International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

AI-Powered Recommendation System for Enhanced E-Commerce Personalization

Prof.D.A. Gaikwad *1,
Pavan Prakash Karale *2, Suhas Bapusaheb Shinde *3, Aditya Satyavan Gorde*4, Rutik Sunil Jambhalkar*5
1Lecturer,IT, JSCOE,Pune,Maharashtra,India.
,2345Student, IT, JSCOE,Pune,Maharashtra,India

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Abstract:
This research develops an E-commerce Recommendation System to enhance online shopping by providing personalized product suggestions using collaborative and content-based filtering. It predicts user preferences based on browsing history, interactions, and preferences, aiming to boost engagement, sales, and conversion rates. The system's accuracy is evaluated using metrics like precision, recall, and F1-score, ensuring scalability and efficiency for improving customer satisfaction and driving business growth.

***Key Words*:** Collaborative Filtering, Content-Based Filtering, Personalization, Precision, Recall, F1-Score, Conversion Rates Etc.

1.INTRODUCTION:

With the rapid growth of online shopping, e-commerce platforms are faced with the challenge of delivering personalized shopping experiences to diverse users. An AI-powered recommendation system has become essential in e- commerce, where it can analyze vast amounts of user data to generate relevant product suggestions. These systems aim to increase user satisfaction, engagement, and sales by presenting users with items that align with their preferences and past interactions. This research paper presents a machine learning-based recommendation system that utilizes both collaborative filtering and content-based filtering to enhance personalization. Collaborative filtering leverages user interactions, such as clicks, purchases, and ratings, to predict preferences based on similar user profiles, while content- based filtering analyzes product features to tailor suggestions. The project also evaluates the effectiveness of the recommendations by employing metrics like precision, recall, and F1-score to measure accuracy and relevance.By integrating advanced recommendation algorithms, this system aims to optimize the user experience, foster customer loyalty, and provide a scalable solution that can adapt to various e-commerce platforms and product types. This research contributes to the growing field of AI in e-commerce by exploring how machine learning models can be effectively applied to improve personalized recommendations..

2. LITERATURE SURVEY

Paper Name: E-commerce Recommendation System Using Machine Learning Algorithm
Author Name: Ataur Rahman, Mamunur Rashid
Description: This paper focuses on utilizing machine learning algorithms to create personalized product recommendations in e-commerce platforms, aiming to enhance the user experience and increase engagement. By leveraging various machine learning techniques, the system tailors product suggestions based on individual user preferences and browsing behavior. The research highlights how personalized recommendations can significantly improve user satisfaction and drive higher sales, making the e-commerce experience more interactive and relevant for each consumer. Through these personalized systems, businesses can ensure that customers are presented with products that best match their interests and needs, ultimately contributing to better retention and increased conversion rates. Decision Tree: A model used to classify users and predict the likelihood of a user's interest in a particular product based on their past behaviour. Random Forest: An ensemble method that improves prediction accuracy by creating multiple decision trees and combining their outputs to avoid overfitting. Principal Component Analysis (PCA): A dimensionality reduction technique used to identify the most relevant features from the large set of user data, helping improve the efficiency and accuracy of the recommendation model [1].

2) **Paper Name:** Exploring Key Issues Affecting African Mobile E-commerce Applications Using Sentiment Analysis
Author Name: Dr. Rita Orji
Description: This paper investigates the key issues impacting African mobile e-commerce applications through the lens of sentiment analysis. By analyzing user reviews and feedback, the study aims to identify common challenges faced by users and app developers, such as user dissatisfaction, interface issues, and performance concerns. Sentiment analysis was applied to categorize reviews into positive, negative, and neutral sentiments, helping to uncover patterns and trends in user feedback. This approach enables businesses to gain insights into user preferences and pain points, allowing for targeted improvements in mobile application design and

functionality. By understanding user sentiment, African mobile e-commerce platforms can enhance user satisfaction and optimize their services for better market adoption. Lexicon-based Approach: A technique used to evaluate sentiment by comparing words in user reviews with a predefined lexicon to determine the emotional tone (positive, negative, or neutral) [2].

3) **Paper Name:** Exploring the Landscape of Hybrid Recommendation Systems

Author Name: Arianit Kurti, Ilir Jusufi

Description: This paper explores the advancements and applications of Hybrid Recommendation Systems (HRS), which combine collaborative filtering and content-based approaches to provide more accurate and personalized recommendations. HRS is particularly effective in addressing the limitations of traditional recommendation methods, such as data sparsity and the cold start problem. By leveraging multiple algorithms, HRS improves recommendation accuracy, scalability, and adaptability to evolving user preferences. The paper also discusses recent trends in HRS, including the integration of deep learning techniques, which enhances the system's ability to dynamically adapt to complex and changing user behaviors. These advancements are valuable in fields like e-commerce, where delivering relevant product suggestions significantly enhances user experience and engagement. Hybrid Recommendation System (HRS): A framework that integrates collaborative filtering and content-based recommendation algorithms to overcome the limitations of single-method systems and enhance the accuracy and relevance of recommendations across diverse user needs [3].

4) **Paper Name:** Matrix Factorization for Personalized Recommendation

Author Name: Hongchen Wu

Description: This paper delves into the application of matrix factorization techniques for personalized recommendations, focusing on the use of latent factors to capture user and item characteristics. Matrix factorization enables recommendation systems to uncover hidden patterns in user behavior, helping deliver personalized content. The approach leverages user-item interaction data, breaking down large, sparse matrices to predict missing entries, which represent user preferences. A key strength of this technique is its ability to generate more nuanced recommendations by modeling complex user-item relationships. By employing these methods, recommendation systems can improve accuracy and relevance, especially in data-rich environments like e-commerce, streaming services, and social media [4].

3)METHODOLOGY

The proposed system will utilize a hybrid recommendation approach combining Collaborative Filtering and Content-Based Filtering to provide personalized product suggestions. The system architecture includes the following components:

3.1 EXISTING SYSTEM:

3.1.1 Data Collection:

- Gather user data such as browsing history, purchase history, clicks, and ratings.
- Use web scraping, APIs, or platform analytics for real-time data acquisition.

3.1.2 Data Preprocessing:

- Clean and normalize the data to handle missing values, duplicates, and inconsistencies.
- Convert text data (e.g., product descriptions) into numerical vectors using TF-IDF or Word2Vec.

3.1.3 Recommendation Engine:

- Implement a hybrid recommendation model:

♣ **Collaborative Filtering:** Use user-item interaction data to predict preferences using:

User-Based CF: Identifies similar users based on interactions.

♣ **Item-Based CF**: Suggests products based on similar items purchased/viewed.

♣ **Algorithm:** Alternating Least Squares (ALS) for Matrix Factorization.

♣ **Content-Based Filtering:** Leverages product features (e.g., category, price, brand) to recommend items that match user preferences.

♣ **Algorithm:** Cosine Similarity or K-Nearest Neighbors (KNN).

3.1.4 Model Training and Evaluation: o Split data into training and testing sets. o Train models and fine-tune hyperparameters. o Evaluate performance using metrics like:

♣ **Precision:** Fraction of recommended items relevant. ♣ **Recall:** Fraction of relevant items recommended.

♣ **F1-Score:** Balances precision and recall.

♣ **RMSE:** For accuracy in ratings prediction.

3.1.5 User Interface:

- Build a front-end interface to display personalized recommendations.
- Allow feedback collection to refine the system

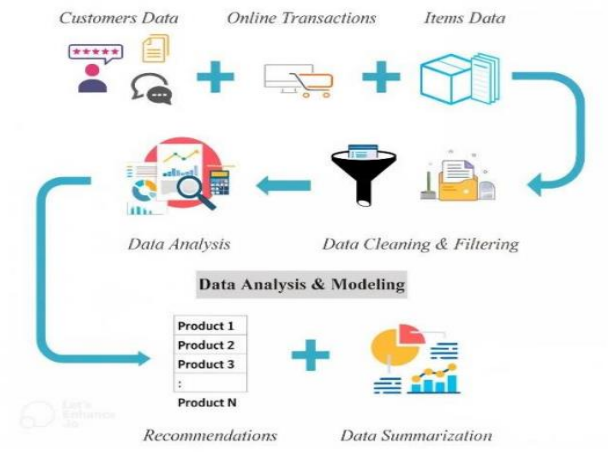

Fig.3.2 The architecture of recommender system

3.2 PROPOSED SYSTEM:

3.2.1. Collaborative Filtering (CF)

- **Approach:** Recommends products based on the preferences and behaviors of similar users or items.
- **Algorithms**:
  - User-based CF: Finds similar users based on interactions (e.g., ratings or purchases) and recommends items they liked.
  - Item-based CF: Finds similar items based on user interactions and recommends items similar to what the user interacted with.
- **Limitations:**
  - Struggles with sparsity in user-item interaction data.
  - Suffers from the "cold-start problem" for new users or products.

3.2.2. Content-Based Filtering (CBF)

- **Approach:**

Recommends products based on the attributes of items the user previously interacted with.

- **Algorithms:TF-IDF(TermFrequency-Inverse Document Frequency):**
  - Identifies keywords from product descriptions to match user preferences.

Cosine Similarity:

  - Measures similarity between items using feature vectors.

- **Limitations:** o
  - Limited by the content available about items.
  - Can become too narrow and fail to explore diverse recommendations

3.2.3. Hybrid Systems:

- **Approach:**
  - Combines collaborative filtering and content-based filtering for more accurate recommendations.
- **Algorithms**:
  - Weighted Hybrid: Assigns weights to CF and CBF outputs.
  - Switching Hybrid: Switches between CF and CBF based on data availability.

Feature Augmentation: Uses one algorithm's output as input for the other. • Limitations: Can increase computational complexity and require careful parameter tuning.

IV. APPLICATIONS

1. Personalized Product Recommendations: Suggests products tailored to individual customer preferences, increasing user satisfaction and engagement.

2. Improved Customer Retention: Delivers relevant recommendations to encourage repeat visits and long-term customer loyalty.

3. Upselling and Cross-Selling: Recommends complementary or premium products to increase average order value.

3. CONCLUSIONS

In conclusion, the e-commerce recommendation system enhances personalized shopping experiences by analyzing user behaviour, preferences, and purchase history to deliver tailored product suggestions. This boosts customer satisfaction, loyalty, and sales while showcasing the importance of data-driven insights in optimizing user experience and business outcomes in modern retail.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Prof. D. A. Gaikwad. For their continuous support and guidance throughout the project. We also extend our thanks to JSPM'S Jayawantrao Sawant College Of Engineering, Hadapsar, Pune for providing us with the necessary resources and infrastructure to carry out this research. Finally, we appreciate the valuable feedback from our project coordinator Prof. D.A.Gaikwad, which helped improve the quality of this work.

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