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# Sentiment Analysis of E-Commerce Reviews Using Machine Learning

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***Abstract***

*In e-commerce, sentiment pertains to the emotional responses, opinions, or perceptions that customers have about their online shopping experiences, including factors like product quality, service, and various processes such as ordering, shipping, and customer support. Sentiment analysis, which involves machine learning techniques, plays a crucial role in deciphering these sentiments. By using sentiment analysis, companies can obtain valuable insights from customer feedback from diverse online sources, including social media, surveys, and e-commerce reviews. The rise of information technology has greatly enhanced convenience, making e-commerce a favored option for purchasing and selling products without the need to visit physical stores. E-commerce encompasses the sale, distribution, and marketing of goods and services, with customer reviews and ratings becoming increasingly important after a purchase. In today's competitive market, sentiment analysis is widely used to enhance operational efficiency and support strategic decision-making. Sentiment analysis commonly employs machine learning models such as support vector machine (SVM), Random Forest, and XGBoost. These models are designed to accurately classify and predict customer sentiments based on the collected data. Their performance is usually measured using metrics like accuracy, F1-score, precision, and recall. Evaluating these metrics helps in identifying the most effective model and providing actionable insights that drive business improvements and growth. Overall, sentiment analysis is an essential tool for understanding customer feedback and achieving success in the e-commerce industry. Using supervised machine learning techniques, models such as Support Algorithms such as SVM, Random Forest, and XGBoost are commonly employed in sentiment analysis. They help accurately categorize and predict customer sentiments based on the collected data. The performance of these models is typically evaluated using metrics like accuracy, F1-score, precision, and recall. Analyzing these metrics helps identify the best-performing model, providing actionable insights that guide business enhancements and foster growth.*

**Keywords:** Machine learning, E-commerce, XGBoost, sentiment analysis, Random Forest

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## INTRODUCTION

Sentiment analysis is primarily utilized for internal business purposes, such as analytics, marketing, and sales. Additionally, it is applied to automate recommendation modules on corporate websites, which predict user preferences and suggest suitable products. Machine learning models for emotion detection require annotated corpora to account for various specificities, including pragmatics. Developing and deploying these models reduces the working time and can yield high performance. Training a machine learning model involves creating a set of automatically generated rules that significantly lower development costs. Although textual cues and dependencies related to emotions might not be immediately apparent to humans, machines can easily detect and encode this information into a model. E-commerce relies heavily on reputation-based trust models that determine a seller's reputation trust score by collecting feedback ratings. Given that shoppers often express their opinions through free-text review comments, we propose a Comment Trust Evaluation by mining these reviews. The proposed model calculates reputation trust scores based on user feedback comments across various dimensions. This study employed machine learning algorithms, including SVM, Logistic Regression, and Random Forest, and presented the findings using Matplotlib for visualization.

## PROPOSED SYSTEM

Our proposed system aims to develop a robust sentiment analysis solution tailored for e-commerce platforms, exclusively leveraging machine learning techniques integrated with web scraping capabilities. We will utilize web scraping methods to collect a substantial corpus of customer reviews and feedback from diverse e-commerce platforms. Employing advanced machine learning algorithms, we preprocess the gathered data, extract pertinent features, and train models for sentiment classification. Throughout this process, the utmost attention will be paid to ensuring data integrity, effectively handling imbalanced datasets, and implementing sophisticated feature engineering techniques. The primary objective is to conduct a predictive analysis of customer sentiment without the need for any application. By enabling e-commerce businesses to gain insights from this predictive analysis, they can make informed data-driven decisions aimed at enhancing their products and services. Our system's design emphasizes efficiency and accuracy and is promising for equipping e-commerce entities with invaluable tools to comprehend and respond to customer sentiments effectively, thus fostering improved customer satisfaction and business success.

## LITERATURE REVIEW

A literature review offers a summary of previously published research on a particular topic, as shown in Table 1. It can be a part of a complete scholarly paper or section within a book or article.

**Table 1.** Summary of literature review.

| Author (Year) | Title | Methodology |
|---|---|---|
| X. Yingchao and L. Qi (2023) [1] | Research on sentiment analyzers of teaching-related messages based on social networks. | Social network analysis |
| D.N.S.B. Kavitha and M.V. Subbarao (2023) [2] | Performance analysis of sentiment classification using optimized kernel extreme learning machine. | Optimized kernel extreme learning machine |
| R. Santhosh et al. (2023) [3] | Sentimental analysis on Amazon camera reviews using Naïve Bayes algorithm. | Naïve bayes algorithm |
| I. Sapthami et al. (2023) [4] | Sentiment analysis using machine learning algorithms for customer product reviews. | Machine learning algorithms |
| P. Kathuria et al. (2022) [5] | Sentiment analysis on e-commerce reviews and ratings using machine learning (ML) and natural language processing (NLP) models to understand consumer behavior. | ML, NLP |
| J.C. Gope et al. (2022) [6] | Sentiment analysis of Amazon product reviews using ML and deep learning models. | ML and deep learning models |
| P. Juyal (2022) [7] | Classification accuracy in sentiment analysis using hybrid and ensemble methods. | Hybrid and ensemble methods |
| S. Hafeez and N. Kathirisetty (2022) [8] | Effects and comparison of different data preprocessing techniques and ML and deep learning models for sentiment analysis. | SVM, KNN, PCA with SVM, CNN |
| F. Jemai et al. (2021) [9] | Sentiment analysis using ML algorithms. | ML algorithms |
| P. Awatramani et al. (2021) [10] | Sentiment analysis of mixed-case language using natural language processing. | NLP |
| R.K.B and N. Chandra Gowda (2020) [11] | A framework for sentiment analysis in customer product reviews using machine learning. | ML |
| Noor and M. Islam (2019) [12] | Sentiment analysis for women's e-commerce reviews using ML algorithms. | ML algorithms |

 

The purpose is to give researchers, authors, and readers a thorough understanding of existing knowledge on the subject. In summary, our project focuses on developing a sentiment analysis system tailored to e-commerce platforms using ML techniques. We collected a diverse dataset of customer reviews from various sources and processed it for analysis.

Exploratory data analysis helps us grasp the distribution and features of customer sentiments. We developed and trained ML models to classify sentiments and evaluated various algorithms to identify the most effective approach. The model performance was rigorously evaluated and tuned to ensure optimal accuracy and generalization to unseen data.

*"Sentiment Analysis for Women's E-commerce Reviews using Machine Learning Algorithms"* [12]—This paper presents a gender-based sentiment analysis, focusing on women's e-commerce reviews from Amazon.com using Weka. This study identifies the most suitable classifier for sentiment analysis by evaluating Naïve Bayes, RJio, J48, and Sequential Minimal Optimization (SMO) across four categories (Bayes theorem, Rules, Trees, Support Vector Machines) in combination with the boosting algorithm AdaBoost and comparing and analyzing their results.

*"Amazon Product Sentiment Analysis using Machine Learning Techniques"* [13] introduced a system that performs preprocessing operations such as stemming, tokenization, boxing, and removal of stop words from datasets to extract meaningful information, such as positive or negative sentiment. The primary goal is to analyze the data at the aspect level, providing significant benefits to marketers by helping them better understand consumer preferences and adapt their strategies accordingly. Additionally, this study offers insights into future text classification.

*"Review on Sentiment Analysis on Customer Reviews"* [14]—This paper describes a system that uses Natural Language Processing (NLP) and various machine learning classification algorithms to analyze customer feedback and reviews. This approach has recently gained popularity and has been widely adopted by many e-commerce companies to enhance performance. The system evaluates feedback and suggestions to determine their positive or negative nature. Among the three algorithms tested, Bernoulli's Naïve Bayes, Linear Support Vector Classifier, and Logistic Regression Classifier achieved the highest accuracy.

The paper "*A feature-based approach for sentiment analysis by using Support Vector Machine*" [15] explores a method for sentiment analysis with Support Vector Machine (SVM). The authors, D.V.N. Devi, C.K. Kumar, and S. Prasad, focus on a feature-based strategy to enhance the precision of sentiment classification. The study involved extracting and selecting relevant features from textual data, which were then used to train the SVM model. This research emphasizes the capability of SVM in managing high-dimensional data and its effectiveness in sentiment analysis tasks. The results indicate that the SVM outperforms other conventional ML algorithms in sentiment classification.

The paper "*Sentiment analysis of positive and negative of YouTube comments using Naïve Bayes–support vector machine (NBSVM) classifier*" [16] investigates sentiment analysis of YouTube comments using a hybrid classifier that integrates Naïve Bayes with support vector machine (NBSVM). The authors A.N. Muhammad, S. Bukhori, and P. Pandunata aimed to enhance the accuracy of sentiment classification by leveraging the strengths of both Naïve Bayes and SVM. The study involved preprocessing YouTube comment data, feature extraction, and the application of the NBSVM classifier to categorize comments as positive or negative. The results demonstrate that the NBSVM classifier provides improved performance in sentiment analysis compared with using Naïve Bayes or SVM alone.

"*Sentiment analysis of mixed-case language using natural language processing*" [10]—This paper by P. Awatramani, R. Daware, H. Chouhan, A. Vaswani, and S. Khedkar introduces a method for performing sentiment analysis on mixed-case language text using NLP. The authors address the challenge of analyzing text that includes a combination of uppercase and lowercase characters, which are common in informal communication, such as social media. This study involves preprocessing techniques tailored for mixed-case text, feature extraction, and the application of various NLP algorithms to classify sentiments. These results suggest that the proposed approach is effective.

"*Research on Sentiment Analyzer of Teaching-related Messages Based on Social Network*" [1]—This paper by Yingchao and L. Qi examines a sentiment analysis method specifically designed for teaching-related messages on social networks. The authors focused on developing a sentiment analyzer that can accurately classify sentiments expressed in messages related to educational topics. The study involved collecting data from social networks, preprocessing the text, and applying sentiment analysis techniques to determine the overall sentiment. The results highlight the effectiveness of the proposed model in understanding and categorizing sentiments in educational settings.

In the paper "*Sentiment Analysis on E-commerce Reviews and Ratings Using ML and NLP Models to Understand Consumer Behavior"* [5]—Kathuria, Sethi, and Negi presented a method for sentiment analysis that targets e-commerce reviews and ratings. The authors utilized machine learning (ML) and NLP models to analyze consumer reviews from e-commerce platforms. This study aims to understand consumer behavior by categorizing the sentiments expressed in reviews. The results demonstrate the ability of the ML and NLP models to accurately interpret and classify consumer sentiment, providing valuable insights into consumer preferences and satisfaction.

## IMPLEMENTATION

### Web Scraping

Web scraping is an automated method that is used to extract data from websites. This process uses software tools or scripts to access webpages, retrieve their content, and extract specific information of interest. It can be employed to collect various types of data from websites, including product prices, reviews, contact details, and news articles. The extracted data can then be analyzed, stored, or used for various purposes such as market research, competitor analysis, content aggregation, and business intelligence.

### Dataset

A dataset obtained through web scraping refers to the collection of structured data extracted from webpages using automated tools or scripts. Web scraping entails extracting specific information from HTML documents, such as text, images, links, or other elements, and converting it into a structured format such as a spreadsheet or database [17]. These datasets can include various types of data depending on the target website, such as product information, customer reviews, financial data, weather forecasts, or news articles (Figure 1).

### Data Preprocessing

Data preprocessing includes cleaning, transforming, and structuring raw data before being fed into an ML algorithm. It involves tasks such as handling missing values, cleaning up irrelevant data, converting categorical variables into a numerical format, scaling or normalizing data, splitting the dataset into training and testing sets, and sometimes reducing the number of features. The goal is to organize the data in a manner that allows the ML model to learn effectively and make accurate predictions (Figure 2).

### Features Extraction

Feature extraction involves the selection and transformation of raw data into a streamlined set of features that are pertinent and useful for a specific task or analysis. It involves identifying important characteristics or patterns in the data and representing them in a more concise and meaningful manner. Feature extraction helps to simplify data while retaining essential information, making it easier for ML algorithms to learn and make predictions (Figure 3).

 

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| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | product_id | Mode_of | product_nam | discounte | actual_pri | discount_p | category | review_titl | rating | sentiment_ | Gender |
| 2 | B07JW9H4J1 | Flight | Wayona Nylo | 399 | 1,099 | 64% | Computer | Satisfied,C | 4.2 | POSITIVE | F |
| 3 | B098NS6PVG | Flight | Ambrane Unb | 199 | 349 | 43% | Computer | A Good Br | 4 | NEGATIVE | F |
| 4 | B096MSW6CT | Flight | Sounce Fast P | 199 | 1,899 | 90% | Computer | Good spee | 3.9 | POSITIVE | M |
| 5 | B08HDJ86NZ | Flight | boAt Deuce U | 329 | 699 | 53% | Computer | Good prod | 4.2 | NEGATIVE | F |
| 6 | B08CF3B7N1 | Flight | Portronics Ko | 154 | 399 | 61% | Computer | As good as | 4.2 | POSITIVE | F |
| 7 | B08Y1TFSP6 | Flight | pTron Solero | 149 | 1,000 | 85% | Computer | It's pretty | 3.9 | NEUTRAL | F |
| 8 | B08WRWPM22 | Flight | boAt Micro U | 176.63 | 499 | 65% | Computer | Long dura | 4.1 | POSITIVE | F |
| 9 | B08DDRGWTJ | Flight | MI Usb Type- | 229 | 299 | 23% | Computer | Worth for | 4.3 | POSITIVE | F |
| 10 | B008IFXQFU | Flight | TP-Link USB W | 499 | 999 | 50% | Computer | Works on | 4.2 | POSITIVE | F |
| 11 | B082LZGK39 | Flight | Ambrane Unb | 199 | 299 | 33% | Computer | A Good Br | 4 | POSITIVE | F |
| 12 | B08CF3D7QR | Flight | Portronics Ko | 154 | 339 | 55% | Computer | Good for f | 4.3 | POSITIVE | M |
| 13 | B0789LZTCJ | Flight | boAt Rugged v | 299 | 799 | 63% | Computer | Good prod | 4.2 | POSITIVE | F |
| 14 | B07KSMBL2H | Flight | AmazonBasics | 219 | 700 | 69% | Electronic | It's quite g | 4.4 | POSITIVE | F |
| 15 | B085DTN6R2 | Flight | Portronics Ko | 350 | 899 | 61% | Computer | Works,Nic | 4.2 | NEGATIVE | F |
| 16 | B09KLVMZ3B | Flight | Portronics Ko | 159 | 399 | 60% | Computer | Great but, | 4.1 | POSITIVE | F |
| 17 | B083342NKJ | Flight | MI Braided US | 349 | 399 | 13% | Computer | Good prod | 4.4 | POSITIVE | F |
| 18 | B0B6F7LX4C | Flight | MI 80 cm (32 i | 13,999 | 24,999 | 44% | Electronic | It is the be | 4.2 | POSITIVE | F |
| 19 | B082LSVT4B | Ship | Ambrane Unb | 249 | 399 | 38% | Computer | A Good Br | 4 | POSITIVE | F |
| 20 | B08WRBG3XW | Ship | boAt Type C A | 199 | 499 | 60% | Computer | Good for c | 4.1 | POSITIVE | F |
| 21 | B08DPLCM6T | Ship | LG 80 cm (32 i | 13,490 | 21,990 | 39% | Electronic | Sound qua | 4.3 | POSITIVE | F |
| 22 | B09C6HXFC1 | Ship | Duracell USB | 970 | 1,799 | 46% | Computer | Good cabl | 4.5 | POSITIVE | F |
| 23 | B085194JFL | Ship | tizum HDMI to | 279 | 499 | 44% | Electronic | Good prod | 3.7 | POSITIVE | F |

**Figure 1.** Web scraping dataset.

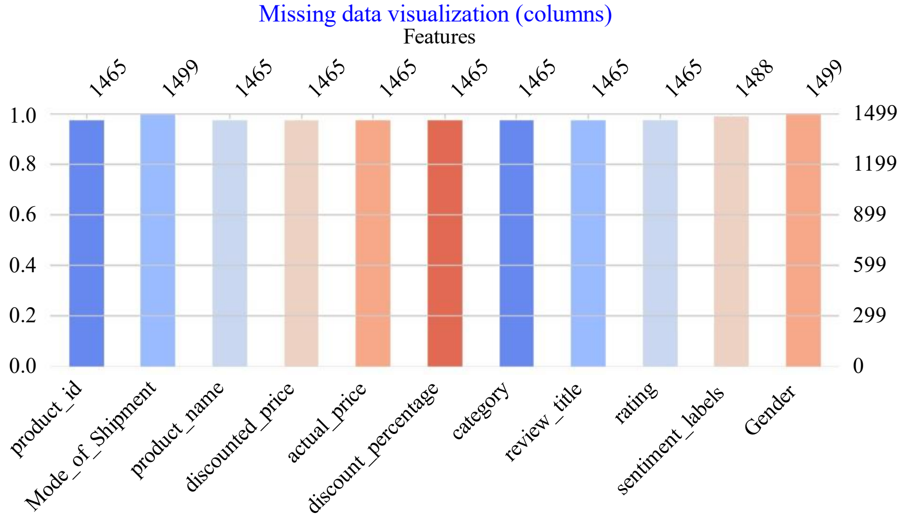



**Figure 2.** Missing data visualization.

| | product_id | review_title | rating | sentiment_labels | sentiment_score |
|---|---|---|---|---|---|
| 0 | B07JW9H4J1 | Satisfied,Charging is really fast,Value for mo... | 4.2 | Positive | 0.4404 |
| 1 | B098NS6PVG | A Good Braided Cable for Your Type C Device,Go... | 4 | Positive | 0.2382 |
| 2 | B096MSW6CT | Good speed for earlier versions,Good Product,W... | 3.9 | Positive | 0.7178 |
| 3 | B08HDJ86NZ | Good product,Good one,Nice,Really nice product... | 4.2 | Positive | 0.8689 |
| 4 | B08CF3B7N1 | As good as original,Decent,Good one for second... | 4.2 | Positive | 0.4926 |

**Figure 3.** Sentiment score analysis.

## Classification

We used three classifiers to do the sentiment analysis on our dataset.

***Random Forest***

It is a versatile and robust ML algorithm that creates a group of decision trees during training. Each tree was built using a random subset of both the training data and features, leading to a diverse collection of models. This ensemble approach reduces overfitting and improves the generalization performance. To make predictions, the algorithm aggregates the outputs of all trees using majority voting for classification tasks or averaging for regression tasks. Random Forest is renowned for its scalability, capability to manage noisy data, and feature importance analysis, making it a favored choice for various ML tasks requiring accurate and reliable predictions (Figure 4).

***Support Vector Machines***

The SVM is a powerful supervised learning algorithm used for both classification and regression tasks. In sentiment analysis, an SVM was designed to classify text data into different sentiment categories. The main idea behind SVM is to find the optimal hyperplane that maximally separates the data points from different classes. This is achieved by transforming the input data into a higher-dimensional space through a kernel function, which makes the classes linearly separable. The SVM selects the hyperplane that maximizes this margin, thereby improving the generalization and robustness to data noise. Moreover, SVM handles high-dimensional data efficiently and performs well even when there are more features than samples. Overall, SVM is valued for its adaptability, capability to manage nonlinear data, and effectiveness across various classification tasks.

SVM works effectively with both linear and nonlinear separable data. For linearly separable data, it determines the hyperplane that maximizes the margin. For nonlinearly separable data, it maps the input into a higher-dimensional space using kernel functions to achieve linear separability. Overall, the SVM is a versatile and powerful algorithm that is widely utilized across different fields owing to its capability to manage complex decision boundaries and high-dimensional data, as well as its solid theoretical foundation (Figure 5).

**Logistic Regression**

Logistic Regression is a fundamental statistical technique used for binary classification tasks. Although it is called regression, it is a linear model that predicts the probability of a binary outcome based on one or more predictor variables. It establishes the relationship between the binary dependent variable and the independent variables by calculating probabilities using a logistic function or sigmoid function. During training, it learns the coefficients of the predictor variables by minimizing the loss function, typically, the logistic loss or cross-entropy loss.

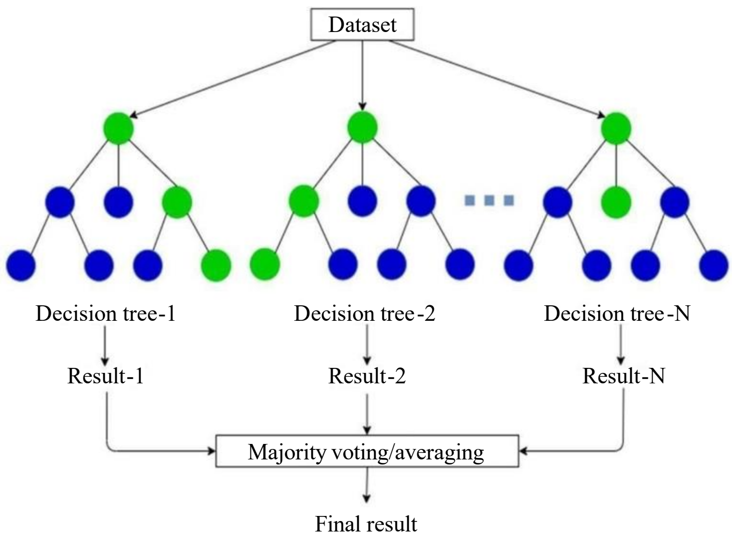
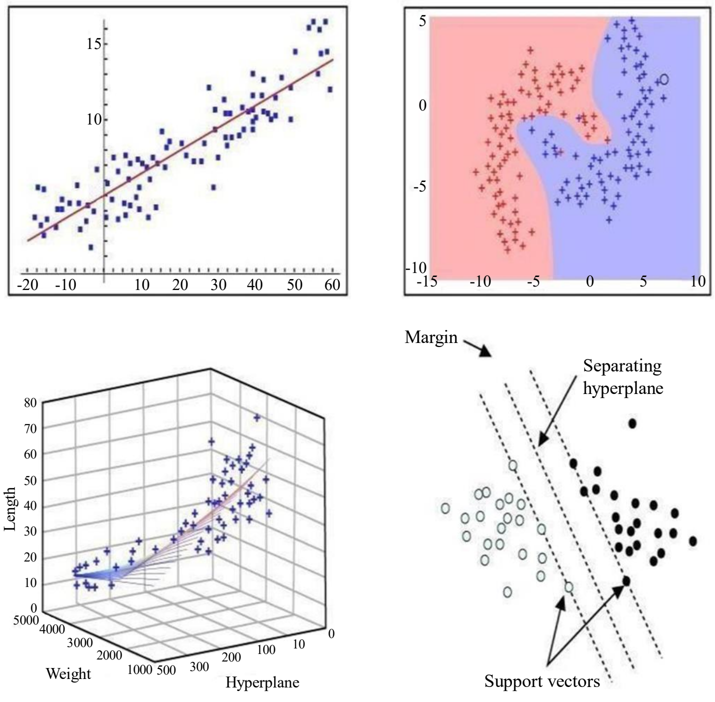


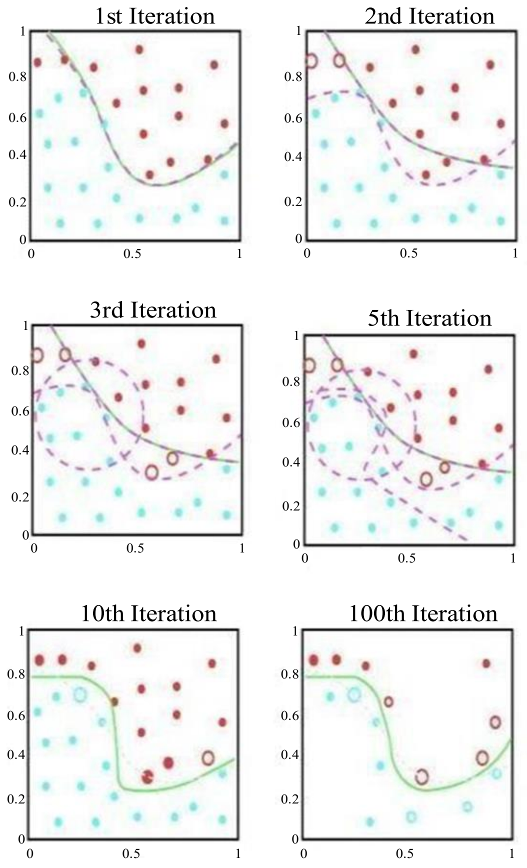

**Figure 4.** Random Forest algorithm approach.




Generalized linear models [8,9]

Support vector machine [1,7]




Adaptive boosting [6]

**Figure 5.** Support vector machines algorithm approach.

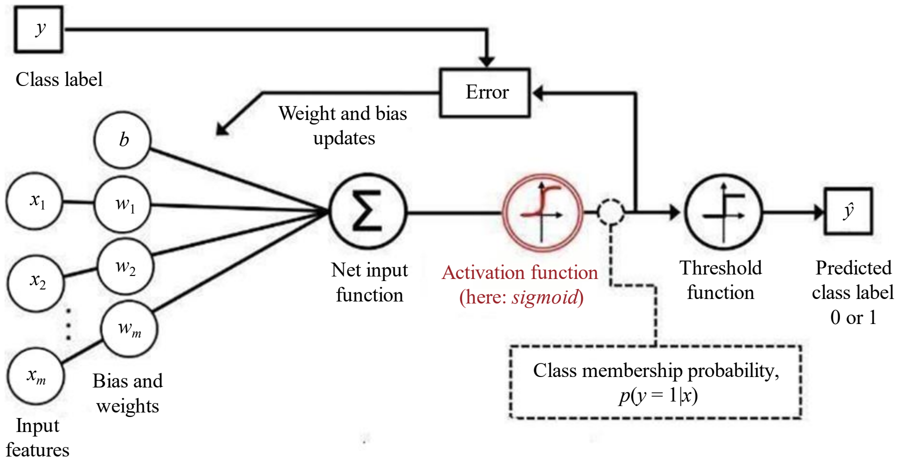



**Figure 6.** Logistic regression algorithm approach.

Logistic regression is particularly effective when the relationship between the independent variables and the log odds of the outcome is approximately linear. It is commonly used across various areas including healthcare, finance, and marketing (Figure 6).

## RESULT

Sentiment analysis conducted on the e-commerce dataset yielded insightful findings regarding customer sentiment toward products and services. Overall, the analysis revealed that the majority of the sentiments expressed by customers were positive, indicating satisfaction with the e-commerce platform. Nevertheless, there were significant occurrences of neutral and negative sentiments, indicating areas of potential enhancement. Additionally, by using classifiers such as SVM, Random Forest, and Logistic Regression, we identified the most effective algorithms for sentiment classification. Each classifier exhibited distinct performance characteristics, with SVM demonstrating high accuracy albeit longer training times, Random Forest showing robust performance with quicker training, and Logistic Regression providing competitive results with its simplicity.

Through feature extraction and analysis, key indicators influencing sentiment are identified, enabling a deeper understanding of customer preferences and concerns. These insights can be leveraged by e-commerce businesses to tailor their offerings, improve customer satisfaction, and enhance overall user experience.

### Evaluation

The evaluation of sentiment analysis models utilized in the e-commerce dataset revealed promising performance across multiple metrics. Each model, including the SVM, Random Forest, and Logistic Regression, was assessed based on key evaluation criteria, such as precision, recall, and F1-score.

Upon evaluation, SVM demonstrated high precision and recall values, reflecting its effectiveness in accurately classifying both positive and negative sentiments. Random Forest demonstrated robust performance across all metrics, showcasing its effectiveness in handling complex data and providing reliable sentiment predictions. Logistic Regression, although slightly less accurate compared to SVM and Random Forest, still achieved commendable results and showed potential for efficient sentiment analysis tasks.

Overall, the evaluation results underscored the effectiveness of sentiment analysis models in accurately classifying sentiments expressed in the e-commerce dataset. These findings provide valuable insights for e-commerce businesses to enhance customer satisfaction, optimize marketing strategies, and improve overall brand perception (Figure 7).

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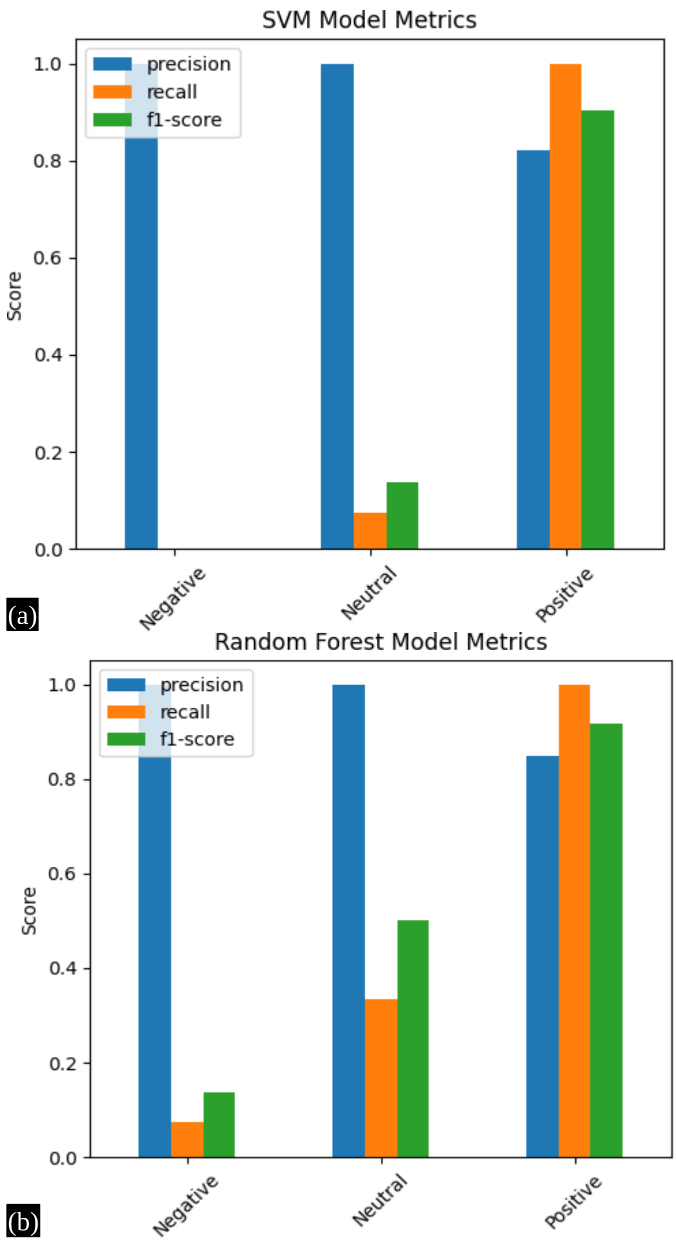
**Precision, Recall, and F1-Score**

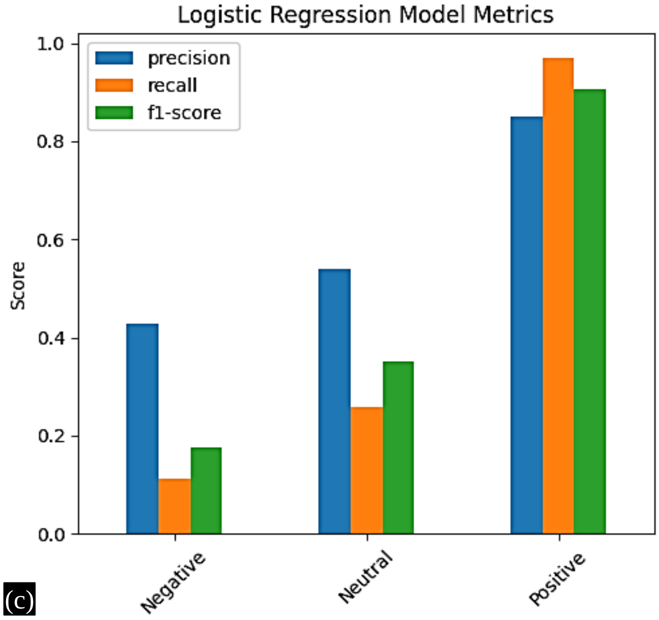
- *Precision:* Precision indicates what proportion of predicted positive reviews is truly positive.
- *Recall:* This measures the percentage of actual positive reviews that the classifier correctly identifies.
- *F1-Score:* Comparing two models with low accuracy and high recall is complicated, or vice versa. Therefore, an F1-score was issued to make them analogous. The F1-score is the harmonic mean of recall and precision (Figure 8).

| | Model | Precision | Recall | F1-Score | Accuracy |
|---|---|---|---|---|---|
| 0 | Logistic Regression | 0.6056 | 0.4470 | 0.4776 | 0.8259 |
| 1 | SVM | 0.9404 | 0.3580 | 0.3466 | 0.8225 |
| 2 | Random Forest | 0.9492 | 0.4691 | 0.5185 | 0.8532 |

**Figure 7.** Classifier and its accuracy.





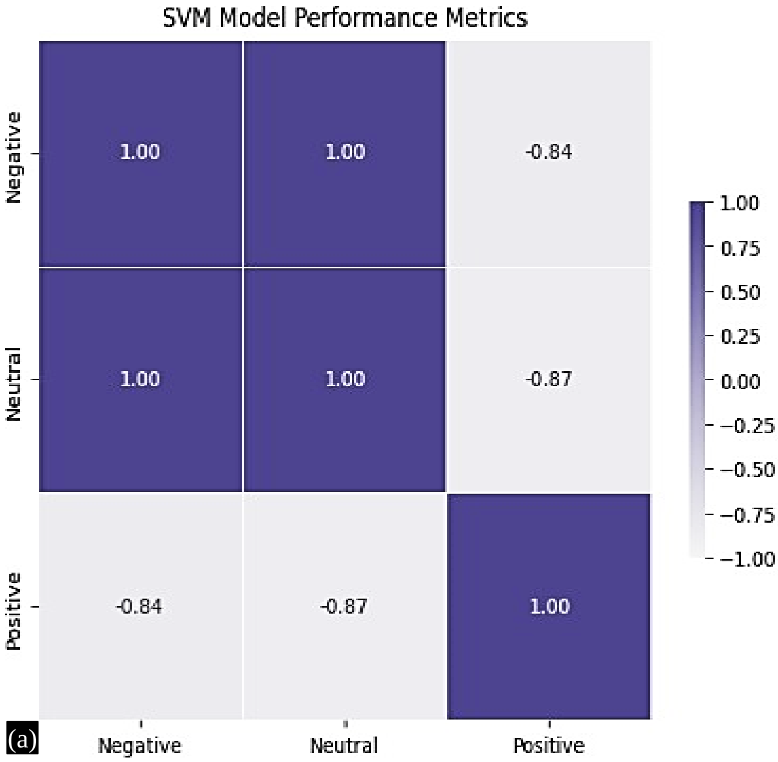

(c)

**Figure 8.** (a) to (c) Precision, recall, and F1 Score of various classifiers.

## Confusion Matrix and Accuracy

The confusion matrix is an important metric used to measure classifier efficiency. It reflects the number of correctly classified samples and is used to calculate the precision, recall, and F1 score. The confusion matrices are shown in Figure 9. All the classifiers predict one-star and 5-star reviews with much higher accuracy than neutral reviews.

- *True positive (TP):* The count of instances correctly identified as positive.
- *False positive (FP):* The count of instances mistakenly identified as positive.
- *True negative (TN):* The count of instances correctly identified as negative.
- *False negative (FN):* The count of instances mistakenly identified as negative.




(a)


**Figure 9.** (a) to (c) Confusion matrices of various classifiers.

## CONCLUSION

In conclusion, our sentiment analysis of the e-commerce dataset has provided valuable insights into customer sentiments towards various product and service ML algorithms such as SVM, Random Forest, and Logistic Regression, and achieved accurate classification of sentiment expressed in customer reviews. The results underscore the effectiveness of these models in predicting sentiment polarity, allowing businesses to gain a deeper understanding of customer satisfaction and identify areas for improvement. SVM demonstrated high precision and recall, Random Forest exhibited robustness in handling complex data, while Logistic Regression offered reliable sentiment predictions.

Overall, our sentiment analysis findings offer actionable insights for e-commerce businesses to optimize product offerings, enhance customer experience, and bolster brand reputation. By leveraging sentiment analysis techniques, companies can make informed decisions that drive customer engagement, foster loyalty, and fuel business growth within a dynamic e-commerce landscape.

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