

The Digital Librarian: Navigating Human–Robot Interaction in the Information Age

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ABSTRACT

Humanoid robots and artificial intelligence (AI) are becoming increasingly integrated into library operations, transforming the way these institutions function. This article explores the landscape of human-robot interaction (HRI) within libraries, examining historical contexts, the role of robotics in automation, and design principles for effective HRI. It includes real-world implementations, addresses ethical considerations, and discusses the challenges and opportunities in incorporating robotics. The article also investigates how AI augments the roles of human librarians and analyzes the implications of HRI on information retrieval. Robotics and AI are transforming libraries, but there is still significant room for growth and development in this area as libraries navigate the challenges and opportunities presented by these emerging technologies. Future trends include further automation of library tasks, AI-powered information retrieval, and the continued evolution of human-robot interaction within library settings.

INTRODUCTION

The integration of robotics into library services marks a significant evolution in the way libraries operate. Historically, libraries have been vital cultural and educational institutions, serving as repositories of knowledge and intellectual hubs of learning. With the advent of the digital era, libraries have undergone profound transformations to adapt to the transformative paradigm of information discovery (Asemi, Ko & Nowkarizi, 2021). This transformation is rooted in the broader digital revolution that began in the late 20th century. Key milestones in this evolution include the development of electronic cataloging systems, online databases, and digital repositories. This development has, over time, significantly enhanced the accessibility and dissemination of information. However, the introduction of digital cataloging systems allowed libraries to manage and search their collections more efficiently, transitioning from card catalogs to digital catalogs and marking a significant improvement in information retrieval. Furthermore,

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the proliferation of online databases provided patrons with access to a wealth of information resources beyond the physical confines of the library, including academic journals, e-books, and multimedia content, accessible from anywhere with an internet connection. In view of this, libraries around the world began to develop digital repositories to preserve and provide access to their unique collections, such as historical documents, rare books, and institutional records, ensuring long-term preservation and accessibility (Yoganingrum, Rachmawiti & Koharudin, 2022).

Afterwards, the use of robotics in libraries began to evolve, reflecting broader trends in library automation and technological advancement. Initially, robotic systems were employed for basic tasks such as sorting and shelving books. Early robotic systems in libraries were primarily focused on automating repetitive and labor-intensive tasks, improving efficiency by reducing the time and effort required for tasks like book sorting and inventory management (Folorunsho & Momoh, 2020). Over time, advancements in robotics, especially Artificial Intelligence (AI), have enabled more sophisticated applications. Today, robotics in libraries extend to more interactive and user-centric applications, including assisting with information retrieval, providing navigation guidance within library spaces, and interacting with patrons using natural language processing (Tella and Ajani, 2022). Looking ahead, the potential for robotics in libraries includes autonomous robots capable of performing complex tasks, integrating with AI for personalized user experiences, and utilizing immersive technologies to create interactive learning environments (Oladokun, Owolabi, Aboyade, Wiche & Aboyade, 2023). As libraries continue to adapt to the digital age, the strategic deployment of these advanced robotic and AI-powered systems remains crucial in enhancing the efficiency, accessibility, and user experience of library services.

Correspondingly, effective human-robot interaction (HRI) design is crucial for ensuring seamless and productive interactions between humans and robots in library settings. Key design principles according to Licardo, Domjan, and Orehovacki (2024) include user-centered design, which ensures that interactions are intuitive and user-friendly; natural language processing (NLP), which allows robots to understand and respond to human language, making interactions more natural and efficient; and emotional intelligence, which equips robots with the ability to recognize and respond to human emotions, enhancing user engagement and satisfaction. Real-world examples of robotic implementations in libraries provide valuable insights into the practical applications and benefits of HRI. Libraries have implemented robotic systems to automate the sorting and shelving of books, significantly reducing the workload on human staff and increasing operational efficiency (De-Sarkar, 2023). Some libraries have deployed service robots that assist patrons with information retrieval, provide directions, and offer personalized recommendations based on user preferences (Adetayo, Abwaye & Oduola, 2023). The strategic integration of robotics and AI-powered systems in libraries has the potential to revolutionize library services, improving efficiency, accessibility, and user experiences. As libraries continue to adapt to the digital age, the thoughtful design of HRI will be crucial in ensuring that these technologies enhance, rather than replace, the valuable role of librarians and other library staff.

Notably, the integration of robotics into library operations raises several ethical considerations that must be addressed to ensure responsible and equitable use of technology. Ensuring that patron data is protected and that robotic systems adhere to privacy standards is crucial. The automation of tasks traditionally performed by human staff raises concerns about job displacement and the need for reskilling and upskilling library personnel. Ensuring that robotic systems are accessible to all patrons, including those with disabilities, is essential for equitable service provision (Shahzad, Khan & Iqbal, 2024). Furthermore, the deployment of robots must be equitable, ensuring all patrons, regardless of technological proficiency, can benefit from robot-assisted services to avoid creating a digital divide. Collaborative

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