



Analyzing the Key Behavioral Features Influencing Customer Decisions in E-Commerce Environments Using Historical and Real-Time Data

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Abstract

The rapid growth of e-commerce has generated vast amounts of customer data, enabling businesses to better understand consumer decision-making processes. This study aims to analyze key behavioral features influencing customer decisions in e-commerce environments by integrating both historical and real-time data. The research identifies critical behavioral indicators such as browsing patterns, clickstream activity, purchase history, session duration, and engagement metrics. A hybrid analytical framework combining machine learning and statistical techniques is proposed to extract meaningful insights. The study demonstrates that integrating historical customer characteristics with real-time behavioral signals significantly enhances prediction accuracy and customer segmentation. The findings contribute to improved personalization, recommendation systems, and strategic decision-making in e-commerce platforms.

transactions into complex, data-driven ecosystems. Its growth has been driven by technological advancements, changing consumer behavior, and the expansion of internet accessibility worldwide.

Keywords: E-commerce, decision making, pattern analysis, velocity streaming,

Introduction

E-commerce has revolutionized the way consumers interact with products and services, offering convenience, variety, and personalized experiences. However, understanding customer decision-making remains a complex challenge due to dynamic user behavior and diverse influencing factors. Customer behavior in e-commerce is influenced by both historical data (past purchases, preferences) and real-time interactions (clicks, browsing activity, session patterns). Traditional approaches relied heavily on static data, but modern systems emphasize real-time analytics for dynamic decision-making [1]. This study focuses on identifying and analyzing key behavioral features that spin purchasing decisions and proposes an integrated framework for predictive modeling. E-commerce has transformed the global retail landscape over the past few decades, evolving from simple online

In the early stages, e-commerce emerged in the 1990s with the rise of the internet, where companies like Amazon and eBay pioneered online retail and auction platforms. Initially, consumers were hesitant due to concerns about security, trust, and lack of familiarity with online payment systems [6]. However, improvements in encryption technologies and secure payment gateways gradually built consumer confidence. In year 2000 there is expansion in increase in use of internet penetration, improved logistics infrastructure, and the rise of digital payment systems. The introduction of smartphones and mobile applications further accelerated growth by enabling anytime, anywhere shopping. Companies such as Alibaba and Flipkart expanded e-commerce into



emerging markets, including India, making online shopping accessible to a broader population.

In recent years, the growth of e-commerce has been significantly influenced by data analytics, artificial intelligence, and personalized marketing strategies. Businesses now leverage both historical data (such as past purchases and browsing history) and real-time data (such as clickstream and session behavior) to understand customer preferences and optimize decision-making processes. Integration of technologies such as cloud computing, big data, and mobile wallets has enhanced scalability, efficiency, and user experience in e-commerce systems. Social media platforms and digital marketing have also played a crucial role in influencing customer decisions and driving traffic to e-commerce websites.

Importance of Understanding Customer Behavior in E-Commerce

In highly competitive digital markets, analyzing how customers interact with online platforms helps organizations identify patterns, preferences, and decision-making processes. Understanding customer behavior is a critical factor in the success of modern e-commerce systems, as it enables businesses to make informed decisions, enhance user experience, and improve overall performance. The primary benefits of studying customer behavior are personalization. By examining browsing history, purchase patterns, and real-time interactions, another important aspect is improved decision-making. Behavioral insights allow businesses to understand what influences purchasing decisions, such as pricing, product reviews, discounts, and user interface design [8]. This enables companies to optimize marketing strategies, product placement, and promotional campaigns to better align with customer expectations.

Customer behavior analysis is also essential for dynamic pricing and inventory management. Businesses can adjust prices based on demand patterns, seasonal trends, and competitor behavior while ensuring optimal stock levels. This reduces operational costs and maximizes profitability. In addition, understanding behavioral patterns contributes to fraud detection and risk management.

Role of Historical vs Real-Time Data in E-Commerce

In modern e-commerce environments, both historical and real-time data play a crucial role in understanding customer behavior and influencing decision-making processes. The integration of these two data types enables businesses to develop more accurate, adaptive, and customer-centric strategies.

1. Role of Historical Data

Historical data refers to previously collected information such as past purchases, browsing history, customer demographics, and transaction records. This type of data provides a long-term perspective on customer behavior and is essential for identifying patterns and trends over time [11].

- **Behavioral Pattern Analysis:** Helps in understanding recurring purchasing habits and seasonal trends.
- **Customer Segmentation:** Enables classification of customers into groups based on preferences and buying behavior.
- **Predictive Modeling:** Supports machine learning models that forecast future actions, such as likelihood of purchase or churn.
- **Strategic Decision-Making:** Assists businesses in planning marketing campaigns, pricing strategies, and inventory management.

Most of E-commerce platforms like Amazon extensively use historical data to build recommendation systems and personalize user experiences.

2. Role of Real-Time Data

Real-time data refers to information generated instantly as users interact with an e-commerce platform, such as click stream data, current session activity, search queries, and time spent on pages [9]. This data provides immediate insights into customer intent and behavior.

- **Instant Personalization:** Enables dynamic product recommendations during a user session.
- **Real-Time Decision Making:** Supports immediate actions like targeted offers or pop-ups based on user activity.
- **Cart Abandonment Reduction:** Detects when users are about to leave and triggers interventions (discounts, reminders).



- **Fraud Detection:** Identifies suspicious behavior instantly to prevent unauthorized transactions.

Literature Review

The literature demonstrates a clear evolution from theoretical models to data-driven approaches in analyzing e-commerce customer behavior. While historical data provides stability and context, real-time data captures immediate intent. The integration of both, supported by machine learning and big data technologies, offers a powerful framework for understanding and predicting customer decisions [6].

However, challenges related to data integration, scalability, and privacy indicate that further research is required to develop robust, adaptive, and explainable models for modern e-commerce environments.

Research Gaps Identified from Comparative Analysis

- Lack of unified frameworks integrating historical + real-time + contextual data
 - Limited research on real-time adaptive behavioral modeling
 - Challenges in handling high-velocity streaming data
 - Privacy and ethical concerns in behavioral tracking
- Pictorial representation showed the research gaps:



Research Methodology

This methodology integrates both historical and real-time data analysis to provide a comprehensive understanding of customer behavior in e-commerce. By combining feature engineering, machine learning models, and real-time analytics, the study aims to accurately predict customer decisions and identify key influencing behavioral factors.

- Data Collection:** historical data is collected from

- E-commerce transaction records (purchase history, order value)
- Customer profiles (demographics, preferences)
- Past browsing behavior etc...

- Real-time data** is collected through by using various web analytics tools:

- Clickstream tracking (page views, clicks)
- Session duration and navigation paths
- Cart activity and abandonment behavior

- Data Preprocessing**

Data preprocessing ensures data quality and consistency before analysis:

- Data Cleaning:** Removal of noise, duplicates, and irrelevant data.
- Handling Missing Values:** Imputation techniques (mean, median, mode).
- Feature Encoding:** Label encoding and one-hot encoding for categorical variables.
- Normalization/Scaling:** Standardization of numerical features.
- Session Identification:** Structuring real-time data into meaningful sessions.

- Feature Engineering**

Key features are extracted and categorized as:

- Demographic Features:** Age, gender, location
- Behavioral Features:** Click frequency, time spent, browsing depth
- Transactional Features:** Purchase frequency, recency, monetary value (RFM)
- Contextual Features:** Time of day, seasonal effects, promotional offers
- Real-Time Features:** Current session activity, recent clicks, dwell time

- Tools and Technologies**

- Programming Languages:** Python, R
- Libraries:** Scikit-learn, TensorFlow, Pandas, NumPy
- Visualization Tools:** Matplotlib, Power BI
- Big Data Tools:** Apache Spark
- Database Systems:** SQL, NoSQL

Feature Identification and Analysis

Feature identification and analysis is a critical stage in understanding customer decision-making in e-commerce. It involves extracting meaningful variables from both historical and real-time data that significantly influence purchasing behavior. These features are used to build predictive models, enhance



personalization, and improve overall business strategies.

Comparative Analysis of Features

S.No.	Feature Type	Data Source	Strength	Limitation
1	Demographic	Historical	Easy segmentation	Static, less dynamic
2	Behavioral	Both	Strong predictor of intent	High dimensional
3	Transactional	Historical	Indicates loyalty	May ignore current intent
4	Contextual	Both	Captures external influence	Variable over time
5	Real-Time	Real-Time	Immediate insights	Requires fast processing
6	Social	Both	Builds trust	Subject to bias

Model Development

Model development is a core component of this research, aimed at building predictive systems that analyze customer behavior and forecast purchase decisions. The approach integrates historical data (long-term patterns) with real-time data (instant user intent) to create accurate and adaptive models.

The process is follows:

1. Problem Formulation
2. Data Preparation for Modeling

3. Dataset Splitting

4. Handling Imbalanced Data

5. Feature Scaling

6. Model Selection like

- Logistic Regression
- Decision Tree
- Random Forest
- Support Vector Machine (SVM)

7. Model Evaluation take place via

- Accuracy
- Precision
- Recall
- F1-Score
- ROC-AUC

Expected Outcomes

- Accurate prediction of customer purchase behavior
- Identification of key behavioral features
- Improved recommendation systems
- Enhanced customer engagement and conversion rates

Conclusion

This research aimed to analyze the key behavioral features that influence customer decision-making in e-commerce environments by leveraging both historical and real-time data. The study demonstrates that customer behavior is inherently complex, multi-dimensional, and dynamic, shaped by a combination of demographic, behavioral, transactional, contextual, and social factors. The findings reveal that historical data plays a crucial role in identifying long-term customer preferences, purchasing patterns, and loyalty trends. In contrast, real-time data provides immediate insights into user intent, enabling dynamic responses such as personalized recommendations, targeted promotions, and timely interventions.

Integration of historical and real-time data provides a comprehensive framework for understanding and predicting customer behavior in e-commerce. The insights derived from this research can help businesses enhance customer experience, optimize marketing strategies, and improve conversion rates. Future research should focus on developing adaptive, explainable, and privacy-preserving models to further advance the effectiveness of customer behavior analysis in rapidly evolving digital environments.



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