International Journal of Engineering Research and Science & Technology

CUSTOMER BEHAVIOUR ANALYSIS USING DATA MINING TECHNIQUES WITH AI-DRIVEN RECOMMENDATION

Mrs. KAKOLLU RANJITHAKALA[1], PONNA RESHMA SRI VALLI[2],
VERANKI SAI KRISHNAVENI[3], POLUKONDA BHAVANA[4],
SURISETTI AYYAPPA[5]
[1]Associate Professor, Dept. of CSE, V.K.R., V.N.B. & A.G.K. COLLEGE OF ENGINEERING
[2345]UG Students, Dept. of CSE,
V.K.R., V.N.B. & A.G.K. COLLEGE OF ENGINEERING, GUDIVADA, A. P

ABSTRACT

Customer behaviour analysis has become an important component for modern businesses to understand customer preferences, improve customer engagement, and support decision-making processes. With the rapid growth of digital platforms and online transactions, large volumes of customer data are generated daily, creating opportunities for effective data analysis.This project focuses on analysing customer behaviour using data mining techniques integrated with Artificial Intelligence (AI)-driven recommendation systems. Data mining techniques such as data preprocessing and pattern analysis are used to identify customer trends, purchasing behaviour, and preferences from the dataset.The proposed system uses a content-based recommendation approach to generate product suggestions. It applies text mining techniques such as Bag of Words (Count Vectorizer) and cosine similarity to identify similar product categories and provide relevant recommendations to users. The system also includes data visualization features to present customer behaviour insights in a clear and understandable manner.By combining data mining with similarity-based recommendation techniques, the system helps improve user experience and supports better decision-making. Overall, the proposed system provides a simple, efficient, and scalable solution for customer behaviour analysis and recommendation in modern digital environments.

Keywords:

Customer Behavior Analysis, Data Mining, Artificial Intelligence, Content-Based Recommendation, Cosine Similarity, Bag of Words, Text Mining, Data Visualization.

I INTRODUCTION

In the digital era, understanding customer behavior has become essential for organizations seeking to remain competitive in rapidly evolving markets. The growth of e-commerce platforms, online services, and digital transactions has resulted in the generation of massive volumes of customer data. This data includes purchase history, browsing patterns, product preferences, feedback, and interaction records. Analyzing such large and complex datasets manually is challenging; therefore, businesses increasingly rely on data mining techniques and Artificial Intelligence (AI) to extract meaningful insights and support strategic decision-making.

Customer behavior analysis aims to identify patterns that explain how customers interact with products or services, what influences their purchasing decisions, and how their preferences change over time. Traditional analytical methods often fail to capture hidden relationships within large datasets. Data mining techniques such as clustering, classification, association rule mining, and predictive modeling help uncover valuable knowledge from raw data. These techniques enable organizations to segment customers into meaningful groups, detect trends, and forecast future buying behavior.

Artificial Intelligence further enhances this process by enabling intelligent recommendation systems that learn from user activities and continuously improve prediction accuracy. AI-driven recommendation systems analyze

user preferences, past transactions, and similar customer profiles to suggest relevant products or services. Such personalized recommendations improve user experience, increase customer engagement, and significantly boost sales performance.

The integration of data mining and AI-based recommendation models provides businesses with automated and scalable solutions for customer analytics. Companies can design targeted marketing campaigns, optimize pricing strategies, and improve customer retention by delivering personalized experiences.

Moreover, these systems reduce information overload for customers by presenting relevant choices tailored to individual interests.This research focuses on applying data mining techniques combined with AI-driven recommendation mechanisms to analyze customer behavior effectively. The proposed approach aims to transform raw customer data into actionable insights, enabling organizations to make data-driven decisions and achieve sustainable business growth in a highly competitive digital marketplace.

II RELATED WORK

Customer behavior analysis and recommendation systems have been widely studied in recent years due to the rapid growth of e-commerce platforms and digital services. Researchers have applied various data mining and Artificial Intelligence (AI) techniques to understand customer preferences and deliver personalized recommendations.

Early research focused on applying **data mining methods** such as web usage mining, decision trees, and association rule mining to analyze customer interactions.

A personalized recommender system based on web usage mining demonstrated that combining browsing patterns with decision tree induction significantly improves recommendation quality and helps overcome information overload in online marketplaces. These studies laid the foundation for intelligent customer analytics by transforming raw user activity data into meaningful behavioral patterns.

Collaborative Filtering (CF) later emerged as one of the most widely used recommendation approaches. Several studies highlighted that CF predicts user interests based on similarities among users or items. However, challenges such as data sparsity and scalability limited its performance. To address these issues, research proposed hybrid models combining clustering and association rule mining with collaborative filtering. Such approaches group users with similar interests and discover hidden relationships between products, improving recommendation accuracy and precision.

Recent works emphasize hybrid AI-driven recommendation systems that integrate multiple algorithms. For example, research in e-commerce recommendation systems applied FP-Growth, and matrix factorization techniques such as SVD to achieve higher prediction accuracy, demonstrating that hybridization improves performance compared to single algorithms. Similarly, behavior-based recommendation models analyze browsing, clicking, and purchasing activities to better capture real customer intentions and enhance personalization.

Modern studies increasingly use deep learning and neural network approaches to model complex customer behavior. Multi-behavior recommendation frameworks analyze different user actions (views, clicks, purchases) simultaneously, allowing systems to understand decision-making stages and produce more accurate recommendations. Session-based recommendation research also shows that neural and sequence-based models outperform traditional methods by learning user interaction patterns within browsing sessions

III LITERATURE REVIEW

Customer behavior analysis using data mining and Artificial Intelligence has gained significant attention in both academic research and industrial applications. Several researchers have explored different techniques to understand customer purchasing patterns and improve

recommendation accuracy. Early studies focused on traditional data mining approaches such as classification, clustering, and association rule mining to discover hidden relationships within customer transaction data. These methods helped organizations identify frequent buying patterns and segment customers based on similarities in behavior, enabling targeted marketing strategies.

Many researchers introduced collaborative filtering techniques to provide personalized recommendations by analyzing similarities among users and products. Although collaborative filtering improved recommendation performance, it suffered from issues such as cold-start problems and data sparsity when limited user information was available. To overcome these limitations, hybrid recommendation models combining collaborative filtering with content-based filtering and clustering techniques were proposed. These hybrid approaches enhanced prediction accuracy and provided more reliable recommendations.

Recent literature emphasizes the use of machine learning and deep learning algorithms for advanced customer analytics. Neural networks, decision trees, support vector machines, and ensemble learning models have been applied to predict customer preferences and future purchasing behavior. Deep learning models, particularly recurrent neural networks and attention-based systems, have shown strong performance in analyzing sequential customer interactions such as browsing and purchase history. These models capture complex behavioral patterns that traditional methods often fail to detect.

IV EXISTING SYSTEM

In the existing customer behavior analysis systems, organizations mainly rely on traditional data analysis and basic recommendation techniques to understand customer preferences. These systems typically use historical transaction records, sales reports, and simple statistical methods to analyze customer activities. Rule-based recommendation approaches and basic filtering methods are commonly implemented to suggest products or services to users. Although these systems provide some level of personalization; they often fail to capture complex customer behavior patterns present in large and dynamic datasets.

Most existing systems depend on collaborative filtering or content-based recommendation methods individually rather than combining multiple intelligent techniques. As a result, recommendations are often limited in accuracy and may not reflect real-time user interests. These systems also struggle with problems such as data sparsity, cold-start issues for new users or products, and inability to process unstructured data like browsing behavior or customer feedback effectively. Furthermore, traditional approaches analyze customer data periodically instead of continuously, leading to outdated insights and less relevant recommendations.

Another limitation of existing models is the lack of advanced machine learning and AI integration. Many systems do not adapt automatically to changing customer preferences, which reduces their effectiveness in dynamic market environments. Scalability is also a concern, as traditional analytical methods face difficulties handling large volumes of data generated from modern digital platforms.

DISADVANTAGES

The existing customer behavior analysis systems suffer from several limitations that reduce their effectiveness in modern data-driven environments. One of the major drawbacks is the dependence on traditional statistical and rule-based methods, which are unable to analyze large and complex datasets efficiently. These systems mainly rely on historical transaction data and fail to consider dynamic customer interactions such as browsing behavior, real-time activities, and user feedback, resulting in incomplete analysis.

Another significant disadvantage is the low accuracy of recommendations. Conventional systems often use single techniques such as collaborative filtering or content-

based filtering, which leads to problems like data sparsity and cold-start issues when new users or products are introduced. As a result, the system cannot generate reliable recommendations for users with limited history, reducing personalization quality.

Existing systems also lack adaptability and intelligent learning capabilities. They do not automatically update according to changing customer preferences or market trends, causing outdated insights and irrelevant suggestions. Moreover, these models struggle with scalability when handling massive datasets generated from e-commerce platforms and digital applications.

V PROPOSED SYSTEM

The proposed system is designed to analyze customer behavior and provide intelligent product recommendations using data-driven techniques and artificial intelligence. The system overcomes the limitations of traditional methods by efficiently handling large customer datasets and generating meaningful insights.

Initially, the system collects customer data such as age, gender, location, purchase frequency, interests, and transaction details. This data is then preprocessed to remove missing values and convert it into a structured format suitable for analysis.

After preprocessing, the system performs data analysis and visualization to understand customer behavior patterns. Various attributes such as purchase frequency, average order value, and customer interests are analyzed to identify trends and patterns.

Based on this analysis, the system generates product suggestions using an AI-based recommendation approach. The recommendation system uses customer preferences and historical data to suggest relevant products to users.

The system is implemented using Python and Django framework, where users can register, log in, load datasets, view customer analysis, and receive product recommendations. The admin module allows monitoring of users and analysis results.

Overall, the proposed system provides an efficient and scalable solution for customer behavior analysis, improving decision-making and enhancing user experience through personalized recommendations.

ADVANTAGES

The proposed customer behavior analysis system offers several advantages compared to traditional approaches by integrating data mining techniques with AI-driven recommendation methods. One of the major benefits is improved recommendation quality, as the system analyses customer data using similarity-based techniques such as Bag of Words and cosine similarity to understand user preferences effectively. This helps in providing relevant product category suggestions based on user input.

Another important advantage is automation. The system automatically analyses customer data and generates recommendations without manual intervention. This reduces time and effort while improving efficiency. The use of data visualization techniques also enhances understanding by presenting customer behavior trends in the form of graphs and charts.

The proposed system is simple, efficient, and easy to implement, making it suitable for academic and practical applications. It can handle structured data such as customer details and purchase information effectively, providing useful insights into customer behavior.

Additionally, the system improves decision-making by helping businesses understand customer preferences and trends. Although the system currently provides category-level recommendations, it can be easily extended to product-level recommendations by using more detailed datasets.

VI METHODOLOGY

The proposed methodology for customer behaviour analysis using data mining techniques with an AI-driven recommendation system consists of several stages designed to transform raw customer data into meaningful insights and recommendations.

The process begins with data collection, where customer information is obtained from a dataset containing attributes such as age, gender,

location, product category preference, purchase frequency,

and total spending. This dataset serves as the foundation for analysing customer behaviour patterns.

In the next stage, data preprocessing is performed to improve the quality and consistency of the dataset. This includes converting text data into lowercase, removing duplicate records, and handling missing values. These steps ensure that the dataset is clean and suitable for further analysis and processing.

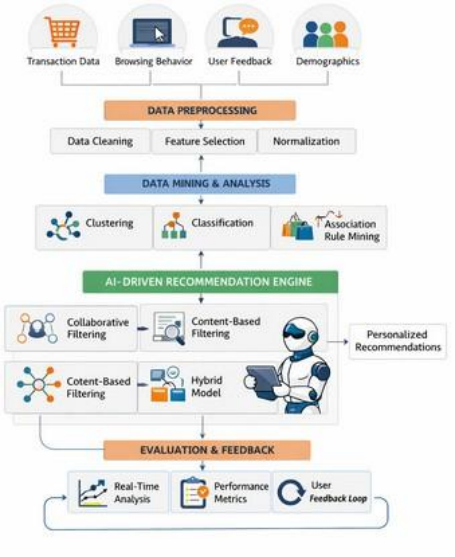
After preprocessing, the system performs data analysis to understand customer behaviour by examining attributes such as age, gender, location, and purchasing patterns. Instead of using complex data mining algorithms, the system uses simple analytical methods and visualization techniques to identify patterns and trends in the data.

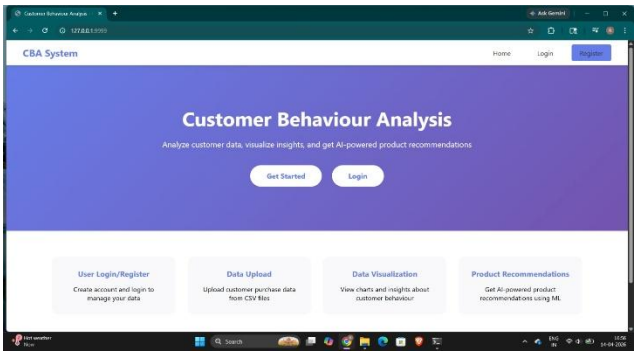
The processed data is then used in the AI-driven recommendation module. The system applies a content-based recommendation approach using text mining techniques. Specifically, it uses the Bag of Words (Count Vectorizer) method to convert product category data into numerical vectors. These vectors are then used to calculate similarity between different product categories.

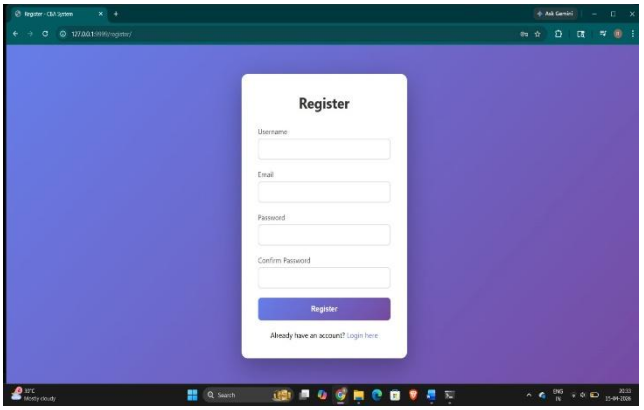
To generate recommendations, the system uses the cosine similarity algorithm to measure how closely related different product categories are. Based on the similarity scores, the system identifies and selects the most relevant categories and provides them as recommendations to the user. The input category is excluded from the final suggestions to avoid repetition.

Finally, the system provides output in the form of recommended product categories and visual representations of customer behaviour. Various charts such as horizontal bar

Graph and pie chart are used to present insights in a clear and understandable manner, helping users and administrators make better decisions







VII SYSTEM MODEL SYSTEM ARCHITECTURE

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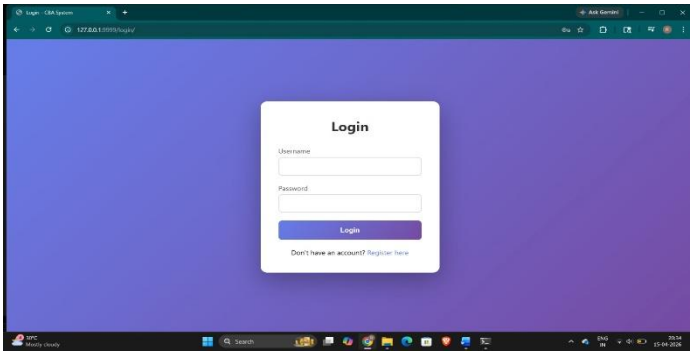
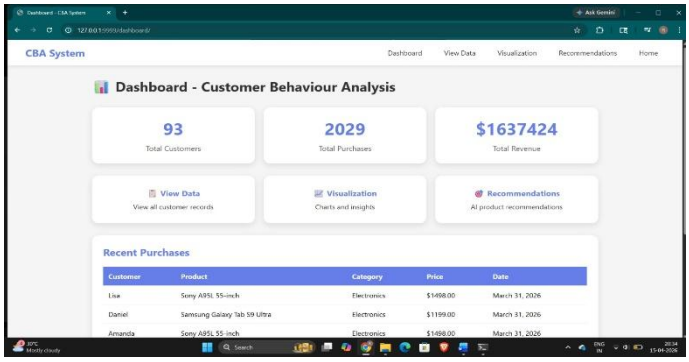
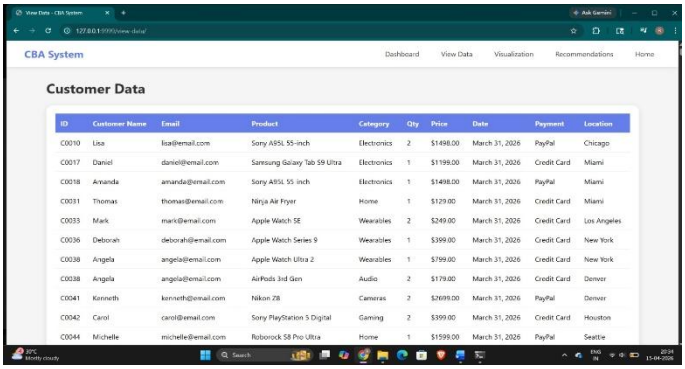
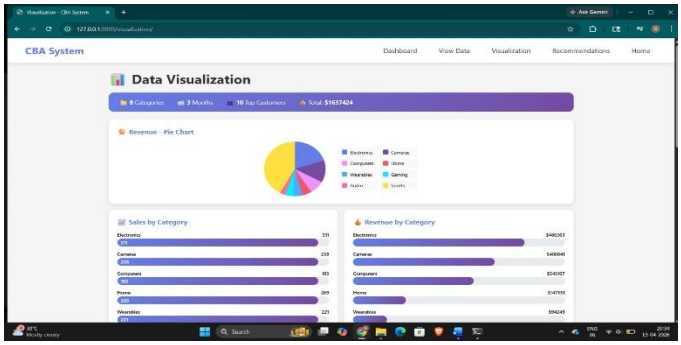


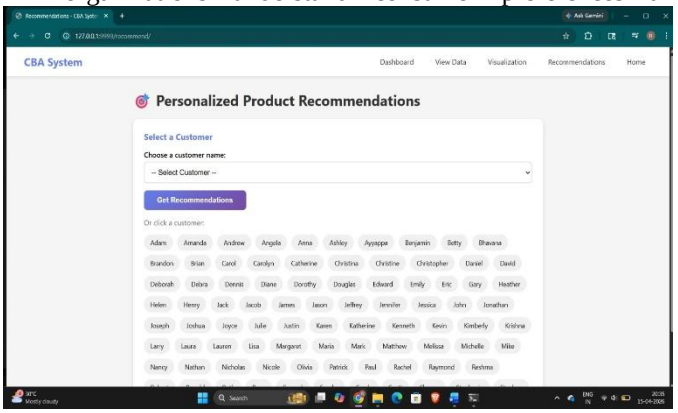




CONCLUSION



Customer behavior analysis plays a vital role in helping organizations understand consumer preferences and



improve business decision-making in today's data-driven environment. The proposed system integrates customer data management, visualization, and an AI-driven recommendation engine to analyze customer activities and generate personalized product suggestions. By processing large datasets and identifying meaningful patterns such as purchase frequency, product interests, and spending behavior, the system provides valuable insights into customer trends. The incorporation of Artificial Intelligence enables the recommendation module to adapt continuously to customer preferences, making the system capable of providing accurate and relevant recommendations.

Compared to traditional approaches, the proposed system improves recommendation accuracy, enhances customer engagement, and supports targeted marketing strategies. Additionally, the system efficiently handles large-scale data and adapts to changing customer preferences in real time. Overall, it demonstrates a scalable and intelligent solution for customer behavior analysis, combining data-driven insights with personalized recommendations to strengthen customer relationships and drive sustainable business growth.

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