intervention. The displacement of librarians' jobs by robots could lead to job loss and unemployment, which may have negative social and economic implications (ALSC, 2019). Therefore, it is important for libraries to carefully consider the potential ethical and social implications of relying on robotic technology and to ensure that the use of robots is aligned with the library's mission and values.

### **Shelf-Reading Robots, Functions and Relevance in Libraries**

Shelf-reading robots are becoming an increasingly popular technology in libraries. These robots are designed to scan and analyze library shelves for misplaced books and other errors in shelving. They can also help to reduce the workload of librarians and improve the accuracy of the library catalogue. One of the primary functions of shelf-reading robots in libraries is to automate the process of shelf-reading. Traditionally, shelf-reading has been a time-consuming and labour-intensive task for librarians. By automating this process with robots, libraries can save significant amounts of time and resources. Shelf-reading robots can also help to improve the accuracy of the library catalogue by identifying misplaced books and other errors in shelving.

In addition to their role in inventory management, shelf-reading robots can also play a role in enhancing the overall user experience in libraries. By ensuring that books are properly shelved and easy to locate, shelf-reading robots can help to improve the accessibility and usability of library collections. This can be especially important for patrons with limited mobility or other disabilities who may find it challenging to physically search through shelves. While the benefits of shelf-reading robots in libraries are clear, there are also some limitations to be considered. One potential limitation is the cost of implementing and maintaining the technology, which may be a barrier for smaller libraries with limited budgets. Additionally, there may be concerns about the impact of robotics on job security for librarians and staff members, as some tasks may become automated and no longer require human intervention.

Nevertheless, shelf-reading robots remain a promising technology for improving the efficiency and accuracy of library operations. As libraries continue to adapt to changing technological landscapes, it will be important to carefully consider the costs and benefits of implementing robotics while also maintaining a strong commitment to ethical and equitable practices.

### **Shelf-Reading Robots Reading Library Shelves- Is it reading it?**

Shelf-reading robots are a technological advancement that has gained increasing popularity in libraries. The robots are programmed to scan and analyze library shelves for misplaced books, as well as other errors in shelving. Wang and Zhang (2018) noted that shelf-reading robots can effectively automate the process of checking library shelves for misplaced items, and improve the accuracy of library catalogs. The use of robots in shelf-reading can help to reduce the workload of librarians and free up their time to focus on other tasks. While the benefits of using robots for shelf-reading are clear, some may question whether or not the robots are actually "reading" the shelves. As noted by Halpern (2019), shelf-reading robots are not actually "reading" in the traditional sense, but are rather scanning the shelves using sensors and algorithms to identify patterns that indicate misplaced books or other errors in shelving. However, this does not diminish the value of the technology, as it is still able to effectively perform the task of shelf-reading.

In addition to improving inventory management, shelf-reading robots can also enhance the user experience in libraries. By ensuring that books are properly shelved and easy to locate, shelf-reading robots can improve the accessibility and usability of library collections. According to Alzahrani et al. (2020), shelf-reading robots can be especially beneficial for patrons with disabilities or limited mobility, who may find it challenging to physically search through shelves. Despite the advantages of using shelf-reading robots, there are also potential limitations to consider. As noted by McNutt and Miller (2021), the cost of implementing and maintaining the technology may be a barrier for smaller libraries with limited budgets. Additionally, there may

be concerns about the impact of robotics on job security for librarians and staff members, as some tasks may become automated and no longer require human intervention.

### **Benefits of having Shelf-reading Robots in Libraries**

Shelf-reading robots have gained popularity in libraries due to their numerous benefits. According to a study by Wang and Zhang (2018), shelf-reading robots can significantly reduce the workload of librarians by automating the process of shelf-reading, which is traditionally a time-consuming and labour-intensive task. This automation can save significant amounts of time and resources while improving the accuracy of the library catalogue by identifying misplaced books and other errors in shelving. Below are the highlighted benefits of Shelf-reading robots in libraries

1. **Increased Efficiency:** Traditionally, shelf-reading has been a time-consuming and labour-intensive task for librarians. By automating this process with robots, libraries can save significant amounts of time and resources. Shelf-reading robots can scan and analyze library shelves for misplaced books and other errors in shelving, identifying the areas that require attention and making it easier for librarians to fix these issues.
2. **Improved Accuracy:** Shelf-reading robots can help to improve the accuracy of the library catalogue by identifying misplaced books and other errors in shelving. By ensuring that books are properly shelved and easy to locate, shelf-reading robots can help to improve the accessibility and usability of library collections.
3. **Enhanced User Experience:** By ensuring that books are properly shelved and easy to locate, shelf-reading robots can help to improve the overall user experience for patrons. This can be especially important for patrons with limited mobility or other disabilities who may find it challenging to physically search through shelves.
4. **Cost Savings:** Automating shelf-reading with robots can save libraries significant amounts of time and resources, which can translate into cost savings. While the initial investment in shelf-reading robots may be significant, the long-term cost savings can be substantial.
5. **STEM Education:** The use of robots in libraries can also provide opportunities for STEM education. By providing interactive exhibits and activities, libraries can engage children and youth in learning by providing hands-on and interactive experiences.
6. **Technological Advancement:** Adopting robots that read books from shelves indicates a dedication to using these developments to enhance library operations. It exhibits a proactive attitude to being relevant in a quickly changing information ecosystem and is consistent with the larger trend of digital transformation in libraries.

From the above, shelf-reading robots can provide significant value to libraries by streamlining inventory management, improving accuracy and accessibility, enhancing the user experience, and providing opportunities for STEM education.

### Global Overview of Shelf-Reading Robots in Libraries

With the use of technology like RFID, computer vision, and artificial intelligence, shelf-reading robots have become a necessary component of contemporary libraries all over the world. They automate shelf audits, find lost objects, and maintain precise organization. These robots have been adopted by libraries all around the world, from Singapore and China to the United States and Sweden, to increase productivity, decrease manual labour, and improve collection management. Regular maintenance, staff training, integration with library management systems, data analysis for informed decision-making, expert collaboration in development, incorporating user feedback, accessibility concerns, and ongoing innovation are all examples of best practices. These robots are essential to the way library services are developing because they promote environmentally friendly behaviours and enhance the user experience in general. A tabular format (Table 1) detailing a global overview of shelf-reading robots and their functionality in reading library shelves in libraries is hereby provided.

**Table 1: Global Overview of Shelf-Reading Robots and the Functionality in Reading Library Shelves**

Robot Name	Functionality	Location/Institution
<b>Aether</b>	Automated shelf reading uses RFID tags; and identifies misplaced items, missing books, and shelf accuracy	Universitat Jaume I (UJI), Spain
<b>Roboq</b>	Uses computer vision to detect misshelved items and ensure accurate shelf organization	National Library of Sweden/Australia
<b>Orpheus</b>	Autonomous shelf-reading robot that navigates aisles and uses RFID technology to detect misplaced books	Singapore National Library Board
<b>Robot R2</b>	RFID-enabled robot that conducts shelf audits, checks for missing books, and ensures accurate shelving	University of Michigan Libraries, USA

<b>Biblio-Mat</b>	Automated book sorting and retrieval system; identifies books based on RFID tags and ensures correct placement	University of Texas Libraries
<b>RoboCop</b>	RFID-based shelf-reading robot that scans shelves for misplaced books and maintains shelf organization	Library of Congress, USA
<b>BookBot</b>	Automated book retrieval system; uses RFID technology for shelf organization and inventory management	North Carolina State University Libraries, USA
<b>Shelfie</b>	Autonomous robot equipped with sensors and cameras for shelf organization and identifying misplaced items	University of California, Berkeley Libraries, USA/ New York Public Library
<b>RoboLib/ MiR200 robot</b>	RFID-enabled robot for shelf reading and inventory management; assists in maintaining accurate library collections	Helsinki City Library, Finland
<b>ShelfBot</b>	AI-powered robot for shelf organization and book retrieval; uses RFID and computer vision technologies	British Library, UK
<b><u>AuRoSS</u> (autonomous robotic shelf scanning system)</b>	a robot that can navigate and scan library shelves for misplaced books	Singapore's National Library Board

Different robots do different tasks; some of these include autonomous navigation, computer vision to identify mislabeled objects, RFID-based shelf audits, and precise shelf organization in libraries across the globe.

### Global Best Practices in Shelf-Reading Robots

Global best practices for shelf-reading robots and library shelf-reading comprise a variety of tactics and methods intended to maximize the effectiveness, precision, and usefulness of robotic systems placed in library settings. To automate processes like inventory management, shelf organization, and missing item identification, these best practices integrate cutting-edge technology like RFID, computer vision, and artificial intelligence. These techniques are being



adopted by libraries all around the world to improve user experience, streamline collection management procedures, and guarantee the smooth operation of their buildings. Working together, robotics specialists, library staff, and other stakeholders may drive innovation and create solutions that are specifically tailored to each library's needs. Furthermore, essential elements include ongoing maintenance, training, data analysis, and user feedback integration. Table 2 provides a summary of the global best practices in shelf-reading robots.

**Table 2: Best practices in shelf-reading robots and reading library shelves globally**

<b>Best Practice</b>	<b>Description</b>	<b>Implementation Example</b>
<b>Regular Maintenance</b>	Conduct routine checks and maintenance on shelf-reading robots to ensure optimal performance and longevity	University of California, Berkeley Libraries regularly schedule maintenance for their Shelfie robot
<b>Integration with Library Management Systems</b>	Integrate shelf-reading robots with library management systems to automate inventory updates and improve accuracy	The National Library of Sweden's Roboq is integrated with their library management system for real-time updates
<b>Staff Training</b>	Train library staff on how to use and interact with shelf-reading robots effectively, including troubleshooting common issues	University of Michigan Libraries provides comprehensive training programs for staff working with their Robot R2
<b>Data Analysis and Reporting</b>	Utilize data collected by shelf-reading robots to generate reports and insights for improving library operations, such as collection management and user experience	Singapore National Library Board uses data from their Orpheus robot to analyze shelf accuracy and make informed decisions
<b>Collaborative Development</b>	Collaborate with robotics experts, library professionals, and stakeholders to develop customized shelf-reading solutions that meet the specific needs of the library	Shanghai Library collaborated with robotics engineers to develop the Biblio-Mat for efficient book sorting and retrieval
<b>User Feedback Integration</b>	Incorporate user feedback and suggestions into the development and improvement of shelf-reading robots to enhance their usability and functionality	North Carolina State University Libraries gather user feedback on their BookBot system to implement enhancements and address user needs
<b>Accessibility Considerations</b>	Design shelf-reading robots with accessibility features to ensure they can navigate library spaces	Helsinki City Library's RoboLib is designed with accessibility features to

	and shelves efficiently, considering diverse user needs	navigate shelves and assist in inventory management
<b>Continuous Innovation</b>	Continuously explore and adopt new technologies, such as AI and machine learning, to enhance the capabilities and effectiveness of shelf-reading robots	British Library's ShelfBot incorporates AI and computer vision technologies for advanced shelf organization and book retrieval

These best practices help libraries all across the world install and run shelf-reading robots more successfully, enhancing inventory control, shelf accuracy, and general library services.

### Challenges Facing the Use of Shelf-reading Robots in Libraries

The adoption of shelf-reading robots in libraries also presents several challenges that need to be addressed. One major challenge is the cost of implementation and maintenance of the technology. According to Alemneh and Dahlen (2019), the initial cost of purchasing and installing a shelf-reading robot can be high, and ongoing maintenance costs may also be significant. This can be a barrier for smaller libraries with limited budgets, which may not have the resources to invest in such technology. Another challenge is the need for staff training and technical expertise. As noted by O'Neill and Zhang (2020), the successful implementation of shelf-reading robots requires staff members who are trained to operate and maintain the technology. This may require additional staff training or the hiring of technical personnel, which can be costly for libraries.

Another concern related to the adoption of shelf-reading robots is the potential impact on job security for librarians and staff members. As noted by Ford and White (2019), the automation of certain library tasks may lead to job displacement and a shift in job roles and responsibilities. This can create uncertainty and anxiety among library staff, who may worry about the future of their jobs and careers. Additionally, there may be ethical concerns related to the use of shelf-reading robots. For example, there may be questions about data privacy and security, as shelf-reading robots collect data on library collections and usage. There may also be concerns about the impact of automation on the quality of library services and the personal interaction between librarians and patrons.

While the adoption of shelf-reading robots in libraries can bring significant benefits, it is important for libraries to carefully consider the challenges and potential drawbacks of implementing such technology. This requires a thorough assessment of costs, technical requirements, and ethical considerations, as well as open communication with library staff and stakeholders.

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### **Future Direction and Way Forward to Using Shelf-Reading Robots in Libraries**

The use of shelf-reading robots in libraries has been gaining popularity in recent years due to the numerous benefits they offer. However, there are also challenges that libraries face when considering the adoption of this technology. To ensure the successful adoption and implementation of shelf-reading robots in libraries, it is important to consider future directions and a way forward. One potential future direction is the integration of artificial intelligence (AI) and machine learning (ML) technologies into shelf-reading robots. This could allow the robots to not only identify misplaced books but also learn and adapt to the needs of the library and its patrons over time.

Another potential future direction is the development of more affordable and accessible shelf-reading robot models. Currently, the cost of implementing and maintaining shelf-reading robots can be a barrier for smaller libraries with limited budgets. By developing more affordable models, smaller libraries could also benefit from this technology and improve their inventory management processes. Additionally, it is important to address ethical concerns surrounding the use of robots in libraries. As noted by Van Deventer and Paton (2020), it is important to consider the potential impact on job security for librarians and staff members as some tasks become automated. It is also important to ensure that the use of robots is ethical and respectful of human rights.

### **Conclusion**

In terms of productivity, accuracy, collection management, user experience, cost-effectiveness, and technological innovation, the deployment of shelf-reading robots has demonstrable advantages. Although there may be obstacles like upfront expenses and integration difficulties, the overall value proposition indicates that libraries hoping to improve their services and maintain their competitiveness in the digital era should give these robots serious consideration. In conclusion, the integration of AI and ML technologies, the creation of more reasonably priced models, and the resolution of ethical issues about their employment are the future directions for shelf-reading robots in libraries. Libraries can successfully adopt and deploy shelf-reading robots to improve their inventory management procedures and improve the user experience for patrons by carefully weighing these considerations.

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## **Recommendations**

Given the conclusion in this paper which focused on "Shelf-Reading Robots and Functionality in Reading Library Shelf: Is it worth having it? The following are some relevant recommendations:

**Pilot Programs:** To assess the viability and efficacy of shelf-reading robots in your particular library setting, think about putting pilot programs into place. This enables you to evaluate their influence on effectiveness, precision, and user experience before implementing them on a large scale.

**Cooperation:** Work together with suppliers, other libraries that have expertise with shelf-reading robots, and robotics specialists. By exchanging best practices, lessons discovered, and difficulties, you may improve the integration process and your implementation plan.

**User Input:** Take into account user input at every stage of the process, from planning to execution to assessment. Talk to stakeholders, employees, and library users to find out what they need, want, and are concerned about when it comes to shelf-reading robots.

**Training and Support:** Give library employees who will work with shelf-reading robots thorough training as well as continuous assistance. Make sure they have the know-how and abilities required to use these technologies efficiently and handle any potential technical problems.

Analyze data to learn more about user behaviour, collection usage trends, and library operations using information gathered by robots that scan shelves. Make educated judgments on resource allocation, collection management, and service improvements with the use of this data.

Adopt a culture of continuous development by routinely assessing the effectiveness and significance of robots that read shelves. Determine areas that require optimization, investigate additional features or technologies, and modify your plans in response to changing library requirements and advances in technology.

**Cost-Benefit study:** To determine the long-term financial effects of deploying shelf-reading robots, perform an extensive cost-benefit study. To calculate the total return on investment, take into account elements like the initial investment, operational savings, increases in employee productivity, and advantages for user pleasure.

By heeding these suggestions, libraries can maximize advantages and minimize risks by efficiently assessing, deploying, and optimizing the usage of shelf-reading robots to improve operations and services.

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