

Design And Development of an AI-Driven Smart Library: Enhancing User Experience Through Personalised Book Recommendations and Voice-Based Natural Language Search

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Abstract:

This This paper presents the design and development of an AI-based smart library system developed as an Android application, which intends to transform the traditional library services into an intelligent and friendly environment. The proposed system applies machine learning algorithms to offer personalized book recommendations to users based on their preferences and reading behaviours, thereby promoting user engagement and interaction. Additionally, the system also applies voice-based natural language search, which enables users to interact with the library in a conversational way, making it simple and efficient to access the library resources. With the provision of both personalization and efficient search, the smart library system intends to make library services more accessible, reduce search time, and provide an engaging learning environment. The proposed system is scalable and user-friendly, which can be used in both educational and public libraries. The experimental analysis highlights the effectiveness of the system in optimizing library management and delivering an enriched user experience, which is an essential requirement for next-generation educational infrastructure. In addition to the technological advancements, the smart library framework also addresses user-centric design. This will ensure that digital engagement is inclusive for all demographics. The integration of artificial intelligence in the system not only optimizes the search process for data but also ensures continuous learning by adapting the dynamics of user behaviour. The integration of voice interaction in natural language processing further enhances inclusivity. This will enable users with diverse digital literacy to engage with the library seamlessly. The integration of personalization and inclusivity in its framework ensures that the system not only positions itself as a management system but also as a learning companion.

Keywords: Artificial intelligence, Smart library system, Personalized book recommendations, Voice based NLP, Android application development, User-Centric design.

1. Introduction

Conventional library management, Although these systems were effective in their era, they tend to be highly dependent on physical records and card indexes, which are time-consuming and often inefficient [1].

Users tend to have difficulty in searching for a particular item, especially in a large collection, and librarians have to put in considerable effort to keep the records up to date [2]. As the complexity of information requirements has increased, the inefficiencies of manual systems have become more apparent. Conventional digital library management systems, although an improvement over manual systems, tend to have deficiencies [3]. Presently available applications tend to offer only basic search and borrowing facilities in catalogs, without the need for sophisticated personalization or intelligent searching. Users tend to get generic search results, which do not take into account individual preferences or learning objectives [4]. Additionally, accessibility is also a problem, as most systems tend to use text-based interfaces, which may not be supportive of different user groups, including the disabled and those with low digital literacy [5]. The accelerated digital change in the education sector has significantly impacted the way students engage with knowledge [6,7].

By leveraging intelligent technologies, libraries can transcend their status as knowledge repositories and become vibrant learning companions that aid in academic and lifelong learning. Artificial Intelligence (AI) has the potential to bring about a paradigm shift in overcoming the

challenges of traditional systems [8]. Recommendation systems can analyze user behavior, reading habits, and preferences to provide highly personalized suggestions, thus encouraging usage and resource utilization [9]. AI-powered analytics can also aid libraries in predicting demand trends and making informed resource allocation decisions. By integrating intelligence into library systems, organizations can develop a system that adapts to changing needs. Natural Language Processing (NLP) further enhances the functionality of smart libraries by allowing easy search options in a conversational way [10]. Rather than searching for information using keywords, one can use the system through voice commands or natural language queries such as “Find me books on cognitive security.” This not only allows easy search options but also allows information to reach all [11]. NLP interfaces are most helpful for people who lack technical knowledge, ensuring that information reaches all. Even though digital library systems have developed, there is a lack of efficient platforms that combine AI-driven personalization and voice-assisted NLP search functionality into one system. Current solutions tend to concentrate on either personalization tools or basic cataloging systems, thus creating a gap in comprehensive intelligent library solutions [12]. Moreover, there has been a lack of focus on the development of systems that are technologically superior as well as user-friendly. The driving force behind this research work is the creation of a smart library system that uses AI and NLP to improve user experience [13]. The proposed system will

aim at minimizing search time, making it more user-friendly, and improving user engagement with the library [14]. The Android platform was selected for development based on its popularity, affordability, and ability to support a wide range of users [15]. The main aim of this research work is to design and develop an AI-based smart library application that improves user experience through personalized book recommendations and voice-assisted natural language search [16, 17].

2. Methodology

Figure 1 illustrates the system Smart library management system architecture, showing the interaction between the Android mobile application, the backend server, and the database. The user interface at the top enables users to enter queries either in text form or voice form. The text query is directly processed by the book search module, while the voice query is processed by the Natural Language Processing module, which converts the voice query into text format and then determines the intent.

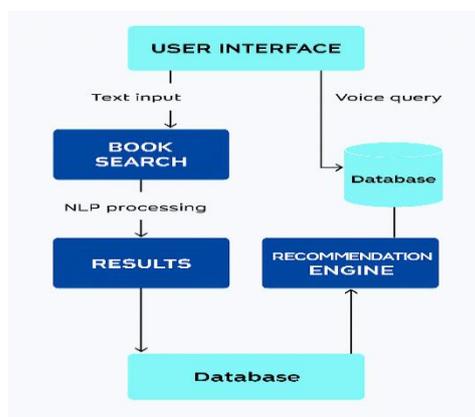


Figure 1: System architecture of the smart library management system

Both modules are able to identify relevant book information from the central database. On the other hand, the AI recommendation engine module is able to identify user history and preferences for recommendations. The backend server acts as the central processing module, which is in charge of the flow of information between modules and offers real-time updates. Each module is represented by a colour for easy identification: blue for the app, green for the backend, orange for the AI engine, purple for NLP, and grey for the database.

2.1 System Management

The A smart library system is developed as an Android application with a backend server and an organized database. The Android application offers accessibility to a wide range of devices, while the backend server offers the major operations such as the list of books, user login, and transactions. The database offers information about the books, users, and borrowing details, which allows for real-time updates and easy accessibility. The system design offers scalability, security, and smooth interaction between the user interface and the database system.

2.2 AI recommendation system

The recommendation engine uses machine learning algorithms to offer personalized book recommendations to users based on their interests and borrowing history. Methods such as collaborative filtering and deep learning are used to analyze user behavior patterns and point to related resources. The engine learns from user behavior on a constant basis, adapting to

changes in user interests, thus promoting user engagement and resource usage. The library becomes a dynamic learning environment rather than a static resource repository due to personalization.

2.3 Voice-based NLP search

The speech-to-text functionality enables users to search using voice commands, and the recognition of user intent and processing of queries ensures that users get the correct interpretation of their queries. The voice search functionality is especially beneficial for users who may not be tech-savvy or have disabilities, thus promoting inclusivity and democratization of access to library resources.

2.4 Implementation tool

The system is built using a mix of programming languages, frameworks, and APIs. Java and Kotlin are used for Android app development, while Python is used for machine learning and NLP components. TensorFlow or PyTorch is used for training and deploying recommendation models, while Google Speech-to-Text API is used for voice recognition functionality. The use of these tools ensures that the system has optimal functionality, efficiency, and interaction of system components.

3. Workflow

Figure 2 shows a workflow diagram that illustrates the functional workflow of the smart library management system. The workflow begins with user input, which could be in text or audio form, depending on the user's choice or need. The user input is then

channeled to the query processing module, where natural language processing and intention analysis are used, especially in audio input, to determine the user's query.

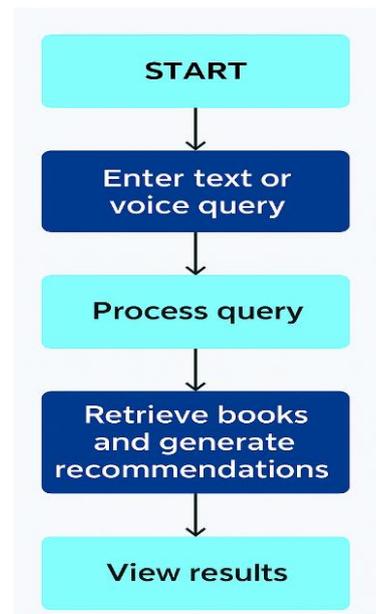


Figure 2: Workflow diagram

After the user's query has been processed, the system will then access the central database, where the relevant book information is obtained depending on keywords, categories, or semantic searches. At the same time, the AI recommendation module will process the user's borrowing history, preferences, and behavior to offer personalized book suggestions. The two outputs are then combined and presented in the results display interface, where users can access available books, borrow new ones, re-issue existing ones, or access related resources. This is a complete process that ensures the two functionalities, search and recommendation, are well integrated into the system. The use of color in the diagram, where blue represents input, green represents

processing, cyan represents database, orange represents recommendation, and purple represents results, makes the diagram more readable and highlights the modularity of the system.

4. Result and discussion

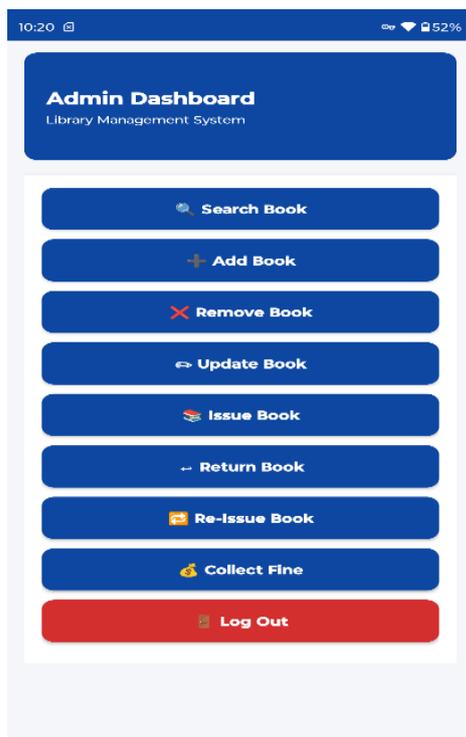


Figure 3: Admin dashboard interface of the smart library management system

Figure 3 above shows the administrative dashboard of the proposed smart library management system. The system is meant to make library management easier and more efficient using an Android-based interface. The administrative dashboard of the system provides easy access to all the required operations such as searching, adding, deleting, updating, issuing, returning, and re-issuing books, as well as fine collection and logout. All the operations are denoted by a button with an icon, making it easy for

administrators to navigate through the system. The system is meant to be efficient and easily accessible, allowing librarians to conduct transactions quickly while maintaining accurate records Table 1. The system applies color coding, with blue and red colors denoting operations and logout, respectively.

Table 1: Dashboard functionalities

Function	Description
Search Book	Allows administrators to locate books within the library database.
Add Book	Facilitates entry of new books into the system with metadata and availability.
Remove Book	Enables deletion of outdated or unavailable books from the catalog.
Update Book	Provides options to edit book details such as title, author, or availability.
Issue Book	Records the lending of books to users with transaction details.
Return Book	Updates the system when borrowed books are returned.
Re-Issue Book	Extends borrowing duration for users with renewed transaction records.
Collect Fine	Manages overdue fines and payment collection from users.
Log Out	Ensures secure exit from the system, protecting administrative access.

Figure 4 demonstrates the search facility in the smart library management system, which is expected to provide users with flexible and convenient ways of searching book information. The search facility contains several input fields, such as book ID and name, as well as a drop-down

menu for selecting categories, which helps the system to filter the search results correctly. The presence of a “GO” button helps users search quickly and easily Table 2. The system is designed to support both casual and research readers by allowing them to search for resources using various parameters.

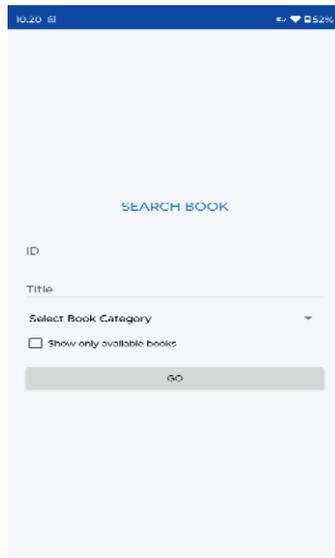


Figure 4: Search book interface of the smart library management system

Table 2: Search interface functionalities

Element	Description
ID Field	Allows entry of a book’s unique identification number for direct retrieval.
Title Field	Enables search by book title for broader or specific queries.
Category Dropdown	Provides options to filter books by subject or category.
Availability Checkbox	Restricts search results to books currently available for borrowing.
GO Button	Executes the search query based on selected parameters.

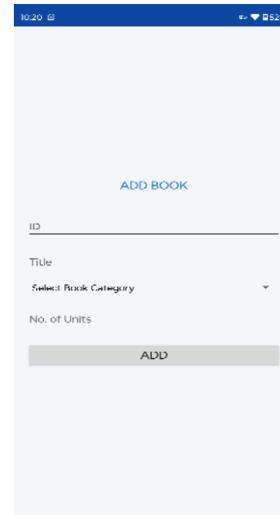


Figure 5: Add book interface of the smart library management system

Figure 5 illustrates the “Add Book” interface, which is intended to make it easy to add new resources to the digital library. The interface is designed to allow the input of a book’s identification number, name, type, and the number of available units. A drop-down menu is also provided to ensure that books are categorized under appropriate types, which helps in the effective storage and retrieval of books. At the bottom of the screen, the “ADD” button is provided to enable administrators to easily add the details inputted, hence updating the system in real time Table 3. The interface is designed to be simple, accurate, and efficient, hence allowing librarians to easily add new resources to the library while keeping accurate records.

Table 3: Add book interface functionalities

Element	Description
ID Field	Records the unique identification number assigned to each book.

Title Field	Allows entry of the book’s title for cataloguing and search purposes.
Category Dropdown	Provides options to classify books under specific categories or subjects.
No. of Units Field	Specifies the number of copies available for circulation.
ADD Button	Submits the entered information to update the library database.

information before removing it from the database Table 4. The interface is designed to be simple and will not increase complexity in managing the database of the library.

Table 4: Remove book interface functionalities

Element	Description
Book ID Field	Accepts the unique identification number of the book to be removed.
FIND Button	Initiates a search to locate and confirm the book record before deletion.
Remove Action	Ensures accurate removal of outdated or unavailable books from the database.

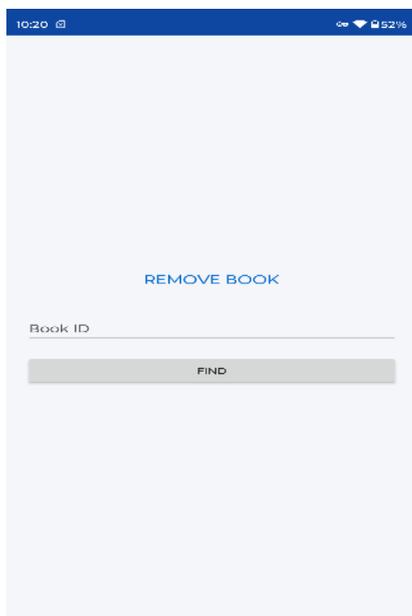


Figure 6: Remove book interface of the smart library management system

Figure 6 shows the interface for “Remove Book,” which aims to make it easier for librarians to remove unavailable or obsolete resources from the library database. The interface has only one input field where the librarian needs to enter the book’s identification number to ensure that the book to be removed is the correct one. There is a “FIND” button that the librarian needs to click to start the searching process, which will enable the librarian to check the book

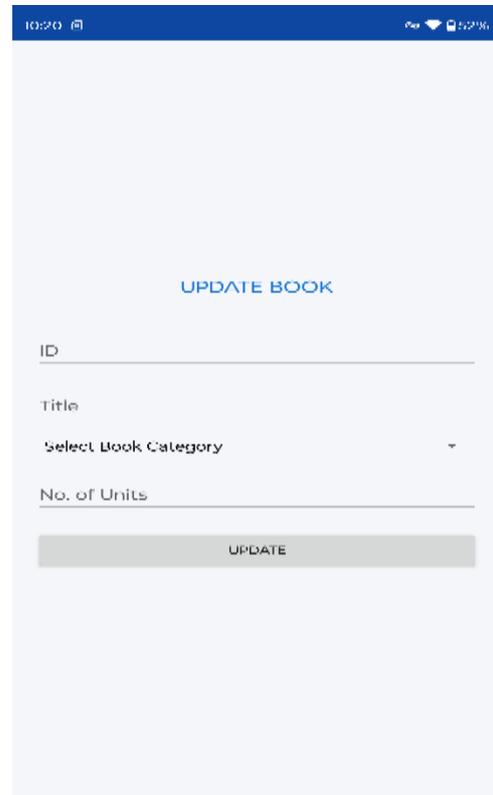


Figure 7: Update book interface of the smart library management system

Figure 7 shows the “Update Book” interface, which helps administrators update existing records in the library database. The interface contains organized input fields that help administrators enter or update the book’s identification number, title, category, and number of available units. The dropdown menu helps ensure that books are organized under the appropriate categories. The “UPDATE” button at the end of the interface helps administrators update the database instantly and ensures that the database is always up to date. The interface is designed to promote accuracy and efficiency in the update process, ensuring that errors are eliminated while allowing dynamic updates of the library resources Table 5. The interface is designed to ensure that librarians can easily update records to fit changes in the library resources.

Table 5: Update book interface functionalities

Element	Description
ID Field	Identifies the specific book record to be updated.
Title Field	Allows modification of the book’s title for catalogue accuracy.
Category Dropdown	Provides options to reclassify or update the book’s subject category.
No. of Units Field	Enables adjustment of the number of available copies in the library.
UPDATE Button	Confirms and applies changes to the selected book record in the database.

Figure 8 shows the interface of the “Issue Book” system, which is intended to facilitate the process of issuing books to users. The interface contains two places where data can be entered: the first is for the book’s identification number, and the second is for the user’s card number. This is to ensure that all transactions are recorded accurately. At the bottom of the interface, the “ISSUE” button is provided for administrators to issue the books instantly Table 6.

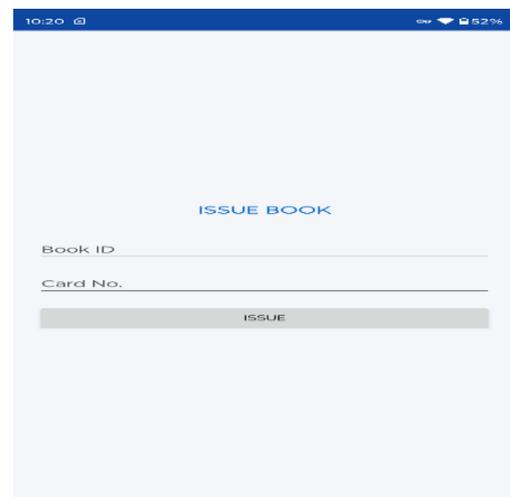


Figure 8: Issue book interface of the smart library management system

The design of the interface is simple and effective, as it eliminates the need for manual processing and ensures that the availability of the books and the user’s record are updated instantly.

Table 6: Issue book interface functionalities

Element	Description
Book ID Field	Accepts the unique identification number of the book to be issued.
Card No. Field	Records the borrower’s library card number for transaction tracking.

ISSUE Button	Confirms and executes the book lending process, updating the system database.
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Figure 9 shows the design of the “Return Book” interface, which is intended to handle the task of registering the return of books in an efficient way. The interface contains two input boxes: one for the registration number of the book and another for the card number of the person who borrowed the book.

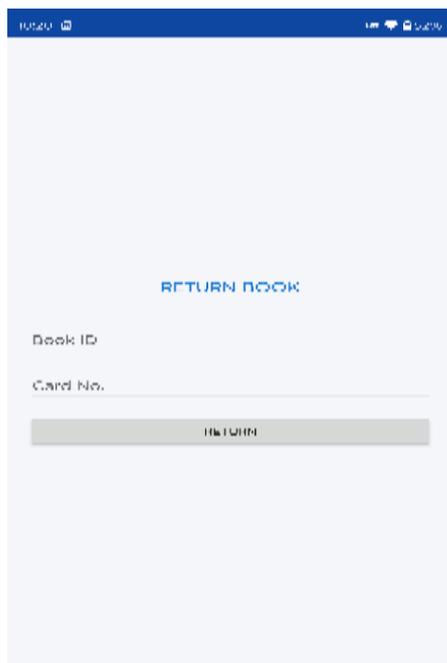


Figure 9: Return interface of the smart library management system

This is done to ensure that the registration of the return of the book is accurate Table 7. At the bottom of the interface, the “RETURN” button is provided. This button enables the administrators to register the return of the book instantly, ensuring that the database of the library is accurate at all times.

Table 7: book interface functionalities

Element	Description
Book ID Field	Accepts the unique identification number of the book being returned.
Card No. Field	Records return the borrower’s library card number to validate the return transaction.
RETURN Button	Confirms and executes the return process, updating the system database in real time.

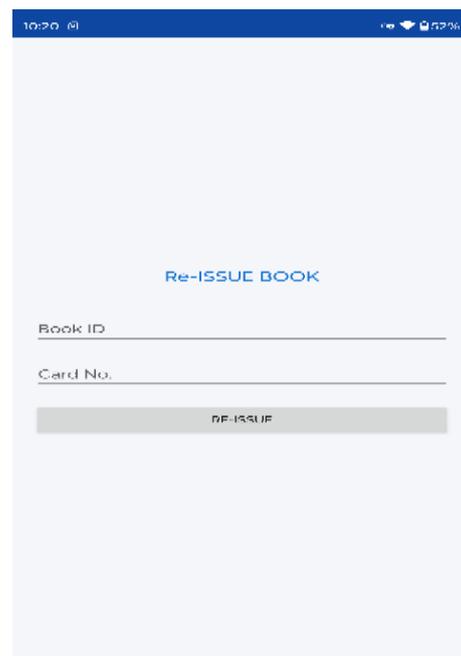


Figure 10: Re-issue book interface of the smart library management system

Figure 10 shows the “Re-Issue Book” interface, which is intended to help extend the loan period of books for those who need more time. The interface consists of two input boxes, one for the identification number of the book and another for the card number of the

person who borrowed the book, to ensure that the right transaction is traced before the extension of the loan period. The “RE-ISSUE” button at the bottom of the interface enables the administrators to extend the loan period of the books instantly, ensuring that the right records are maintained. The design of the interface is simple and focuses on efficiency and accuracy, as it will help users access books without any interruptions.

Figure 11 shows the “Collect Fine” interface, which is intended to handle the issue of late fines in the library system. The interface has only one input field where the borrower enters his/her card number to ensure that the fine is credited to the correct account. After the card number has been entered, the “COLLECT” button is used by the administrators to process the fine payments instantly.

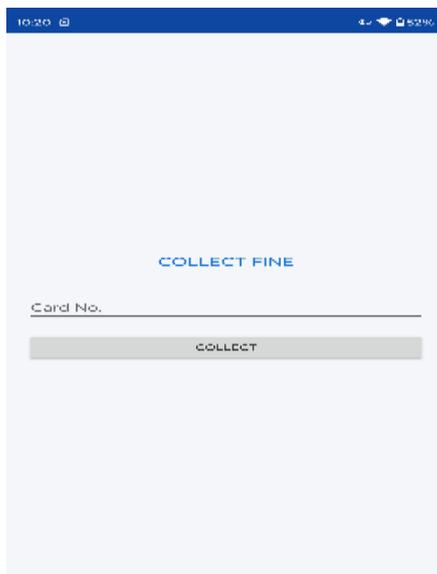


Figure 11: Collect fine interface of the smart library management system

The interface has a simple design that focuses on simplicity and efficiency. The

interface combines fine collection in the digital system to promote transparency, accountability, and efficient circulation management, thus improving the reliability of the smart library system.

Figure 12 shows the “User Dashboard” interface, which serves as a central platform for library users to interact with the system. The interface contains a welcome message and four main operations: searching books, viewing borrowed books, re-issuing books, and logging out of the system. These operations are performed using color-coded buttons with icons, making it easy for users to navigate the system Table 8. The interface also contains real-time notifications, such as notifications for newly added books, which inform users of the latest updates in the library.

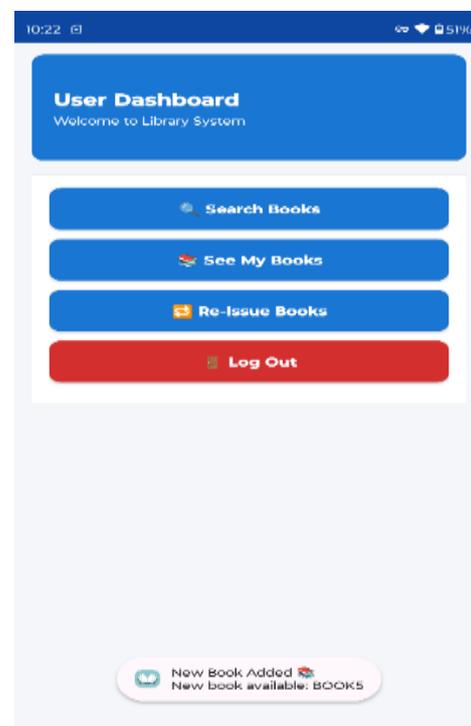


Figure 12: User dashboard interface of the smart library management system

Table 8: User dashboard functionalities

Element	Description
Search Books Button	Allows users to locate books in the library database using search parameters.
See My Books Button	Displays the list of books currently borrowed by the user.
Re-Issue Books Button	Enables users to extend the borrowing period for selected books.
Log Out Button	Provides a secure exit from the system, protecting user account information.
Notification Panel	Displays real-time updates, such as newly added books or system alerts.

Figure 13 shows the terminal-based interface designed for fine collection and monitoring in the smart library management system. The interface provides critical information such as disk usage, storage allocation, and fine categories in a compact text format.

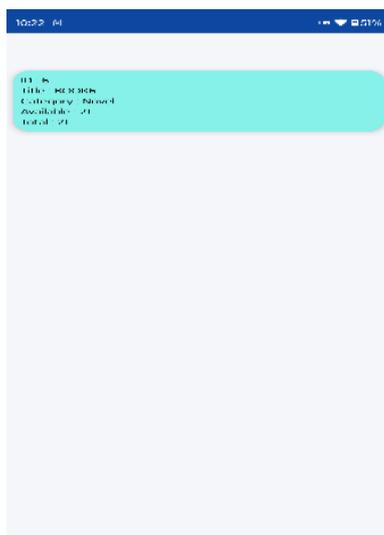


Figure 13: Fine collection interface of the smart library management system

It emphasizes variables such as percentage usage, available storage, and rating values, which help administrators monitor system performance during fine processing. The interface is designed to be clean and efficient, with a focus on providing critical information without unnecessary complexity Table 9.

Table 9: Fine collection terminal interface functionalities

Element	Description
Usage Percentage	Displays the proportion of system resources or fines processed.
Memory Allocation	Shows available storage capacity in MiB for system operations.
Category Field	Indicates the classification of fines or personal records.
Availability Value	Reflects the percentage of resources or fines available for collection.
Rating Value	Provides a numerical indicator of system or fine-related performance.

Figure 14 shows the interface of the “Issued Books List” feature, which gives users a comprehensive view of the books they have borrowed and the details of the transactions. The books are arranged in an organized way, with every book displaying its number, name, type, issue date, and date to be returned. The organized interface makes it simple for users to track the books they have borrowed and the dates they are supposed to return them. The interface is made to be transparent and accountable, with all the information needed displayed at a glance.



Figure 14: Issue book list interface of the smart library management system

5. Conclusion

This paper proposes an efficient and friendly smart library management system based on the Android architecture model, recommendation system using AI, and voice-assisted natural language processing. The proposed system is expected to optimize the most critical activities of search, issue, return, re-issue, and fine collection through friendly interfaces, thereby improving the user experience. The addition of a recommendation system and voice search functionality makes the library more accessible. After considering the modularity and scalability aspects, the proposed system has immense implementation possibilities in the education sector, public libraries, and corporate knowledge repositories. Looking into the future, some of the possible developments that can be integrated into the system include the use of blockchain

technology to ensure the security of transactions, the use of IoT smart shelves to ensure the real-time monitoring of inventory, and the use of AR navigation to assist users in navigating through physical bookshelves, thus turning the traditional library into an intelligent and immersive learning environment. Apart from its usability, the proposed system also showcases the use of intelligent automation to transform the traditional library into a seamless digital experience. The system, which integrates AI-powered personalization and voice search functionality, not only makes the system more accessible but also encourages user engagement. The modularity of the system also ensures that it is flexible and can be applied in different contexts, ranging from academic libraries to corporate knowledge bases. The emphasis on real-time updates and transparency also ensures that resource management is effective. This project, therefore, offers a foundation for future development that has the potential to revolutionize the role of the library in the digital age.

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