Welcome to the Library: Integrating Social Robots in Indian Libraries

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Abstract. Libraries are very often considered the hallway to developing knowledge. However, the lack of adequate staff within Indian libraries makes catering to the visitors' needs difficult. Previous systems that have sought to address libraries' needs through automation have mostly been limited to storage and fetching aspects while lacking in their interaction aspect. We propose to address this issue by incorporating social robots within Indian libraries that can communicate and address the visitors' queries in a multi-modal fashion attempting to make the experience more natural and appealing while helping reduce the burden on the librarians. In this paper, we propose and deploy a Furhat robot as a robot librarian by programming it on certain core librarian functionalities. We evaluate our system with a physical robot librarian (N = 26). The results show that the robot librarian was found to be very informative and overall left with a positive impression and preference.

Keywords: Human-Robot Interaction · Robot Librarian · Education Technology · Social Robotics · Indian Library · Robot Applications

1 Introduction

Revitalizing libraries is essential for ensuring access to Knowledge[1]. However, it has been found that the workload of the Indian librarians continues to be unbalanced with challenges in the inadequacy of staff [1–3]. In recent years, Indian libraries have adopted the Online Public Access Catalog (OPAC) system [4], allowing students to search for books using important keywords. However, they still lack aspects that the user would much rather benefit from or prefer such as giving instructions over voice than text [5].

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[1] https://tinyurl.com/KnowledgeCommissionReport.

O. Palinko et al. (Eds.): ICSR + AI 2024, LNAI 15563, pp. 239–246, 2025.
https://doi.org/10.1007/978-981-96-3525-2_20

Prior works have investigated the use of robotic systems in libraries mainly under two aspects: assistance to the librarian and guiding visitors. Robots are used for automatic retrieval, storage, and cataloging [6,7] to assist librarians better. On the other hand social robots, capable of communicating through a social interface [8,9], have also been used to interact and help the visitors in a library. For example, [10] presented the Xiaotu robot which could communicate with users using voice or text via its mobile app or PC, to provide information about the books in the library. They found such a system to be promising and engaging. Similarly, [11] lists various robots in Japanese libraries, including Pepper robots that are used to guide visitors or provide information via teleoperation. However, [12], found that students who interacted with a library information-providing Pepper robot found the robot creepy and negative. This prompts further investigation into the perception of incorporating similar robotics systems to help library visitors. In this paper, we try to verify if culture plays a role in the perception of such systems (i.e. if Asian library visitors respond positively). Another aspect we try to address is the lack of free-flowing face-to-face conversations in previous systems. Most prior systems either incorporated mechanical-looking robots with touchscreen interfaces such as Pepper robots, or teleoperated human-looking robots for interaction.

In this paper, we program the multi-modal social robot Furhat on certain core librarian modules to act as a robot librarian. We evaluate these modules based on user evaluations of the robot librarian to assess the acceptance and efficiency of the overall solution. This serves as a proof of concept for future scalability within Indian libraries. To the best of our knowledge, this is one of the first attempts at implementing a robot librarian and assessing the implementation of such a system in India.

2 Robot Librarian

2.1 Development

The goal of the Robot librarian is to interact with library visitors, by providing library related information and answering any queries about the library they may have. Additionally, the robot should be able to provide information about any events taking place in the institute and any other miscellaneous information about the library or the institute. A key consideration was to enable face-to-face interaction capabilities in the robot librarian which would emulate interaction with a real librarian. Thus, to that effect, the various modules were defined for the robot librarian.

For each module, corresponding intents were defined using the integrated NLU engine of the Furhat robot[2]. Based on the module selected, data was fetched from the MySQL database, and the information was used to formulate the robot's response. For example, if the visitor asked *"Do you have any books by George RR Martin?"*, the intent classifier would classify it as the *BookAvailability* module.

[2] https://docs.furhat.io/nlu/.

This will query the database to fetch all the books under the author's name and send it to the *Response Formulation* module. An outline of the developed system has been provided in Fig. 1.

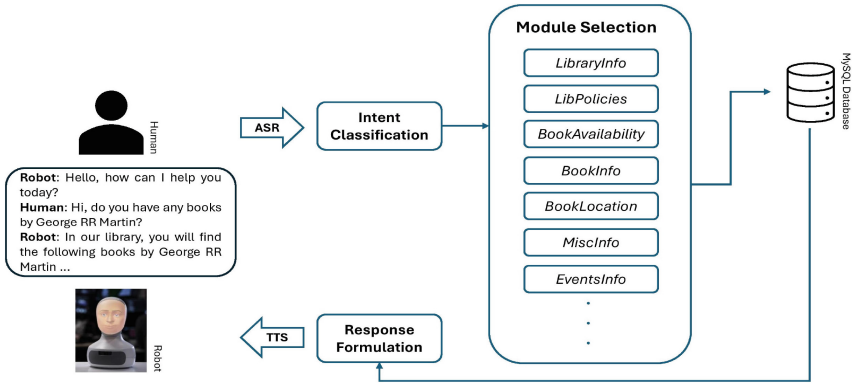

Fig. 1. Outline of the robot librarian architecture

The system was implemented at the Indian Institute of Technology Mandi (IIT Mandi). IIT Mandi uses the Koha library management system's OPAC for catalog searches and user account management with about 50033 books (22595 print books and 27438 E-books)[3]. However, as a first iteration, we opted for a simpler approach using a MySQL database to focus on core functionalities. The MySQL database included fields for Book Name, Author, Genre, Subject, Keywords, a one-line description, renewal count, addition date, and location (aisle and shelf number) to replicate parameters on OPAC.

A Furhat robot [13] was selected as the robotic platform to develop the robot librarian. The robot has a back-projected animated face projected onto a translucent mask making it possible to exhibit nuanced human-like facial movements. It supports Automatic Speech Recognition (ASR) using either Google Cloud or Microsoft and Text-to-Speech (TTS) using Amazon Polly Cloud or Acapela.

2.2 Feedback

Once the development concluded with the features discussed in Sect. 2.1, we collected feedback from immediate stakeholders. Stakeholders were defined as either the direct users of such a robot librarian or the people who have insights into the functioning of a library. Feedback was collected from 6 students, 2 librarians, and 1 administration staff at the IIT Mandi. Participation was voluntary and each stakeholder interacted with the developed system using a virtual Furhat setup. They were asked to evaluate the system and its usability in a library. Table 1 summarizes the feedback points received.

[3] https://library.iitmandi.ac.in/page/about-us.

Table 1. Feedback Collected from Different Roles.

Role	Feedback
Librarian	Missing information on borrowing penalties, library timings, total books in library
Admin	Shelf number format differs from implementation, conversation delays
Students	Missing tailored negative responses, issues with author/book name recognition, unnatural phrase repetition, missing book descriptions

Based on the feedback, several changes were made to the modules, intent classifications, and database querying.

3 Evaluation

The implemented system was evaluated with the help of a user study where the robot librarian was deployed in a real-world setup. A Furhat robot with the 'default' character, "Polly Neural Joanna voice", and a multi-directional microphone was set up on the second floor of the Central Library (A16) of North Campus, IIT Mandi as seen in Fig. 2. A traditional hat was placed on the head of the robot to make it appear more local.

Participants: A total of 26 participants were recruited for the real-world evaluation of the system (9 females and 17 males) with ages ranging from 19 to 40 ($mean = 23.92, SD = \pm 5.06$). All the participants were students (the target population for the robot librarian setup). Participation in the study was voluntary. Participants had to be randomly approached and recruited on the North Campus of IIT Mandi as the evaluation took place during the summer break resulting in a low flow of students in the library. The evaluation took place for 2 days.

Process: The Participants were given a brief overview of the experiment. They were asked to keep in mind the capabilities the robot would mention in its monologue and ask it any questions they might have asked a librarian. We did not restrict the interaction in any way. After obtaining their written consent to participate, they were seated in front of the robot and the experimenter initiated the interaction. The experimenter was also present nearby to tackle technical failures such as internet failure but the participants were given sufficient space. The Robot first introduced itself and gave a monologue on its capabilities before proceeding to an interaction with the participant. At the end of the interaction, participants were handed two questionnaires. The first questionnaire comprised a subset of the Godspeed questionnaire (Perceived Intelligence and Likeability dimensions) [14]. The second questionnaire had 15 5-point Likert scale questions that asked the participants about their interaction with the robot librarian. We decided to hand-craft another questionnaire to ask targeted questions regarding

the interaction with the robot, thus enabling us to obtain an overall rating from the Godspeed questionnaire and targeted ratings from the other. The questions were categorized into 2 dimensions as noted in Table 2. Participants were also asked to provide an overall preference at the end of the questionnaire (the exact question asked was "*I would like to have a robot librarian in the institute.*").

Table 2. Survey Questions for Robot Librarian Evaluation (Dimensions D1-D2)

Dimension	Questions
Informativeness (D1)	Q1: I found the robot to be well-informed about the books in the library Q2: I found the robot to be well-informed about the events in the institution Q3: The robot librarian was able to understand my needs Q4: The robot librarian was able to give me the answers I was looking for
Positive Impression (D2)	Q5: I feel positively about having a robot librarian Q6: I feel positively about asking about books to the robot librarian Q7: I feel positively about the robot librarian giving me book recommendations Q8: I feel positively about the robot librarian giving me details about the events in the institute

Fig. 2. Physical Furhat Setup.

4 Results

On average each interaction with the robot librarian lasted 5–7 mins. It was found that the participants found the robot librarian to be informative (average rating for D1 was 3.519, $SD = \pm 0.974$) and had a positive impression of the interaction (average rating for D2 was 3.923, $SD = \pm 0.845$). Average ratings for the Godspeed questionnaire subscales were also found to be positive with 4.240

($SD = \pm 0.568$) for *Likeability* and 3.615 ($SD = \pm 0.720$) for *Perceived Intelligence*. Additionally, it was found that participants rated the verbal question about overall preference at an average of 4.077 ($SD = \pm 0.935$) showcasing that they would prefer such a robot librarian in the library.

5 Discussion

The objective of this study was to assess the perception of a robot librarian in an Indian library. A robot librarian in a real-world library setup has not been tested so far (to the best of our knowledge) in India and our work would provide an initial assessment of such a system. On the other hand, the conflicting assessments of robot systems in libraries in China [10] and Australia [12] warranted further exploration. If the difference was due to culture then we expected Indian students to prefer a robotic librarian (in line with [10] and [11]).

Results from the real-world evaluations of the system showed that the robot librarian was perceived positively. A few participants pointed out that the robot's ability to gesture and follow the participant with its gaze was a big positive for them. This pointed towards a cultural effect in the acceptability and preference for such a system. However, our study did not control for culture and this could be a potential direction for future research. Additionally, the novelty effect may have also contributed to the positive results. During the evaluation, we noticed that students rarely asked the robot questions about the events in the institutions or for book recommendations. This was further evidenced by the inconsistencies (high individual variation) in their ratings for Q2 ($m = 3.11, SD = \pm 1.24$), Q7 ($m = 3.88, SD = \pm 0.99$), and Q8 ($m = 3.07, SD = \pm 1.29$) during the analysis of data. This could indicate that most students do not expect to get any book recommendations or information about events from a robot librarian. We also noticed that the ASR system struggled with accented speech resulting in difficulty having a smooth conversation. For a robot librarian to be deployed in a language-diverse country such as India [15], ASR systems must be robust enough to detect accented speech correctly. A system having a screen (similar to the Pepper robot) where the user can read the conversation they are having with the robot could mitigate ASR errors and prompt the user to reiterate their speech/ command.

6 Conclusion

In this paper, we proposed and implemented a robot librarian incorporating certain librarian-specific modules. The system was evaluated using a user study with a real-world setup with a robot librarian. Results revealed that students found the robot librarian to be well-informed and it was perceived positively. Our study provides early evidence of a positive impression of adapting such a robot librarian system in Indian libraries. Additionally, it brings to question two crucial aspects that need to be explored further: (i) the influence of culture in adapting such systems and (ii) the influence of a well-defined role when implementing such

a robotic solution. In a broader perspective, a robot librarian could be a solution to address the problem of understaffed Indian libraries.

Acknowledgments. The authors are thankful to the Indian Institute of Technology Mandi, IIT Mandi iHub and HCi Foundation, and Symbiosis Institute of Technology, Pune for providing the research equipments, library facilities and space for this research work.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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