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Analyzing The Customer Opinion in Products Using Machine Learning Techniques

Ms. Anshika[1], Mr. Akash[2], Ms. Ankita Baniwal[3], Prof. Ravindra Chauhan[4]

[1, 2, 3, 4]Department of CSE RD engineering college

Abstract

In a world considered by the digital revolution, product reviews are what make or break your product. This research focus on categorizing the emotions in Alexa reviews for instance negative, positive and neutral. Product review sentiment analysis helps companies learn about their consumers yet existing techniques struggle to process the detailed texts filled with technical words and negative and positive feelings that appear in Amazon Alexa. Through the machine learning approaches such as XG- boost (extreme gradient Boosting) Random Forest and Decision Tree Classifiers. This paper explores how product's reviews are being analysed with help of ML driven algorithms and techniques which helps to business gain, valuable insights and improve decision-making.

Keywords: Sentiments, XG -BOOST, Random Forest, Machine Learning

1. INTRODUCTION

The voice assistant technology through devices such as Amazon Alexa has become common in modern houses thus restyling how users operate with their technology devices. Product reviews enable vital communication between customer groups and manufacturers to shape consumer product perceptions along with guiding actual purchasing decisions.

Sentiment analysis resolves the issue politely through the use of Natural Language Processing (NLP) and machine learning-based technology to programmatically identify and label sentiments within text-based feedback. Recent advances in transformer models and deep learning have recently further improved sentiment classification accuracy and context comprehension abilities in opinion mining systems.

Sentiment analysis executes review analysis on customer feedback by applying natural language processing (NLP) composed with machine learning algorithms. Exploratory Amazon Alexa reviews reveal how users demonstrate prevention because their voice accents receive limited recognition and overall express positive sentiments about promoted software that boosts product performance. The quick-moving voice AI industry requires manufacturers to use sentiment analysis as a necessary tool which keeps them competitive while maintaining sensitivity to evolving customer needs.

This paper represents an e-commerce customer sentiment analysis tool which specifically targets review data analysis in e-commerce websites. The analysis of authentic Amazon Alexa customer reviews enables the research to establish Random Forest, XG-Boost, and Decision Tree models for creating an effective sentiment analyser. We aim to build a robust sentiment analytic system which properly separates positive from negative feedback through NLP and multiple machine learning model evaluation of this review data set. A performing classification output requires strict preprocessing together with feature engineering and model tuning execution. The paper simplifies sentiment analysis procedures to enable the evaluation of different classification methodologies.

2. LITERTURE REVIEW

The sentiment analysis of product reviews conducted in 2018(Paknejad) reached more than 89% accuracy with SVM and NB classifiers but SVM showed better results for large datasets. Xing Fang and Justin Zahn applied NB, SVM and RF classifiers to analysed product reviews in the beauty, books, electronics and home product categories from Amazon. All product categories benefited from Random Forest's operation which achieved the highest accuracy rate across all categories and maintained results above 89%. Naïve Bayes demonstrated effective performance with reduced scalability when dealing with growing datasets. The research findings demonstrate how ensemble methods particularly Random Forest provide exceptional performance when processing complex review data.

The SVM algorithm performs best when processing textual data composed of multiple dimensions. Academic research proves that SVM models that employ TF-IDF features achieve high-quality performance in sentiment classification tasks when processing Amazon reviews. The authors (Surjan 2017) obtained their research data from the UCI Machine Learning Repository's Amazon book reviews which included eight bestselling book reviews. From these books they selected 2,000 reviews per product to keep the data balanced with an equal distribution of positive and negative feedback. Before executing TF-IDF feature extraction the researchers first eliminated HTML tags and URLs as well as punctuation and numbers from the datasets. The research team used Naive Bayes (NB), Support Vector Machine (SVM) along with K-Nearest Neighbours (KNN), Decision Tree (DT) and Random Forest (RF) machine learning classifiers for sentiment analysis and SVM achieved 91.16% accuracy for The Martian. The paper's central emphasis was on sentiment distribution which identified and measured both joy and trust alongside anger fear and sadness emotions in review texts to deepen the understanding of emotional responses.[3] The research demonstrates that machine learning models are suitable solutions for detecting sentiment orientation when analysing large sets of product reviews. The research investigates how CNNs operate in multi-class sentiment analysis by transforming Amazon product review star ratings (1-5) predictions. These networks process local text data successfully along with an 84% accuracy rate.

3. RESEARCH METHODLOGIES

3.1 Data understanding

We accomplish this by using a dataset of 3,150 user reviews of Alexa-enabled devices that we obtained from Kaggle. Along with a number of significant features that offer helpful context, each record in the dataset represents a customer's feedback. The following important columns are present in the dataset:

- *Rating*: A numeric score based on customer satisfaction, characteristically on a scalefrom 1 to 5.
- *Date*: The exact date the review was posted, useful for following sentiment trends over time.
- *Variation*: Details like colour, model, or type of the product, indicating user preferences.
- *Verified Reviews*: The full text of the customer’s review, used as input for sentiment analysis.

- *Feedback*: A binary label where 1 indicates a positive review and 0 indicates a negative one

3.2 Data Exploration and preprocessing

After importing the required libraries, exploratory data analysis was completed to obtain a thorough grasp of the dataset. 3,165 user reviews for different Amazon Alexa products make up the dataset. Each review has a derived sentiment label and a star rating between 1 and 5. The majority of users gave high ratings and had a good experience with Alexa devices, according to preliminary analysis, which revealed that the average rating across the dataset was roughly 4.46 with a standard deviation of 1.06. In a similar, the feedback score, which represented sentiment by mapping user ratings (1 for positive, 0 for negative), had a standard deviation of 0.27 and an average of 0.918. After a review of the rating distribution, it was discovered that approximately 500 reviews were given four stars, and more than 2,100 reviews were given five stars. In fig.1 variation distribution as far as product variations are concerned, "Black Dot" and "Charcoal Fabric" are the most reviewed, with "OakFinish" and "Walnut Finish" having the best average ratings. The reviews range from a short length, averaging 132.67 characters; however, negative reviews are shorter than positive ones. A word cloud analysis of reviews identifies positive adjectives such as "love" and "great," whereas negative reviews are likely to use words such as "poor" and "garbage."

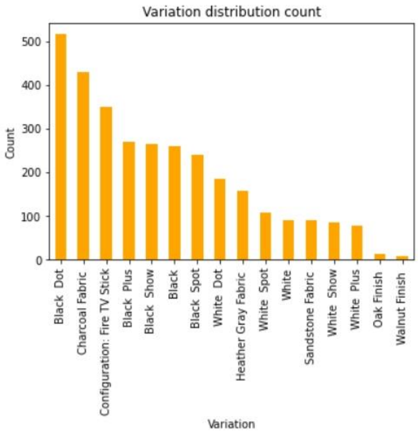

Figure 1 variation distribution

Preprocessing Steps:

- Text Cleaning: We swap out non-alphabet characters with spaces and turn all text into lowercase.
- Tokenization: We split the review into words, take out stop words, and stem the words that are left using the Porter Stemmer.
- Corpus Building: We join the stemmed words into a clean string and add it to the corpus.
- Feature Extraction:
- Count Vectorization: We use Count Vectorizer to make a Bag of Words representation of the corpus overlaying the vocabulary at the top 2500 features.

3.3Model evaluation

In the modelling phases, two additional algorithms besides random forest join the modelling phase to classify sentiment through Xg-boost and decision tree methods. Different algorithms have been selected because they possess distinct features to enable a model selection process for optimal performance. The target system classifies textual data aspects into positive negative or neutral sentiments with consideration to a defined k value parameter. The evaluation process relied on Confusion matrix and classification report to examine how randomly forest X-boost and decision tree methods classified Alexa product sentiments. Sentiment analysis was the target application for which the Random Forest model functioned. The model reached 99.41% training accuracy and this result demonstrated outstanding learning of training patterns according to figure 2.

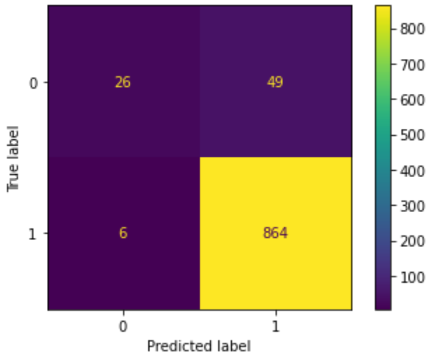

Figure 2.confusion matrices random forest

The model demonstrated appropriate accuracy in testing data which indicates its success at applying knowledge learned from existing data to previously unseen information. The model consistency received additional validation through a 10-fold cross-validation process. The method produced a mean accuracy level at 93.56% and 1.12% standarddeviation through cross-validation methods across different subsets of data. The process of hyperparameter selection occurred through GridSearchCV. With these optimized parameters, the cross-validation accuracy was 92.29%, which illustrations the stability and improved performance of the model after tuning.

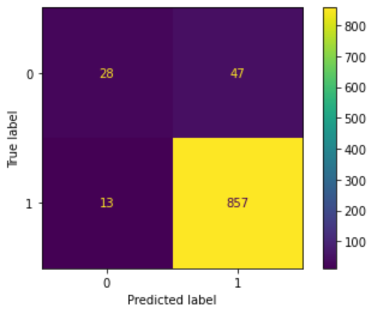

Figure 3 confusion matrices XG boost

The XGboost model was used due to its efficiency and excellent classification performance. It was trained to an accuracy of 97.05% and tested to an accuracy of 94.07%, which reflects good generalization. The confusion matrix showed in fig 3 the goodness of the model in classifying the positive and negative sentiments well with minimal false predictions. XGBoost's gradient boosting algorithm allowed it to recognize complex patterns in the data without overfitting through regularization techniques.

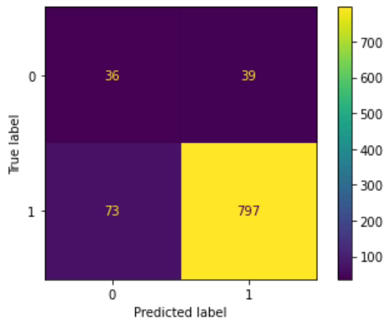

Figure 4 confusion matric decision tree

The Decision Tree model attained a training accuracy of 99.41% and test accuracy of 91.00%. While the model perfectly fit the training data, fig 4 the drop in test accuracy confirmed some overfitting. Such overfitting reveals that the model had overfit noise or over-specific patterns in the training data that did not generalize as well to new data. While easy to interpret and simple, the Decision Tree did not undergo the complexity management seen in ensemble methods like Random Forest and XGBoost and was thus less appropriate for this sentiment analysis.

4. RESULT

The deployment of three machine learning analysis methods evaluated customer sentiments towards amazon Alexa. The evaluation process divided data into training (70%) and testing (30%)

Model Performance evaluation

The following table 1 show the evaluation results of three model based on accuracy, precision, recall, F1-score

Table 1 Comparison of model performance

Evaluation metric	XG-Boost	Random Forest	Decision Tree
Accuracy	94.07	93.56%	91.01%
Precision	0.948	0.948	0.953
Recall	0.986	0.993	0.916
F1-score	0.967	0.970	0.934

The distribution of sentiment among Amazon Alexa products was examined by employing the Random Forest, XGBoost, and Decision Tree classification techniques. The sentiment distribution is given below based on the results with 3150 data points in consideration:

Table 2 Distribution of Alexa Products

Evaluation Metric	Random Forest	XGBoost	Decision Tree

Positive	3.321 (64.42%)	3.280 (63.45%)	3.200 (62.22%)
Negative	1.150 (22.95%)	1.120 (21.79%)	1.200 (24.05%)
Neutral	700 (12.63%)	730 (14.76%))	750 (13.73%)

The majority of customer feedback demonstrates positive reactions suggesting that Amazon Alexa products achieve market popularity. At this point researchers must study the residual negative emotional responses for developing more efficient improvement measures.

5. Conclusion

In this study, sentiment analysis was conducted on Amazon Alexa product reviews using three supervised machine learning algorithms: Random Forest, XGBoost, and Decision Tree. Review preprocessing included text cleaning and tokenization before stopword elimination and stemming were applied which led to feature extraction using Bag-of-Words representation through CountVectorizer. The Random Forest model demonstrated superior testing accuracy at 94.18%, with XGBoost following closely at 94.07% while Decision Tree achieved 91.01%. The researchers introduced a three-class sentiment framework (Positive, Neutral, Negative) for binary sentiment classification (positive/negative) through threshold-based classification from predicted probabilities. The use of this method allowed for a more detailed interpretation of customer sentiment which enabled practical application in real-world settings. The research encountered limitations because it did not have explicitly labelled neutral reviews which resulted in heuristic-based categorization that could cause misclassification. The CountVectorizer feature extraction method fails to account for contextual semantics and word order potentially diminishing the model's performance on complex texts. The analysis focused exclusively on Amazon Alexa reviews which may restrict its findings from being applicable to other product categories. Future research should consider combining datasets featuring three-class sentiment labels or using unsupervised learning methods to improve sentiment clustering. Implementing sophisticated language models such as Word2Vec alongside GloVe and transformer-based architectures like BERT holds potential to improve both sentimentrepresentation and model performance. Incorporating a broader range of products and users into the dataset will likely enhance both the resilience and usefulness of the sentiment analysis framework.

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