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Sentiment Analysis of Amazon Product Reviews

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Abstract

In this study, we conduct the process of sentiment analysis to reviews of the Amazon Alexa product through the use of machine learning models: XgBoost, Random Forest, and Decision Tree. The data set is taken from Kaggle and consists of customer reviews that are either positive or negative. In the first stage of pre-processing, we clean the text, tokenize the text, remove stop words and stem the text of the data. Next, we split the data set into training and testing data set for the model to learn and classify sentiment. The results of the experiments showed that XgBoost returns higher accuracy and generalization than the other models. Therefore, we chose XgBoost as the model of choice for sentiment classification and is helpful for informing business if their customers are satisfied or dissatisfied.

INTRODUCTION

sentiment analysis to gauge opinions on an e-commerce site, like Amazon. Using this as a metric, it helps customers take decisions that arise from emotions expressed in reviews rather than pure rationality. Customers, almost in the last two decades, have witnessed online shopping grow at a phenomenal speed and with it a bevy of e-commerce sites, Amazon being one among them, catering to want lists from huge consumer bases. For traditional customers who can physically touch and feel the products before making their respective decisions regarding buying them, it differs from online shopping. For those looking to make purchases on various products online, reviews can be very telling in terms of making a choice. Using Positive Words and Negative Words, it consists of evaluation of written opinions through Natural Language Processing (NLP) and data mining. When the review tends to weigh more heavily toward positive, it falls into the positive category, and so on. It is defined as negative if the review leans toward negative. If both sides are balanced, then it is labeled as neutral. An e-commerce giant like Amazon utilizes sentiment analysis to track customer thoughts and ensure that emotions are the core element around which the decision-making process revolves for an online shopper.

The last more than two decades have seen online shopping sprouting into numerous e-commerce platform companies, such as Amazon, and all of them are here to satisfy the ever-increasing consumer demand. While a buyer does not actually get to see the product physically in self-shopping, online shopping lacks this feature. This is one of the reasons why customer reviews play a very important role in decision-making. Sentiment analysis is a field that revolves around using Natural Language Processing (NLP) and data mining for measuring written opinion based on reducing both positive

and negative words. Accordingly, a review is put into the categories of positive, negative or neutral. A review gets classed as positive if it comprises mostly positive words, negative if it has mostly negative words and neutral if both words are almost equal innumbers.

LITERATURE REVIEW

Emilie Coyne etal.demonstrates that LSTM networks are highly effective for binary sentiment analysis on Amazon reviews, achieving over 90% accuracy. The results indicate that LSTM performance remains consistent across different product categories[1]. Anjali Dadhichetal. presents the PCSA system for sentiment classification of Amazon reviews using supervised learning techniques like NB, LR, RF, and KNN. Future work aims to enhance accuracy with hybrid and multiple supervised learning methods[2]. Mohamad Faris bin Harunasiretal.compares sentiment analysis models, including MNB, RF, LSTM, and CNN, with LSTM achieving the highest accuracy of 97%. Future work suggests using BERT with GloVe and word2vec for further accuracy improvements[3]. Gagan Kumar Patraetal.highlights the effectiveness of the BERT model in sentiment analysis of Amazon reviews, achieving 89% accuracy. Future work focuses on optimizing BERT for efficiency, expanding sentiment categories, and exploring hybrid models[4].Muhammad Waqaretal.utilizes Social Network Analysis (SNA) and sentiment analysis to evaluate Amazon product and user reviews based on polarity and subjectivity. Using 28,000 reviews, it effectively visualizes sentiment trends through bar graphs for semantic interpretation[5]. Sanjay Dey etal.compares SVM and Naïve Bayes for sentiment analysis of Amazon reviews, with Naïve Bayes achieving 84% accuracy and SVM 82.875%. Results confirm SVM's strong performance in sentiment polarization[6]. Najma Sultana etal.evaluated a newly proposed sentiment analysis method based on POS-based features using six classifiers on the Stanford dataset. We achieved the best results by leveraging a combination of adjectives, adverbs, and verbs as features in predicting sentiment, which demonstrates the importance of these parts of speech[7]. Dr. Prashant Pareeketal.compares Count Vectorizer andTf-IDF vectorizer for sentiment analysis, showing Count Vectorizer's consistency and better performance. It highlights key evaluation metrics, discusses challenges like sarcasm detection, and emphasizes the evolving nature of sentiment analysis in social media and business applications[8]. Arwa S. M. AlQahtanietal.applies sentiment analysis on Amazon mobile phone reviews using supervised ML models (Logistic Regression, Naïve Bayes, Random Forest) and deep learning models (Bi-LSTM, BERT). BERT achieved the highest accuracy (94% multiclass, 98% binary), followed by Bi-LSTM with joint-learned embedding (93% multiclass, 97% binary). Random Forest with glove performed best among baseline models (90% multiclass, 94% binary)[9].Salma Elzeheiryetal. Explores the role of deep learning in recommender systems (RS), emphasizing sentiment analysis and word embedding techniques like Word2Vec and TF-IDF. It highlights the growing impact of customer reviews on decision-making and suggests future research on advanced opinion extraction and false review detection in e-commerce[10].E. Coyneetal.demonstrates that LSTM networks are highly effective for binary sentiment analysis on Amazon reviews, achieving over 90% accuracy. The results indicate that LSTM performance remains consistent across different product categories[11]. A. Iqbaletal.focuses on sentiment analysis of consumer reviews from social media and e-commerce platforms using benchmark datasets (IMDB, Yelp, Amazon). It highlights the importance of feature encoding for sentiment classification and employs deep learning models (LSTM, RNN) with optimized architectures. Performance was evaluated using accuracy, precision, recall, and F1-score, showing improved or comparable results to existing methods. Future work may explore transformer-based architectures[12]. T. U. Haque et al. Proposes a supervised learning model to classify large, unlabeled product review datasets using a combination of feature extraction approaches. The study explores sentiment analysis techniques, compares results with existing works, and achieves over 90% accuracy, precision, recall, and F1-score, with SVM yielding the best classification results. Challenges include limited access to labelled data from e-commerce platforms. Future work aims to automate data labeling with PCA in active learning, integrate the model with customer interaction systems, and apply it to local market sites for broader usability and generalization[13].

METHODOLOGY

Dataset:

The dataset used in this study consists of 3,149 Amazon Alexa reviews, classified into 2,204 positive and 945 negative reviews. This dataset was freely available for download from Kaggle. The data was pre-processed,merged, and then split into training and testing sets, as shown in

Table 1 and Table 2. In conclusion, the dataset included 3,149 reviews, with 2,204 used for training and 945 for testing. Figure 1 illustrates the dataset workflow.

Datasets	Positive	Negative	Total Reviews
Reviews	2204	945	3149

Table(1)

Datasets	Train	Test
Reviews	70%	30%

Table(2)

Flowchart:

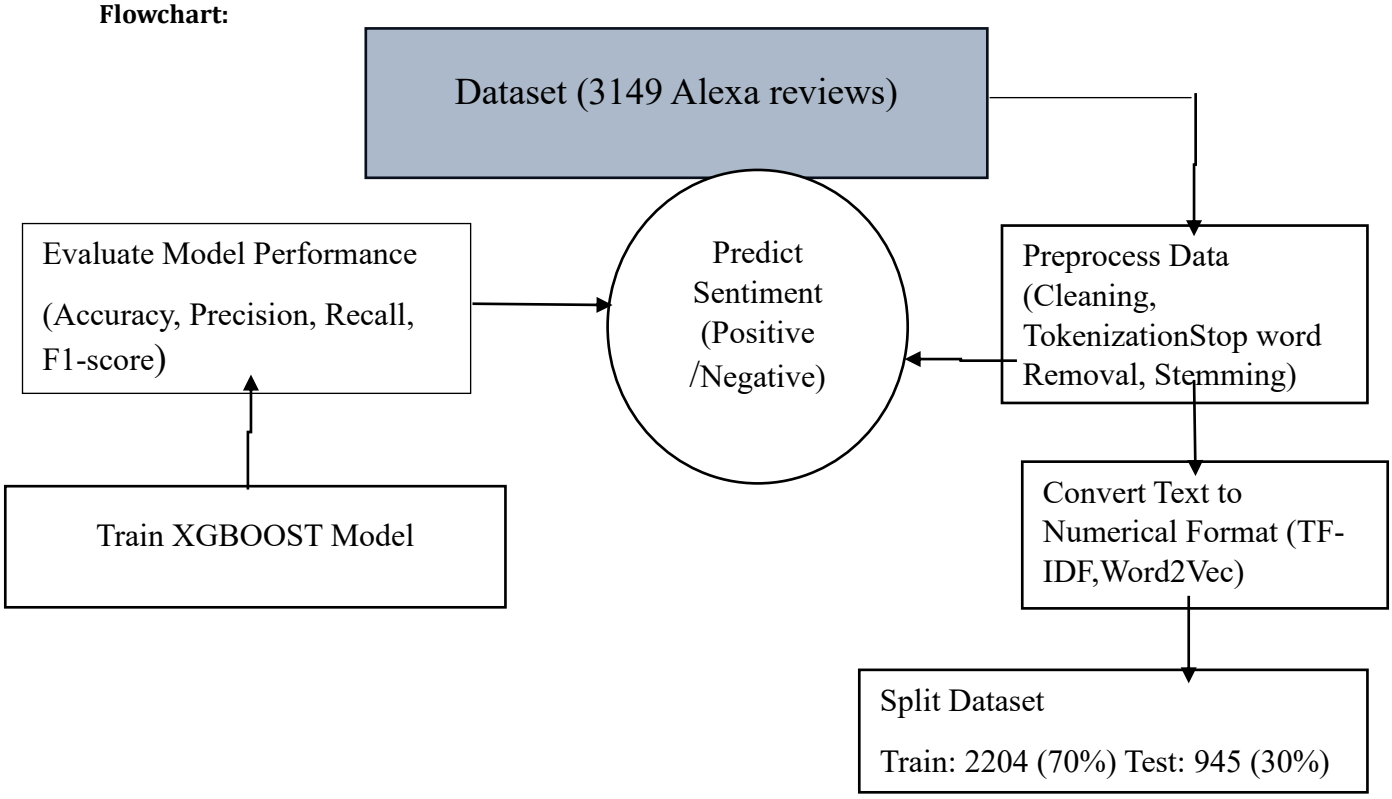

Fig.1 Dataset Workflow

XGBOOST MODEL

In the process of carrying this out, we have employed the XgBoost model, which stands for extreme Gradient Boosting, and is a very fast and efficient ensemble learning algorithm that is commonly applied to conduct sentiment analysis on Amazon reviews because of its high accuracy and high-performance metrics. XgBoost is based on the gradient boosting framework which builds weak learners iteratively which aims to minimize the bias and variance. In our analysis of Amazon review data, text preprocessing steps have been carried out including text cleaning, tokenization, stop word removal, and stemming. The preprocessed text data will then be transformed into numerical form using TF-IDF or word embeddings process before performing the split into training and testing dataset.

XgBoost employs extensively optimized hyperparameters to differentiate between positive, negative, and neutral reviews. XgBoost is known for achieving an even higher performance than Decision Tree and Random Forest, as it is knownfor incorporating different forms of regularization (L1 and L2) and is also less likely to overfit than other models or methods. Additionally, XgBoost is able to impute missing values and can utilize computing power to calculate faster as it is able to run parallel processing. Furthermore, accuracy, precision, recall, and F1-score all show that XgBoost is indeed the model with the highest accuracy. All

of these findings further show that XgBoost is a viable option in accomplishing sentiment classification, which can provide businesses with valuable information about customers and products as well as implementing to improve marketing strategies. Ultimately, implementing XgBoost based sentiment analysis, will allow organizations to understand their customers better and leverage this approach to inform better-product developing and marketing strategies.

VISUALIZING INSIGHTS:ANALYZING DATA THROUGH GRAPHICAL REPRESENTATIONS

The dataset comprises 3,149 Amazon Alexa reviews, with 2,204 classified as positive (labeled as 1) and 945 as negative (labeled as 0). This distribution indicates that the majority of customers had a favorable experience with Alexa products. A bar chart visualization highlights this imbalance, showing a significantly higher count of positive reviews compared to negative ones. This class disparity suggests that sentiment analysis models trained on this data may need techniques like resampling or class weighting to improve performance and ensure balanced sentiment classification.Fig 2.represents feedback distribution count.

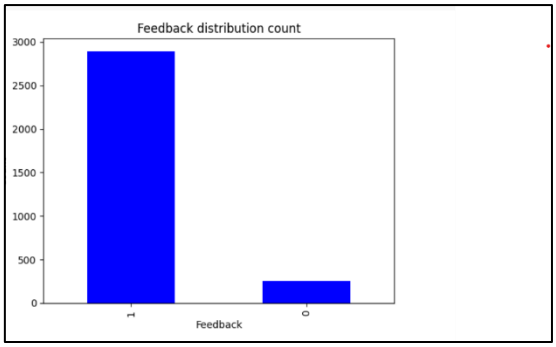

Fig 2. Feedback Distribustion Count

Pie chart illustrates the distribution of Amazon Alexa product ratings across five categories (1 to 5 stars), with each segment representing a percentage of total reviews. The majority of customers (72.6%) gave a 5-star rating, indicating a highly positive sentiment. A 4-star rating was given by 14.4% of users, showing general satisfaction. Lower ratings were significantly less common, with 3-star reviews at 4.8%, 2-star reviews at 3.0%, and 1-star reviews at 5.1%, reflecting a small proportion of dissatisfied customers. The chart highlights that most users had a favorable experience with Alexa products, with the highest ratings dominating the review distribution.

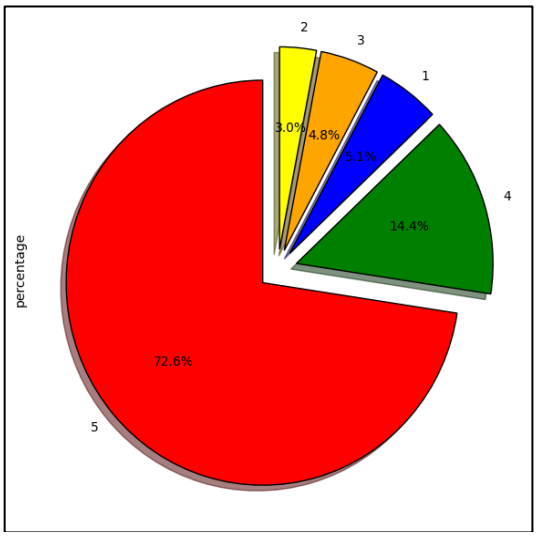

Fig3. Percentage Rating Pie Chart

Comparison Table:

Model Name	Accuracy(%)	Description
XgBoost**(Extreme Gradient Boosting)**	94%	XgBoostperforms exceptionally well with complex datasets, providing high accuracy and making it ideal for sentiment analysis on Amazon reviews.
Random Forest	93%	Random Forest builds multiple decision trees, each making predictions, and aggregates them to improve accuracy and reduce overfitting.
Decision Tree	91%	Decision Tree is a simple, interpretable model that splits data into branches based on feature values. It performs well with 91% accuracy but may overfit complex datasets like Amazon reviews

Table3. Comparison table of Machine learning models

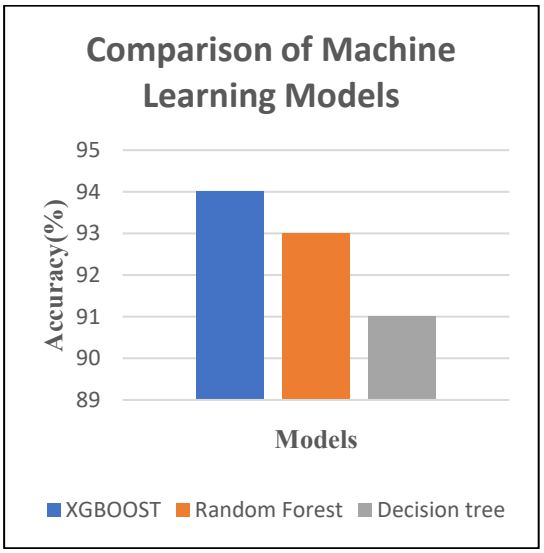

Fig.4 Comparison of Machine Learning Models

This plot shows the accuracy of three Machine learning models – XgBoost, Random Forest Classifier, and Decision Tree Classifier – on prediction of amazon reviews from customer reviews. XgBoostproduced the best accuracy(94%), followed by Random Forest Classifier(93%), and Decision Tree Classifier had the poorest performance rather than XgBoost model(91%), making it useful for lightweight cases.

CONCLUSION

This study analyzed 3,149 Amazon Alexa reviews obtained from Kaggle, categorizing 2,204 as positive and 945 as negative. The dataset underwent preprocessing, merging, and was divided into training (2,204 reviews) and testing (945 reviews) datasets, as detailed in Table 1 and Table 2. The pie chart analysis revealed that the majority of users left 5-star ratings (72.6%), followed by 4-star ratings (14.4%), with lower ratings occurring less frequently. To classify sentiments, Decision Tree, Random Forest, and XgBoostmodels were applied, with XgBoost demonstrating the highest accuracy (94%) due to its advanced gradient boosting mechanism. This research emphasizes the importance of ensemble learning techniques in sentiment analysis, offering businesses valuable insights to enhance product quality and refine marketing strategies. The sentiment analysis model classifies each review as either

positive or negative, providing useful information for both businesses and customers.Figure.1illustrates the dataset workflow, reinforcing the study's methodology.

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