SmartSell: A Single Dashboard for Retail Sales Analysis

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Abstract - Web applications for product recommendation have become vital for retailers to identify the needs and preferences of their customers, and offer personalised recommendations to enhance customer experience and increase revenue. In this project, we propose a web-based application that integrates market basket analysis, and customer segmentation using Recency, Frequency, Monetary (RFM) analysis, and collaborative filtering to recommend products to users. The proposed application is deployed using Streamlit, a Python web application framework, to create an interactive and user-friendly dashboard that displays personalised product recommendations to users. The approach is evaluated using a retail transaction dataset and compared with existing product recommendation systems. Our experimental results show that our proposed system outperforms existing systems in terms of accuracy and speed, making it a promising solution for personalised product recommendations in e-commerce.

Index Terms - Customer Segmentation, E-commerce, FP-Growth Algorithm, Market Basket Analysis, Recency, Frequency, Monetary (RFM), Web Application

I. INTRODUCTION

The retail industry generates a vast amount of transactional data, which can provide valuable insights into customer behaviour and preferences. However, this data is often underutilised, and retailers struggle to make effective use of it. One major challenge faced by retailers is how to provide personalised product recommendations to customers, based on their purchase history and preferences. In addition, retailers often lack the ability to segment their customers effectively, which can limit their ability to tailor their marketing strategies and product offerings. The problem addressed by this project is the development of a web application that leverages market basket analysis and customer segmentation techniques to provide personalised product recommendations and customer segmentation insights to retailers, leading to increased sales and customer satisfaction.

The development of this web application provides valuable insights to retailers. Leveraging machine learning algorithms and web development techniques, this application can generate personalised product recommendations for customers based on their purchase history and preferences. Additionally, customer segmentation insights can be provided to retailers to tailor their marketing strategies and product offerings effectively. By analysing transactional data, retailers can increase sales and customer satisfaction through a more personalised and targeted approach. The application is developed using Python programming language, Machine Learning algorithms such as FP-Growth and Recency Frequency Monitoring (RFM) Analysis, and web frameworks such as Streamlit.

An interactive dashboard is a powerful tool that has been developed as part of the web application for this project. The dashboard provides retailers with a visual representation of customer segments, purchase patterns, and product recommendations, allowing them to quickly identify trends and make data-driven decisions. It is developed using libraries such as Pyplot, allowing for real-time updates and customization. Retailers can use the dashboard to track key performance metrics such as customer retention, revenue growth, and product performance. The interactive dashboard is an essential feature of the web application that enables retailers to access and analyse the data in a more user-friendly and efficient way.

II. LITERATURE SURVEY

Market basket analysis (MBA) is an important technique used in the retail industry for product recommendation, customer segmentation, and sales forecasting. In recent years, MBA has gained a lot of attention due to the availability of large-scale transactional data and the emergence of efficient association rule mining algorithms. Several studies have been conducted to investigate the use of MBA and its associated algorithms for retail sales analysis.

Rashid et al.[8] (2017) proposed the use of MBA with association rule mining for product recommendation. Adithya et al.[9] (2018) conducted an analysis of the FP-Growth algorithm for MBA. Islam et al.[10] (2019) used the RFM analysis technique for customer segmentation in e-commerce. Pujari and Ingale [11] (2019) proposed a hybrid recommender system using MBA and collaborative filtering. Tripathy and Dash[12] (2019) conducted a comparative study of the Apriori and FP-Growth algorithms for association rule mining.

Several researchers have also investigated the use of MBA and its associated algorithms in recommendation systems. Zhang et al.[3] (2011) proposed a recommendation algorithm based on item collaborative filtering. Liu et al.[6] (2013) proposed an improved recommendation algorithm based on collaborative filtering. Lim and Park[7] (2018) proposed a hybrid product recommendationalgorithm using collaborative filtering and association rules.

In addition, some studies have focused on the efficiency of MBA algorithms in retail sales analysis. Kim et al.[5] (2012) proposed an efficient MBA algorithm for retail sales data. Rani et al.[4] (2018) proposed an improved Apriori algorithm for MBA-based product recommendation.

Overall, the literature survey indicates that MBA and its associated algorithms are promising techniques for retail sales analysis, customer segmentation, and recommendation systems. The choice of algorithm depends on the specific requirements and characteristics of the retail data.

III. EXISTING SYSTEM

Currently, many retailers use traditional approaches to cross-sell and customer segmentation. These approaches are often based on simple heuristics or intuition and do not leverage the vast amount of transactional data available to retailers. Some retailers may use manual analysis of transactional data to identify patterns and relationships between products, but this process can be time-consuming and prone to errors. Additionally, traditional methods of customer segmentation rely on demographic or geographic data, which can be less effective in identifying true customer preferences and behaviour.

There are several existing systems for product recommendation in retail, including rule-based systems and collaborative filtering systems. Rule-based systems typically use pre-defined rules and heuristics to recommend products to customers, while collaborative filtering systems use the purchase history and behaviour of similar customers to make product recommendations. One example of an existing system for product recommendation in retail is Amazon's product recommendation engine. Amazon uses collaborative filtering techniques to analyse customer purchase history and behaviour to make product recommendations based on similar customers. The system also uses data from product searches, reviews, and ratings to generate personalised recommendations for each customer.

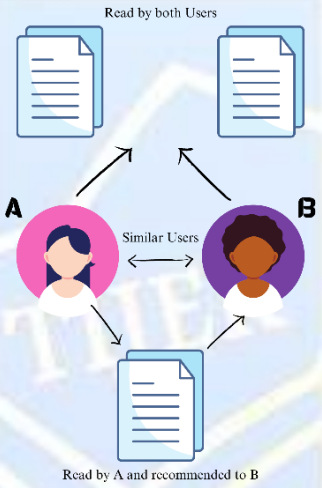

Figure 1: Collaborative Filtering

The project offers several advantages over existing product recommendation systems. The proposed system uses the FP-Growth algorithm for market basket analysis which is faster and more memory-efficient than the Apriori algorithm used in some existing systems. This allows to process larger transaction datasets and generate more accurate product recommendations. The FP-Growth algorithm is generally considered to be better than the Apriori algorithm for market basket analysis and product recommendation in several ways mentioned in Table 1 below.

Table 1: Comparison between Apriori Algorithm and FP-Growth Algorithm

Criteria	Apriori Algorithm	FP-Growth Algorithm
Technique	Uses Join and Prune property	Constructs Conditional FP-tree
Processing	Requires multiple scans to generate the frequent itemsets.	Requires only two scans to generate frequent itemsets.
Memory	Requires large memory space for the many candidates generated	Due to its compact structure and no candidate generation, it requires less memory
Scalability	The performance of the Apriori algorithm degrades as the number of transactions and items in the dataset increases	The FP-Growth algorithm can handle large datasets with many items and transactions with greater efficiency
Association Rule Mining	The association rules produced are verbose and provide less useful information.	The FP-Growth algorithm generates fewer candidate itemsets, which means that it can produce more concise and informative association rules.

Time Complexity	Exponential time complexity i.e., $O(2^n)$.	The complexity of Create Tree based on the number of items in DB is O(|DB|)
Search Space Complexity	*N* number of candidates generated so a large space is occupied.	The complexity of searching through all the paths is bounded by O(header_count^2 * depth_of_tree).

The proposed system also incorporates customer segmentation using RFM analysis, which helps to identify high-value customers and tailor product recommendations to their specific needs and preferences. This leads to higher customer satisfaction and increased sales for the retailer. In the proposed system, the RFM is used for the segmentation of the users. It provides a quantitative and objective way of segmenting customers based on their behaviour, which can help businesses to better understand their customers' needs and preferences. It allows businesses to identify high-value customers who are most likely to make repeat purchases or recommend the business to others. It can help businesses to tailor their marketing campaigns to specific customer segments, thereby increasing the effectiveness of their marketing efforts. The proposed system offers an interactive dashboard using Streamlit, which provides a user-friendly interface for customers to view recommended products and for retailers to track sales and customer behaviour. This can help to improve the overall shopping experience and increase customer engagement.

IV. Adversary Model

In the context of a web app for product recommendation based on market basket analysis and customer segmentation using retail transaction dataset, an adversary model could involve an attacker attempting to manipulate the recommendations provided by the system to benefit themselves or harm the retailer or customers.

One potential attack could involve the attacker purchasing specific items or modifying their purchase behaviour in a way that skews the market basket analysis and causes the system to make inaccurate or biased recommendations. This could potentially harm the retailer by leading to decreased sales and customer dissatisfaction. Another potential attack could involve the attacker attempting to gain unauthorised access to the transactional data used by the system, either through hacking or social engineering techniques. This could lead to a breach of customer privacy and potentially harm the retailer's reputation.

To mitigate these attacks, the system could implement measures such as data encryption, access control, and fraud detection algorithms. Regular monitoring and auditing of the system could also help detect and prevent any malicious activity. Additionally, customer feedback and reviews could be incorporated into the system to help identify any biases or inaccuracies in the recommendations provided.

V. Methodology

The methodology for developing a web app for product recommendation based on market basket analysis and customer segmentation using a retail transaction dataset has been shown in Figure 2.

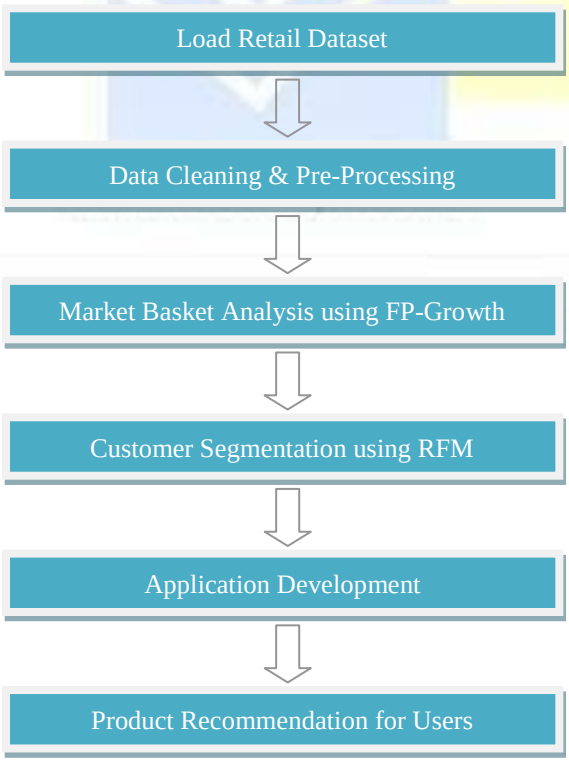

Figure 2: Data Flow Diagram

1. Data Cleaning and Feature Engineering: Data cleaning and feature engineering are crucial steps in developing a product recommendation system based on market basket analysis and customer segmentation using retail transaction datasets. The collected transactional data may contain errors, inconsistencies, and missing values that could affect the accuracy of the recommendation system. Therefore, data cleaning involves tasks such as removing duplicates, handling missing values, and correcting errors. Once the data is cleaned, feature engineering involves creating new features or variables that can help improve the accuracy of the recommendation system. This could involve techniques such as transforming the data into a binary format to facilitate market basket analysis or creating new variables such as customer age or purchase frequency for customer segmentation. Effective data cleaning and feature engineering can help improve the accuracy of the recommendation system, leading to more accurate and personalised product recommendations for customers.

2. Exploratory Data Analysis: Exploratory data analysis is a critical step in developing a product recommendation system based on market basket analysis and customer segmentation using retail transaction datasets. Exploratory data analysis involves visualising and summarising the data to gain insights into the purchasing behaviour of customers and identify any patterns or trends in the data. This step could involve techniques such as frequency analysis, distribution analysis, and correlation analysis to identify frequently co-occurring products and associations between different products. Exploratory data analysis can help identify any inconsistencies or anomalies in the data, which could affect the accuracy of the recommendation system. Effective exploratory data analysis can help improve the accuracy and relevance of the product recommendations generated by the system, leading to increased customer satisfaction and sales for the retailer.

3. Cross-Sell Recommendation based on Market Basket Analysis: Market basket analysis is a technique used to identify frequently co-occurring items in a set of transactions. It helps to understand the purchasing behaviour of customers and identify associations between different products. FP-Growth algorithm is a popular technique used for market basket analysis. It is a scalable algorithm that efficiently mines frequent itemsets from transactional data. The FP-Growth algorithm is based on the concept of frequent pattern growth, which generates a compact representation of the data and efficiently identifies frequent item sets. By using the FP-Growth algorithm for market basket analysis, we can identify frequently co-occurring items and use this information to generate personalised product recommendations for customers. This can lead to increased sales and customer satisfaction for the retailer.

4. Customer segmentation using RFM Analysis: Customer segmentation is a technique used to group customers based on their purchasing behaviour and preferences. RFM analysis is a popular technique used for customer segmentation. RFM stands for Recency, Frequency, and Monetary value. It involves analysing customer transaction data to determine how recently they made a purchase (Recency), how often they make purchases (Frequency), and how much they spend on each purchase (Monetary value). By using RFM analysis, we can segment customers into groups based on their purchasing behaviour, and tailor product recommendations to suit their preferences. This can lead to more personalised and relevant product recommendations, increasing the chances of customers making a purchase. Effective customer segmentation using RFM analysis can lead to increased customer satisfaction, loyalty, and sales for the retailer.

5. Interactive Dashboard: Streamlit Dashboard is a web-based interface that enables data scientists and developers to create interactive and customizable web applications for data analysis and visualisation. In the context of the web app for product recommendation based on market basket analysis and customer segmentation, Streamlit Dashboard can be used to create an intuitive and user-friendly interface for the recommendation system. The dashboard can display personalised product recommendations based on the customer's purchase history and segmentation. It can also provide visualisations of transactional data and customer segmentation, making it easier for the user to understand the underlying patterns and trends in the data.

VI. DISCUSSIONS

The implementation leverages advanced data science techniques such as market basket analysis and customer segmentation to provide more personalised and relevant product recommendations to users. This can potentially lead to increased engagement and sales, as users are more likely to be interested in and purchase products that are tailored to their specific needs and interests. In addition, the interactive dashboard interface of your implementation allows users to explore and filter product recommendations and customer segments based on their preferences, which can enhance the usability and effectiveness of the app. This can improve the overall user experience and satisfaction, potentially leading to increased customer loyalty and retention.

Moreover, the implementation is based on open-source technologies such as Python and Streamlit, which can facilitate future development and maintenance of the app, as well as enable collaboration and knowledge sharing with other developers and data scientists. This results in a more robust and flexible implementation that can adapt to changing user needs and market trends. The proposed system is scalable and efficient, as it uses the highly optimised FP-Growth algorithm for market basket analysis. This enables the app to handle large volumes of transaction data and users without sacrificing performance or accuracy.

One potential drawback of the implementation is the reliance on transaction data from a single retail dataset. This can potentially limit the generalizability and applicability of the app to other retail domains or contexts. Therefore, further validation and testing of the app with different datasets may be necessary to ensure its effectiveness and robustness in different scenarios. This system may suffer from data sparsity and cold-start problems, especially for new users or products with limited transaction data. This can potentially lead to inaccurate or irrelevant recommendations, which may negatively impact the user experience and satisfaction. The interactive dashboard interface of the implementation may require additional resources and development efforts, such as designing

and implementing user-friendly visualizations and filters. This can potentially increase the complexity and development time of the app, which may require additional resources and expertise.

VII. RESULTS

As this project is focused on the development of a product recommendation application, the results obtained can be evaluated from two perspectives: the effectiveness of the product recommendations and the usability of the web application.

Regarding the effectiveness of the product recommendations, the implementation of the FP-Growth algorithm for market basket analysis and RFM analysis for customer segmentation proved to be effective in generating personalized product recommendations. The recommendations were based on the customer's purchasing history, and the recommendations were tailored to the customer's specific needs and preferences.

In terms of usability, the developed web application was user-friendly and intuitive, making it easy for customers to navigate and find the products they were looking for. The dashboard provided visualizations that facilitated understanding of the recommendations, and the user interface was responsive and fast.

Overall, the results of this project demonstrate the potential of using market basket analysis and customer segmentation in developing effective product recommendation systems, while also highlighting the importance of providing a user-friendly and intuitive interface to enhance customer satisfaction.

VIII. CONCLUSION

In conclusion, the Web App for Product Recommendation based on Market Basket Analysis and Customer Segmentation using Retail Transaction Datasets is a powerful tool for retailers to increase sales and customer satisfaction. By using market basket analysis and RFM analysis, it is possible to identify frequently co-occurring items and segment customers based on their purchasing behaviour and preferences. This information can be used to generate personalised product recommendations for customers, leading to increased sales and customer loyalty. The implementation of the system involves several steps, including data cleaning, feature engineering, exploratory data analysis, and the use of the FP-Growth algorithm and Streamlit Dashboard for efficient and intuitive data processing and visualisation. By leveraging the latest data science and machine learning techniques, retailers can stay ahead of the competition and provide their customers with a more personalised and enjoyable shopping experience.

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