COLLABORATIVE FILTERING ALGORITHMS BASED — UKM LIBRARY LOAN DATA CHART VISUALIZATION MANAGEMENT SYSTEM

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ABSTRACT

This project proposes the development of a Library Loan Data Visualization Management System based on Collaborative Filtering Algorithms. Collaborative filtering algorithms are recommendation techniques that predict a user's interests by analyzing patterns of borrowing behavior across many users, so that items liked by similar readers can be suggested. The main goal is to address the current inefficiencies in handling large volumes of borrowing records, which lack real-time data insights and hinder service improvement. The core component of the system is data collection from a library loan database. Borrowing records will be continuously collected and stored in a unified repository. A collaborative filtering engine will analyze these data to identify borrowing patterns and generate personalized book recommendations for users. The system enables students and administrators to access borrowing history, recommendation lists, and trend charts through a simple and intuitive interface. Visualization components such as Chart.js will display real-time borrowing trends and popular titles. Compared with traditional systems, this platform provides smarter, data-driven decision support for book acquisition and inventory management. The system will be built using Vue.js for the frontend and Java Spring Boot for the backend, following an agile development model. Security is ensured through authentication and encrypted data access. Ultimately, the system aims to help UKM Library shift from manual operations to intelligent, data-driven services, improving operational efficiency and enhancing the user experience for both students and library staff.

1 INTRODUCTION

With the rapid development of modern digital technology, university libraries are facing increasing pressure to manage and analyze a growing volume of book loan records efficiently. At most of the libraries, the current book loan management system relies on outdated manual operations and lacks real-time data visualization tools, resulting in low efficiency and poor decision-making capacity. Therefore, a new intelligent system is needed to help the library shift from manual to automated and data-driven service management.

To address this, many modern libraries have started adopting intelligent algorithms such as Collaborative Filtering Algorithms (CFA), a technique widely used in recommendation systems. CFA identifies patterns in user borrowing behavior and suggests books based on similarities between users or items. This approach enables the system to

provide personalized book recommendations, reduce users' search time, and improve borrowing satisfaction. More importantly, it also supports libraries in predicting high-demand books, reducing procurement waste and improving inventory accuracy.

According to Fortune Business Insights (2023), the global Collaborative Filtering Algorithms market was valued at USD 19.8 billion in 2023 and is projected to grow at a CAGR of 30.4% by 2032. In the United States, AI investment in information systems, including CFA, is expected to reach USD 33 billion by 2024 (IDC, 2024). These trends indicate the growing relevance and value of CFA in data-intensive environments like libraries.

In response to the library's current situation, there is a need for a more efficient and intelligent management tool, this project proposes the development of a Collaborative Filtering Algorithms Based ─ Library Loan Data Chart Visualization Management System. The system will collect real-time borrowing data from the library's database, apply CFA to generate personalized recommendations, and visualize borrowing trends using Chart.js. By doing so, the system aims to reduce librarian workload, improve procurement planning, and enhance the overall user experience.

2 PROBLEM STATEMENT

Contemporary university libraries are grappling with the dual challenge of managing vast and growing volumes of borrowing data while simultaneously catering to the heightened expectations of digitally fluent users. Conventional library management systems, such as the one currently deployed at UKM, are primarily transaction-based and operate through static user interfaces. These systems lack the capability to learn from user behavior, adapt dynamically to evolving reading interests, or offer personalized recommendations, thereby limiting the overall user experience. Students often encounter difficulties locating relevant books amidst extensive catalogs, leading to frustration, disengagement, and inefficient use of library resources. Furthermore, the absence of real-time borrowing insights prevents administrators from making timely, data-informed decisions regarding inventory management, procurement planning, and resource allocation.

This disconnect results in several operational inefficiencies: surplus copies of rarely borrowed books, shortage of in-demand titles, and missed opportunities for proactive service improvements. Without intelligent analytics, the system remains reactive rather than strategic, hindering the library's ability to function as a modern, user-centered learning hub. According to recent industry research, such as the 2023 report by Fortune Business Insights, the global collaborative filtering market—valued at USD 19.8 billion—is projected to grow at an annual rate of 30.4% by 2032, underscoring the increasing demand for smart, predictive technologies across sectors. The lack of such technology in academic libraries represents not only a missed opportunity but also a growing gap between user expectations and system capabilities. Addressing these critical shortcomings forms the core motivation for developing a data-driven, intelligent platform that transforms how library services are delivered and experienced.

3 RESEARCH OBJECTIVE

i. To improve the efficiency of loan data management: Use Collaborative Filtering Algorithms technology and develop a system to process and store large-scale library loan data. The system will make predictions and perform intelligent data processing to enhance the overall efficiency of library operations.

ii. To improve data visualization: Real-time data visualization tools (such as Chart.js) will be used to generate intuitive borrowing trends and charts of popular books, allowing both librarians and students to easily view and interpret borrowing data.

iii. To improve student accessibility and transparency: Use the Vue.js framework to design a simple and intuitive user interface, ensuring that non-technical users ─ such as librarians and students ─ can operate the system and access relevant data without requiring complex training.

4 RESEARCH METHOD

To ensure high flexibility, adaptability, and incremental improvement, this project adopts the Agile methodology. Development cycles are broken into multiple iterations, each followed by testing, feedback, and refinement. The system architecture is divided into layers (UI, business logic, collaborative filtering, data access, and security) to maintain modularity and scalability. Frontend and backend development proceeds in parallel using Vue.js and Java Spring Boot, respectively.

4.1 PLANNING PHASE

A Gantt chart and implementation schedule guide the structured development process, covering phases from requirement gathering to final deployment. Tasks such as frontend/backend development, database design, and testing are prioritized to ensure balanced resource allocation.

4.2 ANALYSIS PHASE

User roles, system requirements, and functional specifications are clearly defined. Two primary user roles—students and administrators—have distinct access privileges. Multiple diagrams (context, flow, and use-case) were created to model user interaction and system processes.

4.3 DESIGN PHASE

The system adopts a five-layer architecture with dedicated modules for recommendation logic, UI rendering, data storage, and security. A comprehensive database schema supports loan records, user profiles, borrowing trends, and recommendation logs. Class diagrams and data dictionaries were created to structure these modules.

4.4 TESTING PHASE

The project incorporates rigorous testing, including black-box methods (equivalence partitioning, boundary value analysis, decision table testing, and state transition testing). Both functional (login, recommendations, chart viewing) and non-functional (usability, performance) aspects were tested to ensure system robustness.

4.5 OPTIMIZATION AND DEPLOYMENT PHASE

After iterative testing, the system underwent performance optimization and was deployed in a production-ready environment using Maven and Tomcat. Encrypted authentication mechanisms ensure secure user interaction. Future enhancements include AI-powered adaptive recommendation models and cross-platform integration.

5 RESEARCH OUTCOME

The development of the UKM Library Loan Data Chart Visualization Management System Based on Collaborative Filtering Algorithms resulted in a robust and intelligent platform that substantially enhances both user experience and administrative efficiency in library management at Universiti Kebangsaan Malaysia (UKM). The system successfully integrates personalized recommendations, interactive visualization tools, and comprehensive administrative management features. Below are detailed illustrations of key system modules and their functionalities:

Figure 5.1: presents the initial homepage for visitors, providing users with essential navigation and access to key functionalities of the library loan system. The clear and intuitive design ensures visitors can easily find login and registration options to engage fully with the platform.

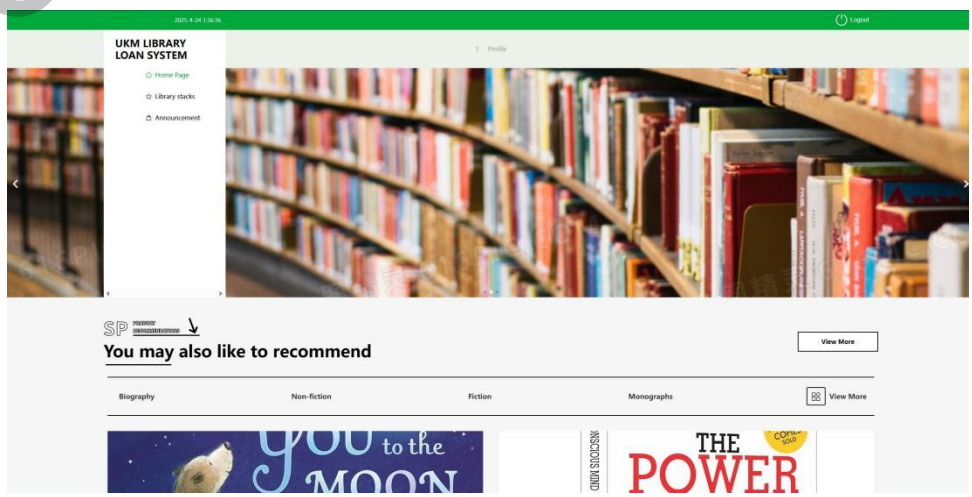

Figure 5.1 User Homepage

Upon clicking the login option, users are redirected to the login interface. This interface provides two distinct login panels for students (highlighted in blue) and administrators (highlighted in black), clearly differentiating access privileges and ensuring system security.

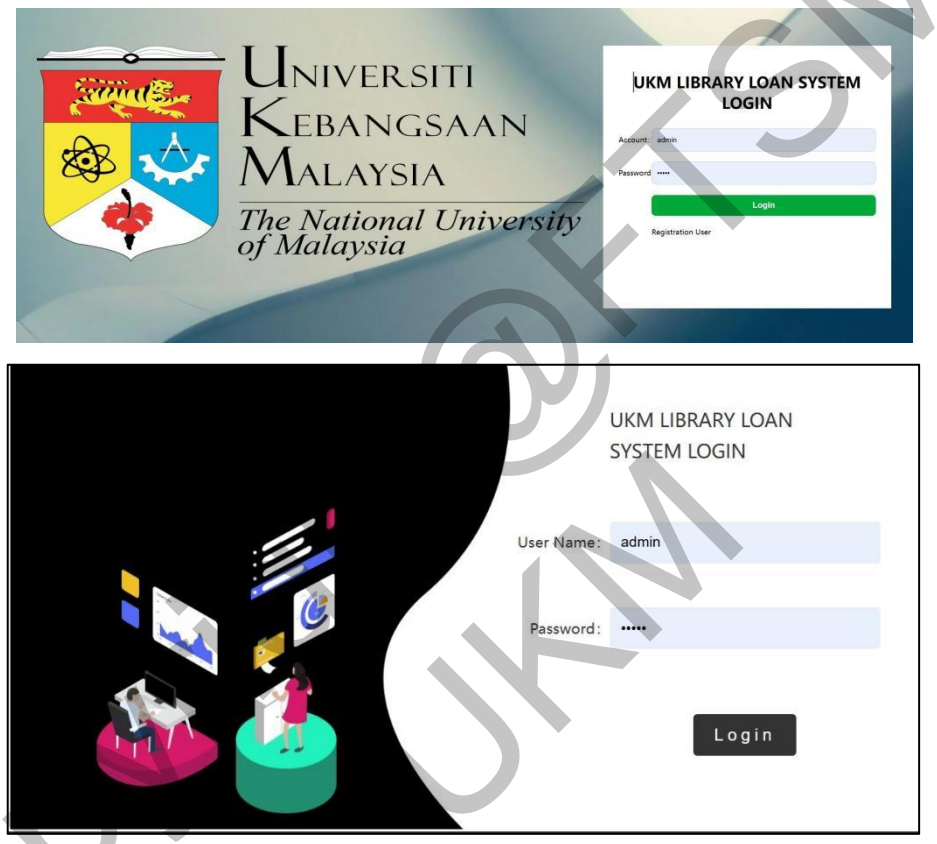

Figure 5.2 Login page with student (blue) and admin (black)

After successful login, students access their personalized homepage (Figure 5.3). This page prominently features dynamically generated book recommendations based on collaborative filtering algorithms, a browsing-friendly interface displaying popular books, and easy access to user borrowing history. The personalized recommendations significantly enhance student engagement by predicting relevant reading materials tailored to individual user profiles.

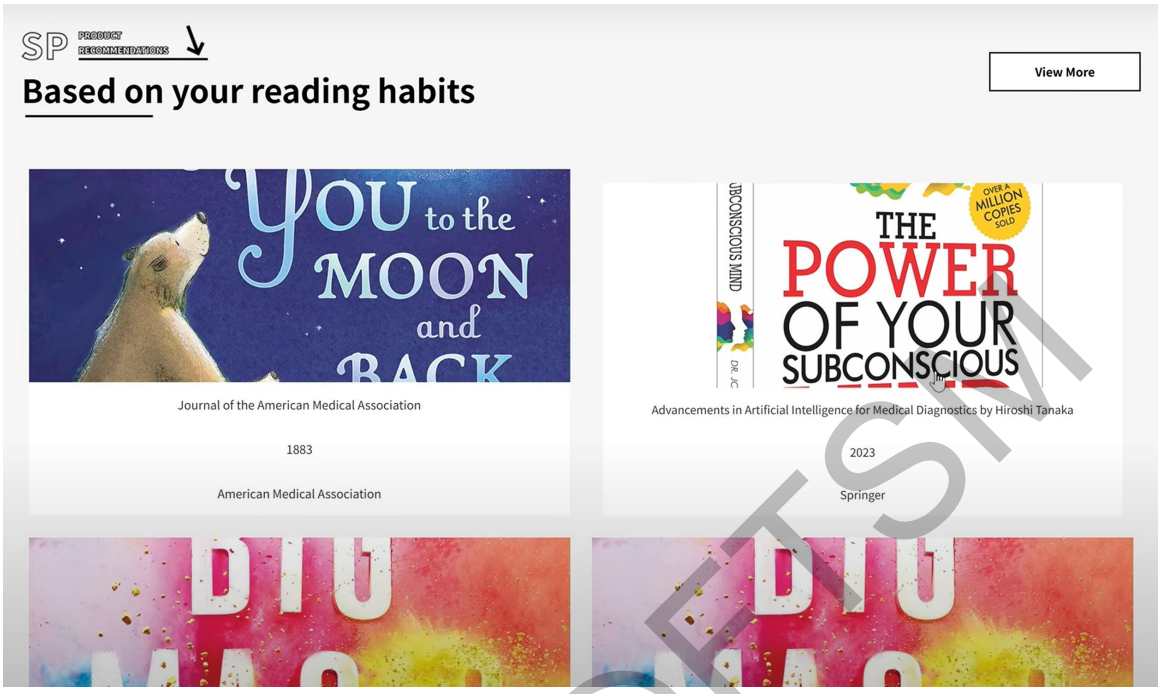

Figure 5.3 Student Personalized Recommendation Homepage

Further enhancing user engagement, the system includes an intuitive Announcement interface (Figure 5.4), presenting timely library notifications, emergency alerts, and informative articles. This keeps users consistently updated with library news, improving overall user satisfaction and involvement.

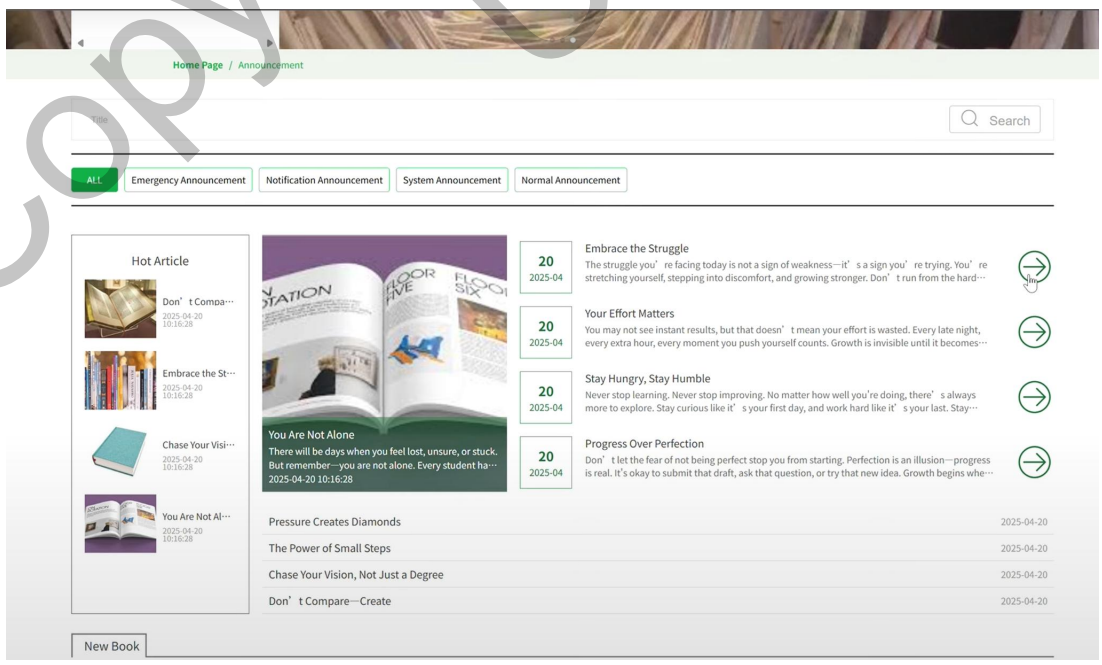

Figure 5.4 Announcement Interface

Administrators, upon logging in, are first directed to the Admin welcome interface. Figure 5.5 shows the clean, professional admin dashboard entry page, from which administrators navigate smoothly to various management sections.

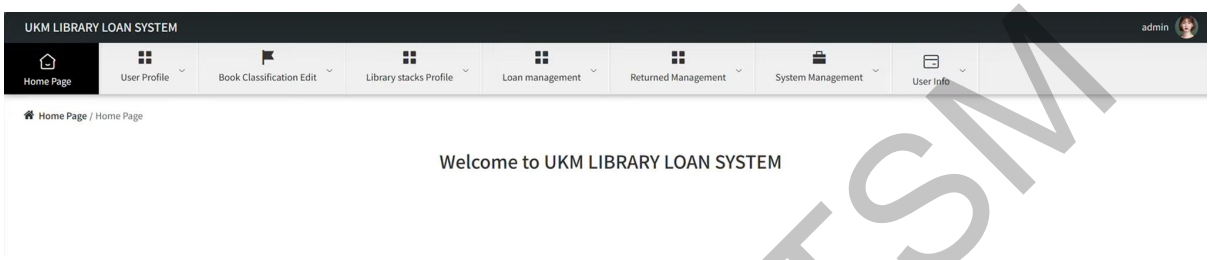

Figure 5.5 Admin Welcome Interface (Homepage)

A core innovation of this system is its real-time, interactive visualization module, built using Chart.js. This module provides administrators with a powerful data-driven dashboard (Figure 5.6), clearly displaying borrowing trends, book classification statistics, popular book categories, and detailed resource utilization metrics. Such real-time insights dramatically improve resource management and procurement planning, enabling proactive administrative decision-making.

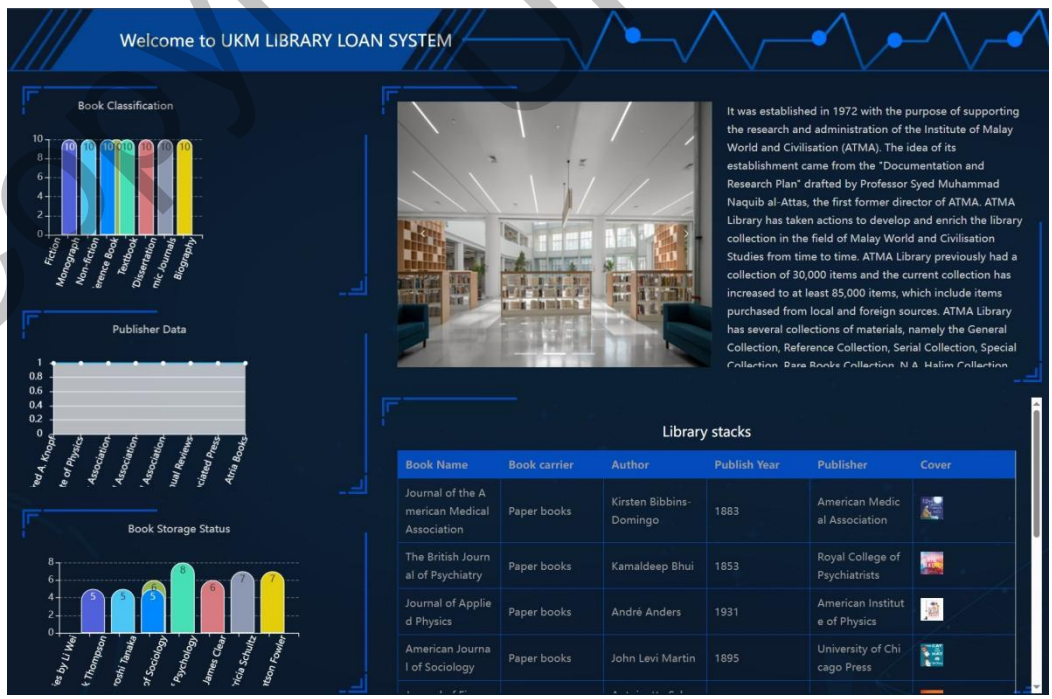

Figure 5.6 Interactive Real-time Visualization Dashboard (Chart.js)

Finally, the system provides administrators with a comprehensive back-end management interface (Figure 5.7). This detailed administrative dashboard supports critical operations, including book inventory management, user profile editing, loan management, and data-driven predictive analytics. The clear and organized presentation enables efficient daily library administration and strategic resource allocation.

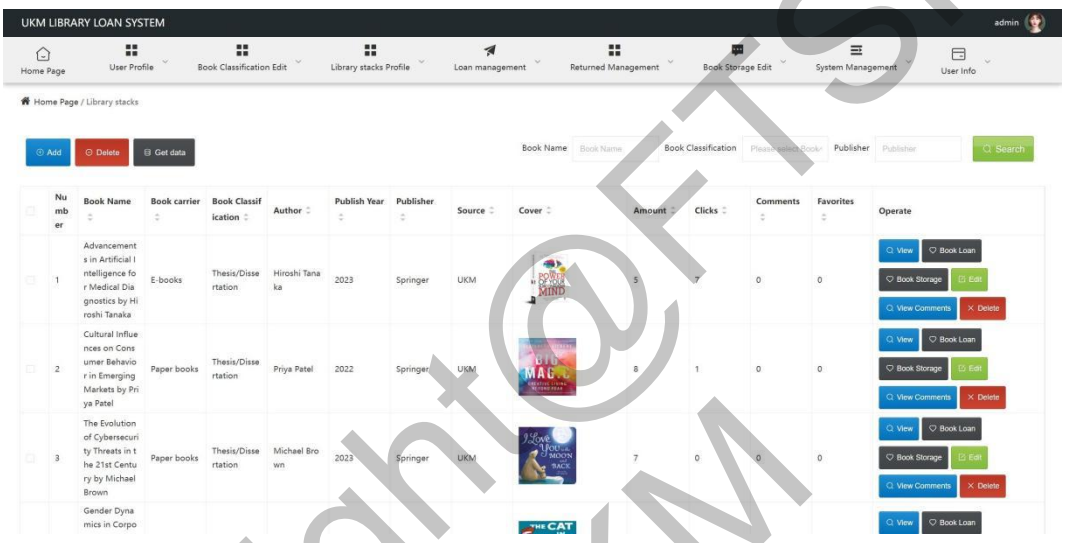

Figure 5.7 Administrator's Back-end Management Interface

Through rigorous testing, including functionality verification, performance evaluation, and user feedback analysis, the developed system consistently demonstrated reliability, efficiency, and high user satisfaction. It successfully combines advanced recommendation technologies, sophisticated visual analytics, and streamlined administrative management into a single integrated platform. This comprehensive library loan management solution not only addresses current user needs but also positions UKM Library to effectively meet future demands, serving as an exemplary model for intelligent, data-driven academic library management systems.

6 CONCLUSION

The successful implementation of the "UKM Library Loan Data Chart Visualization Management System Based on Collaborative Filtering Algorithms" represents a meaningful advancement toward intelligent, data-driven library management at UKM. By effectively integrating collaborative filtering methods for personalized recommendations with intuitive real-time data visualization, the system significantly improves the quality and efficiency of interactions between users and library resources. Throughout development, considerable challenges such as tight deadlines, complex algorithm implementation, and stringent data security requirements were systematically addressed by adopting an agile methodology coupled with extensive testing procedures. As a result, the platform not only demonstrates strong practical feasibility but also positions itself as a scalable solution suitable for broader implementation within academic libraries. Looking ahead, the project opens opportunities for further enhancements, including deeper integration of advanced artificial intelligence technologies, extended deployment across multiple campuses, and development of multilingual capabilities. These future improvements will ensure sustained adaptability and responsiveness, enabling libraries to better support the dynamic needs of contemporary academic communities.

7 ACKNOWLEDGMENT

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Finally, acknowledgment must be extended to the broader open-source software community, whose exceptional tools, robust frameworks, and comprehensive documentation were integral to this project's realization. High-quality resources such as Vue.js and Spring Boot, combined with strong community support and detailed technical documentation, provided a solid foundation that greatly enhanced the efficiency and sophistication of the system developed within the constraints of this academic endeavor.

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