RESEARCH & INNOVATION DIVISION
IJIST

Implementation of Renthub System: An Intelligent Online Rental Marketplace with ML-Powered Personalized Product Discovery and Recommendations

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Citation | Ismaeel. A, Qayyum. A, Mehmood. M, Matloob. I, Masood. S, "Implementation of Renthub System: An Intelligent Online Rental Marketplace with ML-Powered Personalized Product Discovery and Recommendations", IJIST, Special Issue. pp 1-13, Oct 2024
Received| Oct 02, 2024 **Revised|** Oct 05, 2024 **Accepted|** Oct 09, 2024 **Published|** Oct 15, 2024.

The rapid expansion of peer-to-peer rental services has significantly influenced the share economy by connecting consumers with short-term access to diverse rental products. However, existing platforms primarily focus on specific categories, limiting consumer choices and creating a gap in the market. This study introduces RentAll, a comprehensive multi-category rental platform offering access to houses, automobiles, furniture, gadgets, and jewelry, while prioritizing data privacy through anonymized transactions. To enhance user experience, we developed a recommendation system utilizing content-based filtering, cosine similarity, and collaborative filtering through FP-Growth Frequent Itemset Mining to suggest products based on customer behavior. Additionally, a chatbot powered by a Sequence-to-Sequence model using RNN and LSTM units was integrated for real-time customer support. The results demonstrate RentAll's effectiveness in providing a unified rental solution with personalized recommendations. The platform streamlines the rental process, reduces financial strain, and expands product offerings to serve diverse demographics. High user satisfaction is reported due to its user-friendly interface and engaging features, including secure payment processing via Easypaisa. Moreover, the implementation of robust security measures protects user information and builds trust. In conclusion, RentAll effectively addresses key issues in online rentals by offering a user-friendly platform with diverse rental categories, enhancing consumer convenience and satisfaction while maintaining stringent data protection standards.

Keywords: Rent All, Recommendation System, Content-Based Filtering, Collaborative Filtering, Chatbot.

Introduction:

The rapid growth of the sharing economy has revolutionized various industries, leading to the emergence of peer-to-peer (P2P) rental platforms. These platforms cater to the increasing demand for access-based consumption, offering flexible and economical alternatives to traditional ownership. By leveraging technology, these platforms connect individuals with surplus items to those in need, facilitating a mutually beneficial exchange. The sharing economy has significantly impacted sectors such as travel, lodging, and the rental of common goods, enabling consumers to save money, reduce waste, and access a diverse range of products without long-term commitments. The reuse of items through these platforms also aligns with sustainability efforts, reducing the need for new products and mitigating their environmental impact. One such platform, "Rent All," enters this growing market by providing a comprehensive solution for connecting suppliers and customers. "Rent All" offers a wide variety of products for short-term rental, including electronics, furniture, jewelry, and dresses, catering to a broad customer base. The platform's user-friendly interface allows customers to quickly browse and select items, while suppliers can list available products and manage rentals efficiently. This streamlined approach enhances the overall user experience, simplifying transactions for both renters and owners. Furthermore, "Rent All" promotes sustainable consumption by encouraging the reuse of items, which aligns with the principles of the circular economy, aiming to maximize resource efficiency and minimize waste. By reducing the demand for new products.

"Rent All" distinguishes itself through its diverse product offerings, personalized product recommendations, and a customer care chatbot, providing a seamless and user-friendly platform for communication between customers and vendors. In Table 3 the comparison of accuracy in the model used is shown and in Table 4 the comparison with chatbot used in different platforms is discussed. As the sharing economy continues to expand, platforms like "Rent All" will play a crucial role in fostering a more sustainable and interconnected society.

Objectives:

The primary objective of "Rent All" is to develop a user-friendly, all-inclusive rental platform that facilitates communication between buyers and sellers, promotes access-based consumption, and supports sustainability. The specific goals and contributions of "Rent All" are as follows:

- To encourage access-based consumption by enabling consumers to borrow goods temporarily, reducing financial strain and enhancing resource efficiency.
- To create an intuitive platform that simplifies the rental process for both customers and vendors, ensuring a seamless experience.
- To expand the range of products available for rental to cater to a diverse customer demographic.
- To incorporate machine learning techniques for developing a chatbot that provides real-time assistance during the rental process.
- To implement a machine learning-based recommendation system for personalized product suggestions.
- To automate the rental management system, streamline operations, and reduce manual effort.
- To promote sustainable consumption through shared product rentals, thereby minimizing environmental impact.

- To integrate secure payment processing through Easypaisa, ensuring user trust and convenience.
- To ensure continuous availability of the platform, allowing users to rent products at any time, thereby enhancing user satisfaction.
- To leverage Django's MVC architecture for easy updates and enhancements, ensuring the platform's adaptability.
- To enforce CNIC verification for customers, ensuring product security managed by vendors.
- To optimize database queries and algorithms, for quick and accurate recommendation system responses.
- To maintain compatibility with modern web browsers, ensuring a broad user reach.

Literature Review:

The authors [1] fuzzy recommender systems for housing manage uncertainty well in real estate. Using the PRISMA 2020 approach, 50 out of 1003 articles were identified as primary. Fuzzy logic (65%) and spatial data (60%) are widely used. Future research should explore hybrid approaches and practical assessments. [2] Examined factors affecting consumers' rental intentions in the sharing economy using a survey of 259 Indian consumers. Consumer minimalism and environmental awareness positively influence rental intentions, moderated by consumer skepticism. [3] Discusses the commodification of residential real estate under financial capitalism, introducing the concept of the "bed-as-asset." The study highlights how real estate is increasingly aligned with investor interests. [4] Proposes "HouseCritic," a deep network that addresses the scarcity of data in home rental recommendations by using e-commerce data and meta-learning to improve user satisfaction predictions. [5] Presents the Frequent Pattern Mining Framework (FPRS) to solve the cold-start problem in recommender systems by integrating collaborative and content-based filtering with frequent pattern mining, showing strong results with benchmark datasets. [6] Developed a movie recommendation system using TF-IDF and cosine similarity. The system effectively matches movies to user preferences based on the MovieLens dataset, with good performance metrics. [7], [8], [9] Developed a website that facilitates renting and lending of items, helping users save costs and earn money by renting out items they temporarily need or own. [10], [11], [12] Introduced MFP-growth, a modified FP-growth algorithm that improves performance in association rule mining, particularly for large datasets, by avoiding the repetitive creation of conditional subtrees. [13] Proposed a web-based Rent-a-Car application that allows global car reservations. It includes features for owners, administrators, and tenants, built using .NET Core in Visual Studio. [14] Investigated the use of content-based filtering and cosine similarity for movie recommendations, focusing on enhancing user engagement through personalized content delivery. [15] Developed a genetic algorithm-based recommendation system for tourist sites and bicycle rentals in Desa Alamendah, integrating Google Maps for efficient route and rental price recommendations. [16] Proposed an online platform for house rentals that streamlines the leasing process and offers additional services like packaging and moving, using HTML, CSS, JavaScript, Bootstrap, PHP, and MySQL. [17] Designed a movie recommendation system using association rule mining techniques like FP-Growth and Apriori to help users with decision-making in movie selection. [18] Created a web-based platform for smart house rentals in urban areas, particularly in Bangladesh, aiming to improve communication between landlords and tenants and simplify the rental process. According to [19], [20] study to digitally transform the manual vehicle rental

process. To validate the rental automobile system, a customer satisfaction test was conducted. Create documents like Software Requirement Specification (SRS) and Software Design Description to serve as a reference for system developers. Below Table 1 shows the comparison of related papers with their limitations and methodology used.

Table 1: Comparison of related papers

S. No	Authors/Year	Paper Name	Methodology Used	Limitations	Results
1	Malhotra & Fatehpuria (2024), Ravindhar et al. (2023)	Sharing Economy & Consumer Behavior	Structural Equation Modeling	Limited geographic scope	Environmental consciousness and minimalism influence rental intentions
2	Paul (2022), Rathore et al. (2023), Voumick et al., Setty (2022)	Real Estate & Rental Systems	Web-based platforms, HTML, CSS, JavaScript, PHP, MySQL	Poor implementation in some studies	Streamlined rental processes, Enhanced landlord-tenant communication
3	Permana et al. (2023), Benjamin et al. (2022), Prayudha & Algifari (2022), Singh et al.	Recommendation Systems for Movies & Entertainment.	TF-IDF, Cosine Similarity, Association Rule Mining (FP-Growth, Apriori), KNN	Evaluation metrics, Scalability	Effective personalized movie recommendations.
4	Khan (2022), Thakur, Pathak et al., Mon et al. Ahmed et al. (2023), Barbour et al. (2022)	Vehicle Rental Systems	.NET Core, Visual Studio, Agile Development, Mobile apps	Security concerns, Usability issues	Improved rental processes, Convenience for users
5	Mujawar et al. (2022), Siefen, Kapoor & Vij (2023), Lang et al.	Fashion & Furniture Renting	Data Mining (LDA), HTML, CSS, JavaScript, Django	Market saturation, Hygiene concerns	Increased convenience, Identified consumer motivations and barriers
6	Lu & Lin (2022), Quijano-Sánchez et al. (2022)	Smart Cities & IoT	Recurrent Neural Network (RNN)	Data privacy, Integration challenges	Accurate prediction of rental demand, Enhanced urban infrastructure

Novelty Statement:

Rent all distinguishes itself from other systems by offering a comprehensive, multi-category rental platform that caters to diverse product categories such as houses, automobiles,

furniture, gadgets, and jewelry, unlike existing systems that focus on a single category. Its advanced recommendation system blends content-based and collaborative filtering to provide more personalized and varied suggestions, introducing novel items to users. RentAll prioritizes data privacy by using anonymized transactions, ensuring minimal user data collection. It is future-ready, with plans for advanced techniques like PrefixSpan for sequential pattern mining, and offers real-time support through an AI-powered chatbot and seamless integration with WhatsApp for enhanced user engagement. With its unique offerings and user-friendly interface, Rent All stands out as a leading force in the rental industry.

Material and Methods:

Data Preparation:

Textual Data:

Product descriptions (names and categories) are extracted from the database. TF-IDF (Term Frequency-Inverse Document Frequency) is a method for converting text descriptions into numerical vectors. This is accomplished using the Tfidf Vectorizer from sk-learn. feature_extraction. text. TF-IDF assesses the value of words in each description in comparison to all other descriptions. Our recommendation system leverages two distinct approaches: FP-Growth frequent itemset mining for collaborative filtering and content-based filtering using cosine similarity. Additionally, a **chatbot** has been implemented using Long Short-Term Memory (LSTM) networks.

Content-Based Filtering for Logged-In Customers:

For logged-in customers, the system uses content-based filtering, which starts by extracting product details like names and classifications from the database. These details are then transformed into a data frame containing product descriptions. We applied TF-IDF (Term Frequency-Inverse Document Frequency) vectorization to convert these descriptions into a format suitable for machine learning. This vectorization process emphasizes significant terms while excluding common ones. The resultant TF-IDF matrix represents each product in a high-dimensional space, allowing for precise similarity calculations.

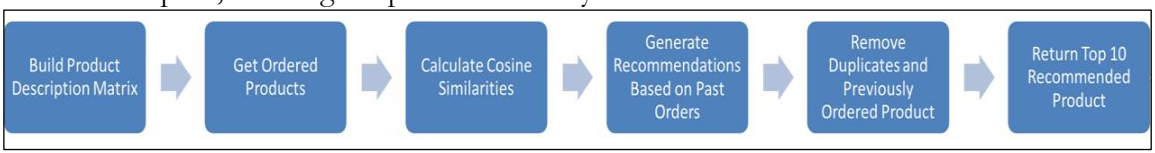

Figure 1. Content-Based Filtering

Cosine Similarity:

Cosine similarity is computed for all product pairs using their TF IDF vectors, determining their similarity by comparing the cosine of the angle between the vectors. For each product a user has previously ordered, the system identifies the top five most similar products and combines them into a recommended list. To avoid redundancy, products that the user has already ordered are excluded from the recommendation list, ensuring that only new, unique products are suggested. Figure 1 shows how content-based filtering work step by step.

Collaborative Filtering for All Customers:

Our system employs Collaborative Filtering to generate recommendations based on the collective interests of multiple users. Specifically, it uses the FP-Growth algorithm to mine frequent itemsets from transactional data. These itemsets represent groups of products that are often ordered together. This approach is particularly effective for generating recommendations for anonymous users or those who haven't logged in, making it a non-personalized

recommendation system. In Figure 2 the working of Collaborative filtering is shown step by step.

User Interaction and FP-Growth:

The system analyzes user interactions, specifically rental history, to suggest products that align with users' preferences. By leveraging the FP-Growth algorithm, the system efficiently extracts frequently purchased item sets, making recommendations that reflect common purchasing patterns across the user base.

Figure 2. Collaborative Filtering

Chatbot Model:

The chatbot model utilizes natural language processing (NLP) techniques, beginning with tokenization, which divides text into smaller units (typically words). We employed the NLTK library's word_tokenize function to achieve this. The sequences are then padded using TensorFlow's pad_sequences to ensure uniform length for batch processing in neural networks.

Embedding and LSTM:

The first layer in the chatbot's neural network is an embedding layer, which converts tokens into dense vectors, capturing the semantic meaning in a continuous vector space. The core of the model is a Recurrent Neural Network (RNN) with Long Short-Term Memory (LSTM) units, designed to capture long-term dependencies in sequential data, making the chatbot capable of generating coherent and contextually relevant responses. The model is trained on a dataset of question-answer pairs, learning to predict the next word in a sequence during training. Post-training, the chatbot generates responses by iteratively predicting the next word until a complete response is formed, providing an interactive customer support experience on the rental website. The working of Chatbot is given as shown in Figure 3.

Figure 3. Chatbot

Recommendation System Workflow:

This is the architectural design of a recommendation system as shown in Figure 4, which shows how it works, the past order data is stored in a database, and on the basis of these past orders, the items are recommended to the user. In this, we use two recommendation systems collaborative base and content based.

Proposed Framework:

Figure 5 display the proposed framework of the system. The system has three panels (customer, Vendor, and admin).

The system manages customer, vendor, and admin data in its database, enabling features like customer profiles for viewing past orders, searching products, and communicating with vendors. Vendors can manage products, orders, and earnings, while admins oversee all user data. The platform supports item and order management, integrates a payment gateway via Easypaisa, and offers personalized recommendations using collaborative filtering (FP-Growth) and content-based filtering (Cosine Similarity). Additionally, an LSTM-based chatbot provides support for both customers and vendors.

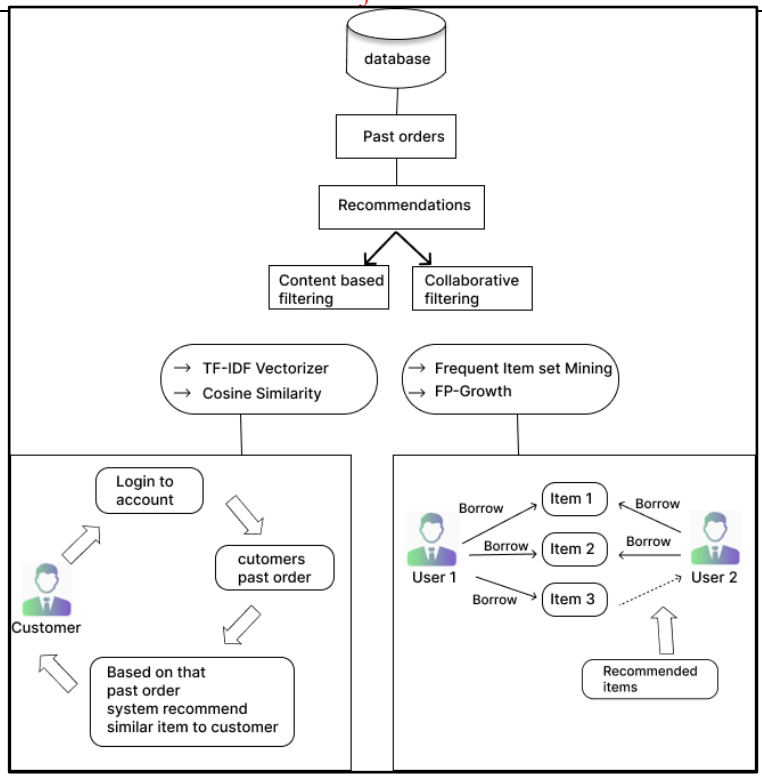

Figure 4. Recommendation System Workflow

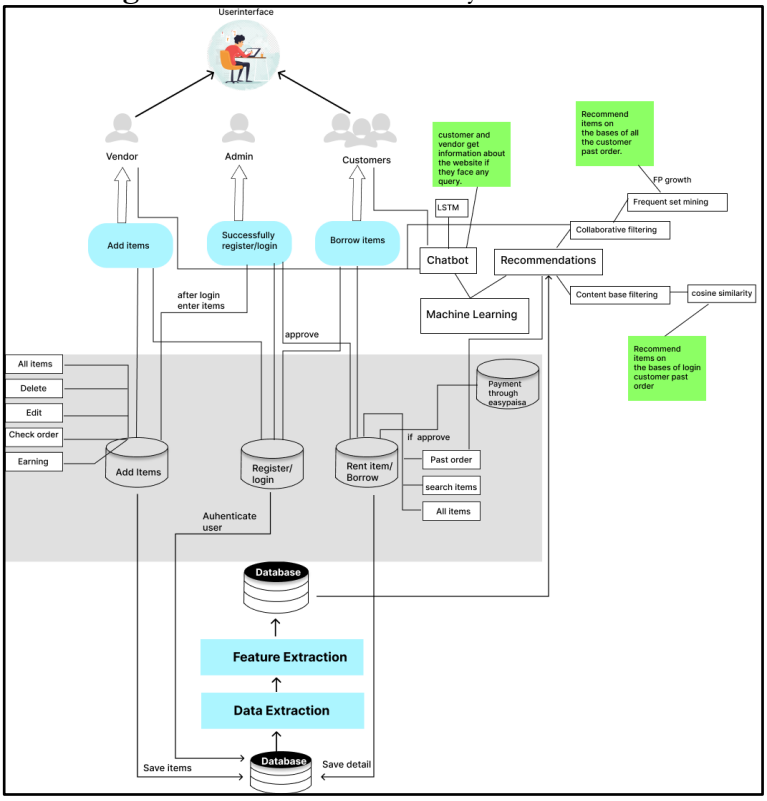

Figure 5. Proposed Framework

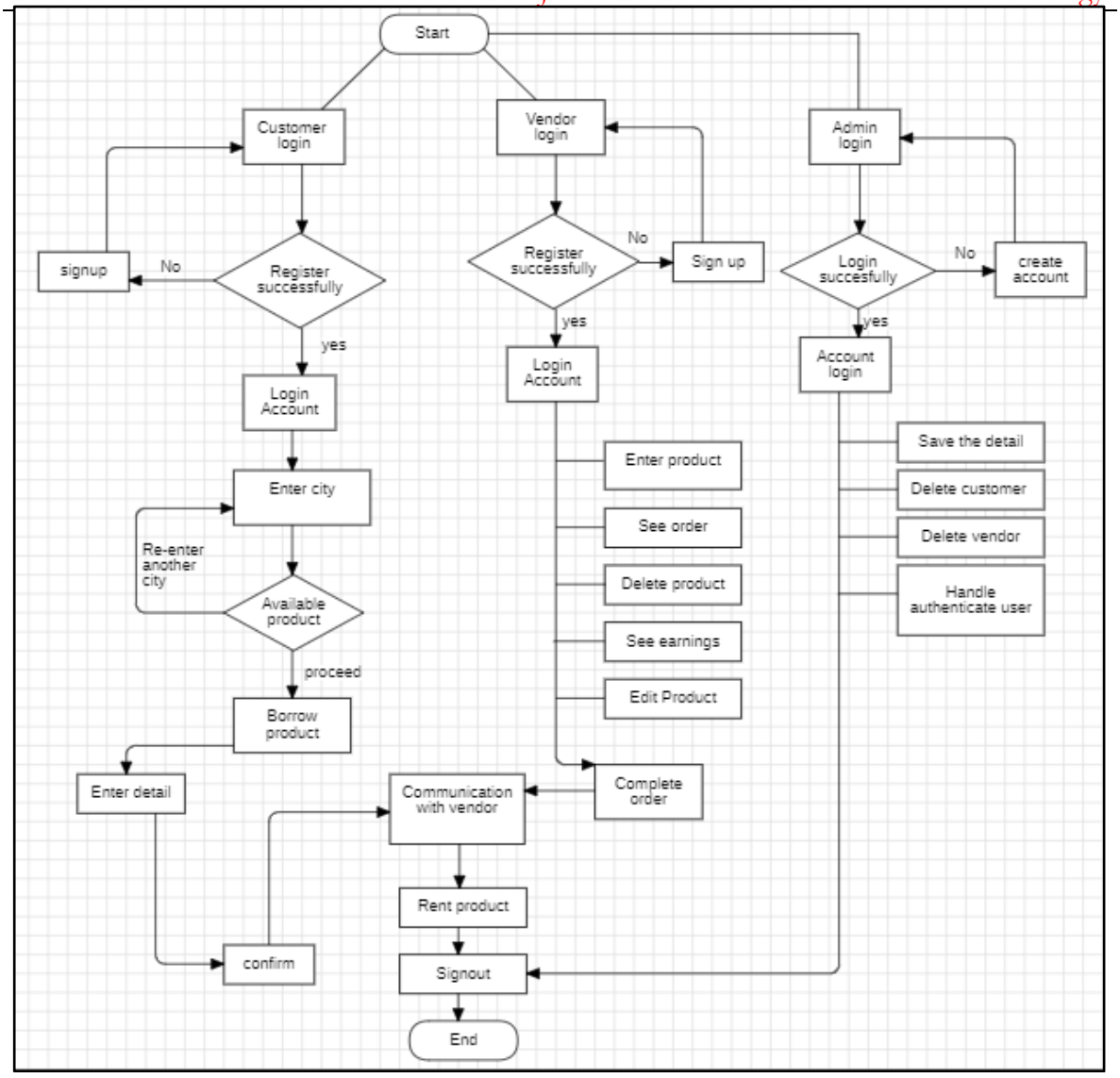

Figure 6. Flow Diagram of a System

The customer flow on the Rent All platform as shown in Figure 6, involves logging in, searching for products by city, and submitting rental requests after confirming details. Vendors log in to add products, manage orders, edit listings, and communicate with customers. Admins oversee user authentication, manage customer and vendor profiles, save product and order details, and handle platform security, with each role concluding their tasks by securely logging out.

Result and discussion:

We have looked through a lot of sites as well as papers about rental management systems. There are several existing systems for product rental web applications after researching these systems to identify their shortcomings, we created a new method that tackles the difficulties encountered by both local and international rental platforms. Current rental websites are less engaging due to a few issues. In order to make the system simpler and more exciting we corrected and improved these issues and explained new features and comforts.

- Enabled efficient access-based consumption through short-term borrowing, reducing financial strain.
- Established a user-friendly platform that streamlined the rental process for both customers and vendors.
- Expanded product offerings to effectively serve diverse customer demographics.
- Implemented a responsive machine learning-based chatbot for real-time rental assistance.
- Integrated a personalized recommendation system enhancing user experience with tailored product suggestions.
- Automated rental management operations, significantly reducing manual effort and improving efficiency.
- Promoted sustainable consumption practices by encouraging shared product rentals.
- Secured payment processing with Easypaisa.
- Maintained high website availability, ensuring seamless access for product rentals.
- Enhanced application flexibility and scalability with Django's MVC architecture.
- Implemented CNIC verification for enhanced product security managed by vendors.
- Ensured compatibility across major web browsers, enhancing accessibility for users.

Table 2. Comparison of Pervious Systems vs. Rent-All

Aspect	Rent All (Novel Approach)	Existing Systems (Limitations)
Comprehensive, Multi-Category Platform	Provides a single platform for renting houses, automobiles, furniture, gadgets, and jewelry, offering a wide range of products.	Focus on a specific product category (e.g., homes or cars), limiting user choices and making it harder to find diverse rental options
Recommendation System	Combines content-based filtering, and collaborative filtering to provide accurate and personalized recommendations.	Typically rely on one filtering technique, such as content-based or collaborative filtering, resulting in less precise or varied recommendations.
Novelty in Recommendations	Balances popular products with novel or less familiar items to introduce new discoveries to users, encouraging broader engagement.	Focus mainly on recommending frequently rented or popular items, leading to repetitive and less diverse suggestions for users.
Data Privacy as a Core Feature	Operates with minimal user data, using anonymized transactions to ensure privacy while still providing effective recommendations.	Often collect detailed personal information for recommendations, raising privacy concerns and limiting user control over their data.
Scalability and Future-Readiness	Future-ready with plans to integrate advanced techniques like PrefixSpan for mining sequential patterns, ensuring continued adaptability.	Lack advanced plans for scaling or incorporating more complex recommendation systems, making them less adaptable to evolving user demands.
Chatbot for Real-Time Assistance	Includes a chatbot using Sequence-to-Sequence models (RNN, LSTM) to provide personalized, real-time customer support.	Customer support is often handled through traditional methods, leading to slower response times and less personalized interactions.
User Interface (UI)	Highly user-friendly with real-time assistance and easy navigation	Standard UI without advanced real-time support features
Integration with WhatsApp	Direct communication via WhatsApp for better user engagement	Limited to in-app communication (OLX, Airbnb)

Table 2 clearly highlights the novel features of the RentAll system, which make it unique and competitive in the market. These distinctive aspects position RentAll as a forward-thinking platform, providing users with a more comprehensive, secure, and user-friendly rental experience. The Comparison of accuracy between different platforms is also shown in Figure 7.

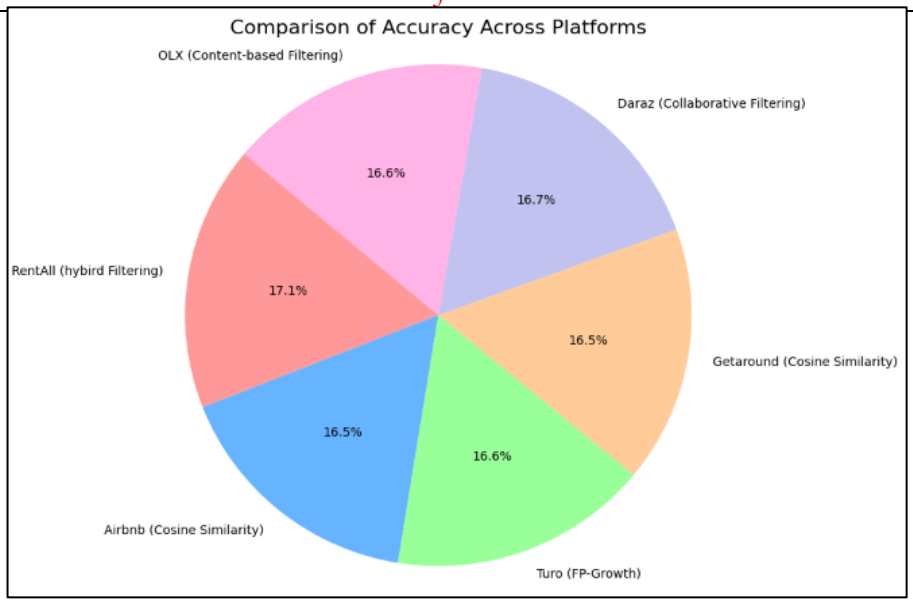

Figure 7: Comparison of accuracy across platforms

Table 3: Comparison of Accuracy of chatbot model

SNO	STUDY BY	MODEL USED	ACCURACY
1	Amna,Muneeba,Ayesha (2024)	LSTM (Long Short-Term Memory)	91.00 %
2	Anki, Bustamam, et al. (2021)	LSTM (Long Short-Term Memory)	99.49 %
3	Adilaksa, Y., and Musdholifah, A. (2021)	Content-Based Filtering with Weighted Cosine Similarity	64.00 %

Table 4: Comparison of Chatbot with other platforms

Feature	OLX Chatbot	Daraz Chatbot	Airbnb Chatbot	Turo Chatbot	Rent All Chatbot (Innovative Features)	Differentiation and Innovation
Technology Used	Rule-based chatbot with predefined flows	Limited machine learning chatbot	Hybrid chatbot (rule-based + ML)	Rule-based with limited ML	Fully machine learning-based chatbot with real-time learning and adaptation	Real-time learning allows the chatbot to adapt to user preferences quickly.
Responsiveness	Slow response times due to static answers	Moderately fast but lacks personalization	Moderately fast with some personalization	Moderately fast but lacks personalization	Fast response times, personalized suggestions based on user interaction history.	Highly responsive, offering tailored support for each user.
User Interaction	Limited to answering FAQs and basic queries	Can handle product-related queries but lacks depth	Handles complex queries, offers booking support	Limited to FAQs and basic queries	Handles complex queries, understands user context, and provides personalized responses.	Contextual understanding improves user engagement and query resolution.
Personalization	No	Limited	Personalized based on user profiles	Minimal personalization with basic data	Highly personalized	Dynamic personalization ensures users receive suggestions tailored to their needs.
Integration with System	Basic integration with platform	Moderate integration with shopping flow	Integrated with booking and reviews	Integrated with booking and reviews	Deep integration with the entire system, including recommendation engine, payments, etc.	Seamless integration allows the chatbot to access all platform features like payments, rentals, etc.

Root Mean Squared Error (RMSE):

RMSE (Root Mean Square Error) has widely been used in evaluating the accuracy of a recommender system, by the given formula:

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

Where yi is the actual rating, and yi' is the predicted rating. The RMSE for the recommendation system is approximately 0.463. The closeness of the predicted ratings to the actual ratings for each user can be visually inspected. The smaller the vertical distance between the blue and orange lines as shown in Figure 8 at each user ID, the better the model's predictions.

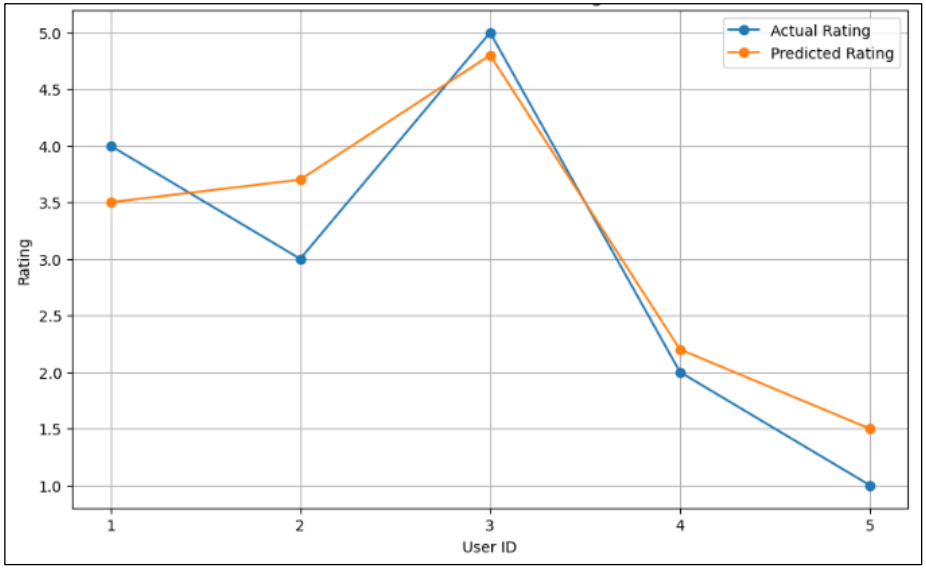

Figure 8. Actual vs. Predicted Rating

Lower RMSE:

Indicates that the predicted ratings are close to the actual ratings, implying a more accurate recommendation system.

Higher RMSE:

Indicates larger errors in predictions, suggesting that the recommendation system needs improvement. Given the RMSE of approximately 0.463, this indicates that the predicted ratings are fairly close to the actual ratings on average, suggesting a reasonable level of accuracy in the recommendation system.

Table 5. At **a** competitive market edge

Platform	Key Features	Market Saturation	Competitive Edge
Airbnb	Housing rentals, personalized recommendations	High	Established global presence, unique stays
OLX	Classified ads for various product categories	Moderate	Large user base, local classifieds
Daraz	E-commerce, various categories	Moderate	Strong in e-commerce and product delivery
Turo	Vehicle rentals, content-based suggestions	Niche market	Specializes in vehicle rentals
Getaround	Vehicle rentals, collaborative filtering	Niche market	Focus on shared vehicle rentals
RentAll	Diverse product categories, WhatsApp integration	Highly competitive market for rentals	Novel recommendation engine, local sorting

RentAll challenge is to clearly demonstrate in Table 5 and in Table 6 how its offerings differ from other saturated platforms to establish a unique identity in the market.

Table 6. Challenges in integrating various aspects of rental systems

Challenge	Impact	Solution
Diverse Product Categories	Difficulty in managing inventory and availability for multiple categories	Modular system with category-specific rules
Personalized Recommendations	Irrelevant or generic product suggestions	Regular tuning of machine learning algorithms based on user data
Real-Time Chatbot	Incorrect or irrelevant responses leading to user frustration	Continuous chatbot learning and fallback to human support
Payment Integration	Failed transactions or security issues	Partnering with secure payment gateways and offering multiple payment options
Location-Based Sorting	Inaccurate location data leading to poor search results	Regular testing and updates to geolocation services
User Interface	Cluttered design leading to poor user experience	Focus on responsive design and scalability
Peer-to-Peer Communication	Delayed transactions due to poor communication between users and vendors	Encrypted messaging and in-app communication options

Conclusion:

The proposed rental system effectively addresses key issues in online rentals by offering a user-friendly platform with features like simple registration, diverse rental categories, location-based sorting, and a machine-learning recommendation engine. The integration of WhatsApp for direct contact, and detailed product descriptions ensures users have all necessary information. The system has shown promising results, with high user satisfaction reported due to its ease of use and convenience. The recommendation algorithm enhances user engagement by suggesting relevant products, and the location-based tool simplifies finding nearby items. RentAll addresses data privacy concerns by implementing robust security measures to protect user information. The platform employs encrypted data storage and secure transmission protocols, ensuring that sensitive data like CNIC, payment details, and personal information are safeguarded from unauthorized access, providing users with confidence in the system's protection. Compared to platforms like OLX and Daraz, RentAll emphasizes secure payment methods such as Easypaisa and it limits data sharing to third parties, ensuring users feel safe while using the platform. Direct communication with suppliers improves transaction speed and query resolution. Future work should focus on:

- **Incorporating User Feedback**: Refine the platform based on user input.
- **Expanding Product Range**: Include more rental categories.
- **Enhancing Security**: Improve data protection measures.
- **Forming Partnerships**: Establish strategic alliances to broaden market reach.

These steps will further advance the rental market, making it more efficient and secure.

Acknowledgment: The writers express their gratitude to Fatima Jinnah Women University for lending us the tools required to carry out this study. This project and publication is funded by PEC (Pakistan Engineering Council).

Author's Contribution: Every author has contributed equally to this research.

Conflict of Interest: The authors declare no conflict of interest in publishing this manuscript in IJIST.

Project Details: Nil

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