

Machine Learning Based Sentiment Analysis and Forecasting for E-Commerce Decision Support

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ABSTRACT:

In the era of digital commerce, e-commerce platforms such as Amazon generate vast volumes of user-generated content in the form of product reviews, which offer valuable insights into customer sentiment and purchasing behavior. This study investigates the integration of sentiment analysis and forecasting techniques using machine learning to extract actionable knowledge from large-scale e-commerce data. Sentiment analysis methods, including Support Vector Machine (SVM), Naïve Bayes, K-Nearest Neighbors (KNN), and deep learning models such as Convolutional Neural Networks (CNN), Artificial Neural Networks (ANN), and bidirectional Long Short-Term Memory (Bi-LSTM) networks, are employed to classify customer opinions and identify emerging trends. In addition, forecasting models are utilized to predict future market behavior, supporting informed decision-making in areas such as inventory management, customer satisfaction, and strategic planning. The combined use of sentiment analysis and forecasting enables businesses to move beyond descriptive analytics toward predictive and prescriptive intelligence. The study demonstrates the effectiveness of these techniques through applications involving Amazon product reviews and market trend prediction, highlighting the role of machine learning and natural language processing in enhancing business intelligence and improving customer experience.

Keywords: Sentiment Analysis, Data Forecasting, Machine Learning, Support Vector Machine, Naïve Bayes, KNN, CNN, Artificial Neural Network, Bi-LSTM.

1. Introduction

In the digital era, e-commerce platforms generate massive volumes of user-generated content that provide valuable insights into customer preferences, behavior, and satisfaction. Among these platforms, Amazon stands out due to its extensive collection of customer reviews, where users openly share their experiences and opinions regarding products and services. This rich source of textual data has enabled the application of advanced analytical techniques to extract meaningful insights and support data-driven decision-making [1], [2], [3]. Sentiment analysis also referred to as opinion mining, plays a vital role in understanding the emotional polarity of customer reviews. By classifying reviews into positive, negative, or neutral sentiments, businesses can evaluate how their products and services are perceived by consumers. This understanding helps organizations improve product quality,

enhance services, and refine marketing strategies to better meet customer expectations [4], [5], [6]. Customer reviews further allow businesses to identify specific product aspects that influence consumer satisfaction. Repeated negative feedback on a particular feature may indicate areas requiring improvement, while consistent positive feedback can highlight competitive advantages. Such insights help organizations detect emerging trends, anticipate customer needs, and adapt to market dynamics more effectively [7], [8]. When sentiment analysis is integrated with forecasting techniques, its impact is significantly enhanced. Forecasting enables the prediction of future trends in sales, demand, and customer satisfaction based on historical data. This integration allows businesses to proactively manage inventory, optimize supply chains, and align strategic decisions with anticipated consumer behavior [9], [10], [11].

Recent advancements in machine learning and natural language processing (NLP) have revolutionized sentiment analysis and forecasting by enabling efficient processing of large-scale textual data. These technologies can automatically classify reviews, identify key themes, and uncover hidden patterns with high accuracy. As a result, the combined use of sentiment analysis and forecasting has become indispensable for e-commerce platforms seeking to maintain competitiveness in a data-driven marketplace [9], [12].

2. Sentiment Analysis

The Sentiment analysis is a natural language processing technique used to identify and classify emotions, opinions, or attitudes expressed in textual data. It categorizes text

into sentiment classes such as positive, negative, or neutral, thereby providing insights into user perceptions and experiences. With the increasing volume of online content from social media, blogs, forums, and product reviews, sentiment analysis has gained widespread importance across multiple domains [13], [14]. In e-commerce, sentiment analysis assists businesses in evaluating customer feedback, assessing product quality, and improving decision-making. It also benefits consumers by enabling them to understand public opinion before making purchasing decisions. Beyond e-commerce, sentiment analysis is applied in healthcare, politics, finance, and entertainment, where understanding public sentiment is crucial for shaping policies and strategies [15].

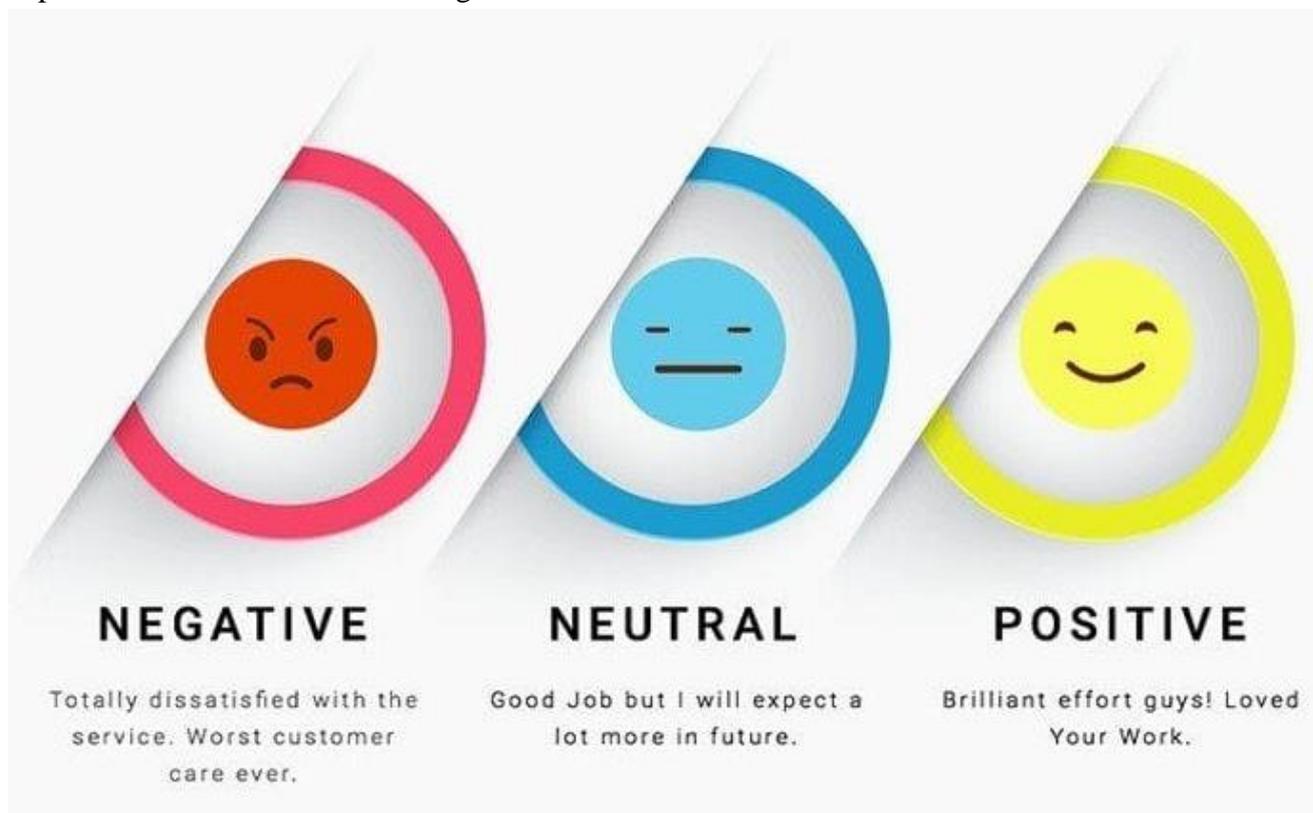


Figure 1: Sentimental Analysis

The field has advanced significantly with the adoption of machine learning and deep learning techniques. Algorithms such as Naïve Bayes, Support Vector Machines (SVM), and Long Short-Term Memory (LSTM) networks are widely used to process unstructured text data [16]. These approaches rely on feature

extraction and vectorization methods to represent textual information in structured formats, improving classification accuracy. Several types of sentiment analysis exist depending on the application scope. Binary and fine-grained sentiment analysis classifies text into basic or detailed sentiment categories.

Aspect-based sentiment analysis focuses on specific product features, while emotion detection identifies emotions such as joy, anger, or sadness. Multilingual and contextual sentiment analysis enables global applicability and improved interpretation of complex statements. The choice of sentiment analysis type depends on the objectives and domain of the study.

3. Data Forecasting

Machine Data forecasting involves predicting future outcomes based on historical and current data patterns. It plays a crucial role in various sectors, including healthcare, finance, and business, by supporting informed planning and decision-making. Although forecasts are not always perfectly accurate, they provide valuable estimates that reduce uncertainty and guide strategic actions. In business applications, forecasting is widely used to predict sales trends, customer demand, and market behavior. These predictions help organizations allocate resources efficiently, manage inventory, and plan budgets. In financial markets, forecasting assists investors in analyzing stock price movements and economic indicators, influencing investment strategies [17].

Forecasting techniques are also valuable in healthcare for early disease risk prediction and in economics for estimating indicators such as inflation or GDP growth. Overall, forecasting enhances preparedness and enables organizations to respond proactively to future challenges by leveraging insights derived from historical data.

4. Sentiment Analysis and Forecasting Using Machine Learning

Recent studies have demonstrated the effectiveness of machine learning and deep learning techniques in sentiment analysis and forecasting. Chauhan et al. (2024) applied SVM and Naïve Bayes to classify Amazon reviews, achieving accuracies of 76% and 80%, respectively [18]. Sridhar et al. (2024) proposed a hybrid GRCA-SBFNN model that

achieved high accuracy and precision in sentiment classification across multiple platforms. Deep learning approaches have shown superior performance in handling complex textual data [19]. Chhabra et al. (2024) used a bidirectional LSTM model for Amazon reviews, achieving an accuracy of 93.92%. Deepa et al. (2023) introduced a novel CNN-based model for emotion detection, attaining 98.3% accuracy. Hybrid and big data-based approaches have also gained attention [20]. Byali et al. (2024) combined rule-based and machine learning techniques and utilized Hadoop to improve processing speed for large datasets [21]. Liashenko et al. (2024) demonstrated that incorporating sentiment indicators improved stock price forecasting accuracy [22]. These studies collectively highlight the growing importance of integrating sentiment analysis with forecasting using machine learning to support business intelligence and predictive analytics.

5. Conclusion

This study highlights the effectiveness of combining sentiment analysis and forecasting techniques for extracting actionable insights from e-commerce data, particularly Amazon product reviews. Machine learning and deep learning models such as SVM, Naïve Bayes, CNN, and LSTM enable accurate sentiment classification and trend detection, while forecasting techniques support predictive decision-making. The integration of these approaches allows businesses to anticipate market trends, improve customer satisfaction, and optimize operational strategies. Furthermore, hybrid models and big data frameworks enhance scalability and efficiency when handling large datasets. As machine learning and NLP technologies continue to evolve, the synergy between sentiment analysis and forecasting will remain a critical tool for data-driven decision-making and long-term business success.

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