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Implementation of the Naive Bayes Method in Sentiment Analysis of Spotify Application Reviews

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Abstract

This study focuses on sentiment analysis of Spotify application reviews on Google Play Store using the Naive Bayes algorithm. As a leading music streaming platform, Spotify receives diverse user feedback that reflects their experiences, complaints, and satisfaction. Sentiment analysis aids in understanding user opinions, enhancing services, and innovating features. The research involves collecting user reviews via web scraping, followed by preprocessing steps such as text cleaning, tokenization, normalization, stopword removal, and stemming. The Term Frequency-Inverse Document Frequency (TF-IDF) method is employed to assign weights to words, highlighting their significance in reviews. The Naive Bayes algorithm categorizes sentiments into positive, negative, and neutral classes. Performance evaluation uses a confusion matrix to measure accuracy, precision, recall, and F1-score. Results indicate that Naive Bayes effectively classifies large volumes of unstructured data with high accuracy and efficiency. This study contributes practically by offering actionable insights to improve Spotify's services and theoretically by advancing sentiment analysis methodologies using machine learning. The findings highlight the algorithm's potential to understand user needs and address issues, reinforcing its value in text analytics for mobile applications.

Keywords*: Sentiment analysis, Naive Bayes algorithm, Spotify reviews, text preprocessing, machine learning.*

1. Introduction

The rapid advancement of information technology has transformed various sectors, including entertainment, with music streaming applications becoming a key part of daily life. Spotify, one of the leading music streaming platforms, has garnered millions of users globally who regularly leave feedback on platforms like Google Play Store. These reviews, rich in user experiences and expectations, provide valuable insights for improving application features and user satisfaction[1], [2], [3].

Sentiment analysis, a branch of text analytics, plays a pivotal role in interpreting such unstructured data. It allows the classification of user opinions into positive, negative, or neutral sentiments, enabling developers to address user concerns more effectively. Among the available methods, the Naive Bayes algorithm is widely recognized for its simplicity, efficiency, and capability to handle large volumes of text data, making it a preferred choice in many sentiment analysis studies [4], [5], [6].

Despite its utility, sentiment analysis faces challenges such as managing slang, abbreviations, and ambiguous text in user reviews. These issues underscore the need for robust preprocessing techniques, including cleaning, tokenization, normalization, and feature extraction, to ensure accurate classification results [7].

This study focuses on applying the Naive Bayes algorithm for sentiment analysis of Spotify reviews. The research aims to evaluate the algorithm's performance and provide actionable insights for enhancing Spotify’s user experience, contributing to the broader field of machine learning-based text analytics [8], [9], [10].

2. Research Methods

This study employs a quantitative descriptive research approach with an experimental design to analyze user sentiments toward the Spotify application. The primary objective is to classify user reviews into positive, negative, and neutral categories using the Naive Bayes algorithm. The research process consists of five major phases [11], [12].

2.1. Data Collection

User reviews were collected from the Google Play Store using web scraping techniques, leveraging the Python programming language and the google-play-scraper library. A dataset of 1,000 reviews was curated to ensure a balanced representation of user feedback. The selected attributes for analysis included review text and ratings, while other metadata such as review dates were stored for supplementary insights.

2.2. Data Preprocessing

The collected reviews underwent several preprocessing steps to ensure quality and consistency for analysis:

- Data Cleaning: Removal of irrelevant elements such as special characters, punctuation, and numbers.
- Tokenization: Splitting of text into individual words for further analysis.
- Stopword Removal: Elimination of commonly used words that do not contribute significantly to sentiment (e.g., “and,” “with,” “the”).
- Normalization: Conversion of non-standard words into their standard forms.
- Stemming: Reduction of words to their base forms to standardize variations.

2.3. Sentiment Classification

The Naive Bayes algorithm was employed to classify reviews based on their sentiment. This algorithm is well-suited for text classification due to its simplicity and efficiency. The processed text data was converted into numerical form using Term Frequency-Inverse Document Frequency (TF-IDF), allowing the algorithm to assess the importance of each word.

2.4. Model Evaluation

The model's performance was evaluated using a confusion matrix, which provided metrics such as accuracy, precision, recall, and F1-score. These metrics were used to assess the model's ability to classify sentiments accurately across the three categories.

2.5. Research Framework

The research followed the Knowledge Discovery in Databases (KDD) methodology, encompassing stages of data selection, preprocessing, transformation, and analysis. This structured approach ensured the integrity of the research process and the reliability of the results.

By systematically applying these methods, this study aims to provide actionable insights into user sentiments and demonstrate the effectiveness of the Naive Bayes algorithm for sentiment analysis on Spotify reviews.

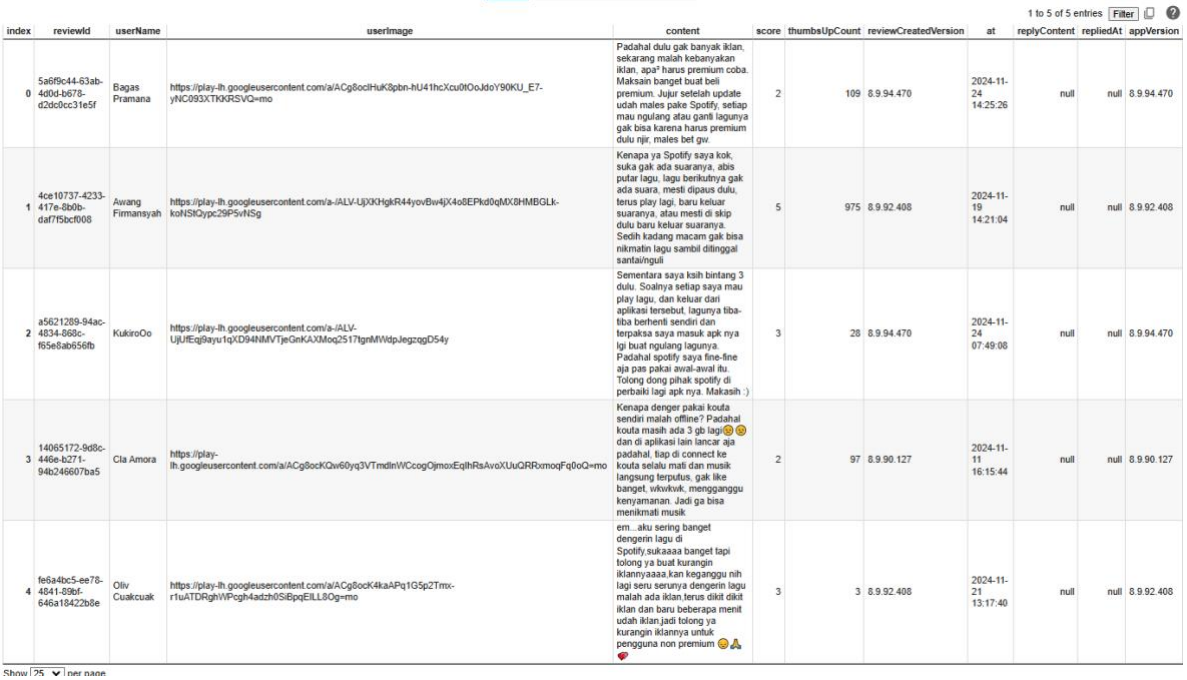
3. Result and Discussion

3.1. Result

This study aims to develop a web-based chatbot by implementing Natural Language Processing (NLP) technology. The analysis was conducted through a series of stages, including data collection from questionnaires, data preprocessing, Naive Bayes model implementation, model evaluation, and result interpretation. The study focuses on measuring the chatbot's accuracy and response relevance, as well as evaluating user satisfaction when interacting with the developed system. The steps undertaken and the findings of this research are explained in detail in this report.

3.1.1. Selection Data

Data selection is the process in which the researcher extracts data from a specific source and selects relevant attributes for the study. In this research, the author uses the data scraping method to collect user review data of the Spotify app from the Google Play Store by utilizing the google-play-scraper library. The entire process is carried out using the Python programming language on the Google Colaboratory platform. The obtained dataset contains 11 attributes, namely: reviewId, userName, userImage, content, score, thumbsUpCount.



1 to 5 of 5 entries Filter

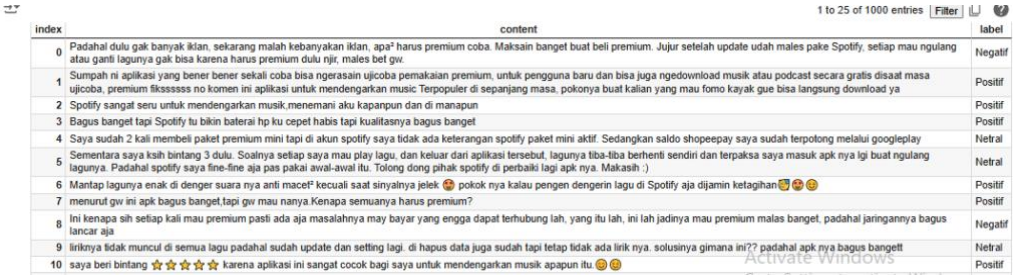
index	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	appVersion
0	5a6f9c44-63ab-4d0d-b678-d2dc0cc31e5f	Bagas Pramana	https://play-lh.googleusercontent.com/a/ACg8ocIHuK8pbn-hU41hcXcu0tOoJdoY90KU_E7-yNC093XTKKRSVQ=mo	Padahal dulu gak banyak iklan, sekarang malah kebanyakan iklan, apa² harus premium coba. Maksain banget buat beli premium. Jujur setelah update udah males pake Spotify, setiap mau ngulang atau ganti lagunya gak bisa karena harus premium dulu njir, males bet gw.	2	109	8.9.94.470	2024-11-24 14:25:26	null	null	8.9.94.470
1	4ce10737-4233-417e-8b0b-daf7f5bcf008	Awang Firmansyah	https://play-lh.googleusercontent.com/a-/ALV-UjXKHgkR44yovBw4jX4o8EPkd0qMX8HMBGLk-koNStQypc29P5vNSg	Kenapa ya Spotify saya kok, suka gak ada suaranya, abis putar lagu, lagu berikutnya gak ada suara, mesti dipaus dulu, terus play lagi, baru keluar suaranya, atau mesti di skip dulu baru keluar suaranya. Sedih kadang macam gak bisa nikmatin lagu sambil ditinggal santai/nguli	5	975	8.9.92.408	2024-11-19 14:21:04	null	null	8.9.92.408
2	a5621289-94ac-4834-868c-f65e8ab656fb	KukiroOo	https://play-lh.googleusercontent.com/a-/ALV-UjUfEqj8ayu1qXD94NMVTjeGnKAXMoq2517tgnMWdpJegzqgD54y	Sementara saya ksih bintang 3 dulu. Soalnya setiap saya mau play lagu, dan keluar dari aplikasi tersebut, lagunya tiba-tiba berhenti sendiri dan terpaksa saya masuk apk nya lgi buat ngulang lagunya. Padahal spotify saya fine-fine aja pas pakai awal-awal itu. Tolong dong pihak spotify di perbaiki lagi apk nya. Makasih :)	3	28	8.9.94.470	2024-11-24 07:49:08	null	null	8.9.94.470
3	14065172-9d8c-446e-b271-94b246607ba5	Cla Amora	https://play-lh.googleusercontent.com/a/ACg8ocKQw60yq3VTmdlnWCcogOjmoxEqlhRsAvoXUuQRRxmoqFq0oQ=mo	Kenapa denger pakai kouta sendiri malah offline? Padahal kouta masih ada 3 gb lagi😡😡 dan di aplikasi lain lancar aja padahal, tiap di connect ke kouta selalu mati dan musik langsung terputus, gak like banget, wkwkwk, mengganggu kenyamanan. Jadi ga bisa menikmati musik	2	97	8.9.90.127	2024-11-11 16:15:44	null	null	8.9.90.127
4	fe6a4bc5-ee78-4841-89bf-646a18422b8e	Oliv Cuakcuak	https://play-lh.googleusercontent.com/a/ACg8ocK4kaAPq1G5p2Tmx-r1uATDRghWPcgh4adzh0SiBpqEiLL8Og=mo	em...aku sering banget dengerin lagu di Spotify,sukaaaa banget tapi tolong ya buat kurangin iklannyaaaa,kan keganggu nih lagi seru serunya dengerin lagu malah ada iklan,terus dikit dikit iklan dan baru beberapa menit udah iklan,jadi tolong ya kurangin iklannya untuk pengguna non premium 😡🙏❤️	3	3	8.9.92.408	2024-11-21 13:17:40	null	null	8.9.92.408

Show 25 per page

Fig 1: Data colection

3.1.2. Labeling Data

Sentiment data labeling is performed to categorize user reviews into three main categories: positive sentiment, neutral sentiment, and negative sentiment. In this study, the labeling process is conducted manually by reading and understanding each review that has been collected. Positive sentiment is marked by reviews that express appreciation, pleasant experiences, or satisfaction with the app.



1 to 25 of 1000 entries Filter

index	content	label
0	Padahal dulu gak banyak iklan, sekarang malah kebanyakan iklan, apa² harus premium coba. Maksain banget buat beli premium. Jujur setelah update udah males pake Spotify, setiap mau ngulang atau ganti lagunya gak bisa karena harus premium dulu njir, males bet gw.	Negatif
1	Sumpah ni aplikasi yang bener bener sekali coba bisa ngerasain ujicoba pemakaian premium, untuk pengguna baru dan bisa juga ngedownload musik atau podcast secara gratis disaat masa ujicoba, premium fikssssss no komen ini aplikasi untuk mendengarkan music Terpopuler di sepanjang masa, pokonya buat kalian yang mau fomo kayak gue bisa langsung download ya	Positif
2	Spotify sangat seru untuk mendengarkan musik,menemani aku kapanpun dan di manapun	Positif
3	Bagus banget tapi Spotify tu bikin baterai hp ku cepet habis tapi kualitasnya bagus banget	Positif
4	Saya sudah 2 kali membeli paket premium mini tapi di akun spotify saya tidak ada keterangan spotify paket mini aktif. Sedangkan saldo shopeepay saya sudah terpotong melalui googleplay	Netral
5	Sementara saya ksih bintang 3 dulu. Soalnya setiap saya mau play lagu, dan keluar dari aplikasi tersebut, lagunya tiba-tiba berhenti sendiri dan terpaksa saya masuk apk nya lgi buat ngulang lagunya. Padahal spotify saya fine-fine aja pas pakai awal-awal itu. Tolong dong pihak spotify di perbaiki lagi apk nya. Makasih :)	Netral
6	Mantap lagunya enak di denger suara nya anti macet² kecuali saat sinyalnya jelek 😡 pokok nya kalau pengen dengerin lagu di Spotify aja dijamin ketagihan😴😍😊	Positif
7	menurut gw ini apk bagus banget,tapi gw mau nanya.Kenapa semuanya harus premium?	Positif
8	Ini kenapa sih setiap kali mau premium pasti ada aja masalahnya may bayar yang engga dapat terhubung lah, yang itu lah, ini lah jadinya mau premium malas banget, padahal jaringannya bagus lancar aja	Negatif
9	liriknya tidak muncul di semua lagu padahal sudah update dan setting lagi. di hapus data juga sudah tapi tetap tidak ada lirik nya. solusinya gimana ini?? padahal apk nya bagus bangett	Netral
10	saya beri bintang ⭐⭐⭐⭐⭐ karena aplikasi ini sangat cocok bagi saya untuk mendengarkan musik apapun itu 😊😊	Positif

Fig. 2: Data labeling

3.1.3. Preprocessing data

The review data preprocessing stage is carried out to prepare the text for further analysis. The steps involved include data cleaning, case folding, tokenization, normalization, stopword removal, and stemming. The cleaning process aims to remove irrelevant elements such as punctuation, numbers, or certain symbols.

3.1.1.1. Cleaning data

Data cleaning is the step of removing unnecessary or disruptive elements from the dataset, making the data more structured and ready for analysis.

Table 1: Cleaning data

No	Ulasan	Cleaning data
1.	Sebenarnya bagus,cuman pas udah dikasih lagi di playlist gak muncul muncul lagu yang ku pengen	Sebenarnya baguscuman pas udah dikasih lagi di playlist gak muncul muncul lagu yang ku pengen
2.	Tidak ada optimize ewualizer, tolong adakan pilihan ewualizer seperti bass booster, original, atau penyesuaian ewualizer sendiri.	Tidak ada optimize ewualizer tolong adakan pilihan ewualizer seperti bass booster original atau penyesuaian ewualizer sendiri

3.1.1.2. Stopword

Stopwords are words that frequently appear in text but do not provide significant meaning or contribute to the analysis, such as conjunctions, prepositions, or common verbs.

Table 2: Stopword

No	Ulasan	Stopword
1.	Semua musik yg kalian mau pasti ada di Spotify ini semuanya lengkap dan praktis semuga bisa menjadi lebih baik😇😇😇😊😊😊❤️❤️❤️	musik yg spotify lengkap praktis semuga
2.	Saya dowload aplikasi ini karna saya suka bernyanyi tapi saya kasih bintang 1 karna setiap saya mau putar lagu harus premiumin dulu saya yang bukan premium rasanya kesal karna tidak bisa mendengar musik secara tenang jadi mohon di perbarui ☹️ saya tunggu pembaruan nya 🙏, 'begini', 'gimana', 'gak', 'tambah', 'ngerusak', 'mood'	dowload aplikasi karna suka bernyanyi kasih bintang karna putar lagu premiumin premium kesal karna mendengar musik tenang mohon perbarui tunggu pembaruan nya

3.1.1.3. Tokenizing

Tokenizing is a process in text processing that aims to break down text into smaller parts called tokens, which can be words, phrases, or symbols.

Table 3: Tokenizing

No	Ulasan	Tokenizing
1.	bagus minus nya premium lirik sepuasnya batasan bulanan	bagus,minus,nya,premium,lirik,sepuasnya,batasan,bulanan
2.	bagus bngt lagu spotify tp sygnya ad iklan yg mengganggu gapapa bagus si	[bagus, bngt, lagu, spotify, tp, sygnya, ad,iklan, yg,mengganggu, gapapa, bagus,si

3.1.1.4. Stemming

Stemming is a process in text processing that aims to convert words into their base or root form by removing affixes such as prefixes, suffixes, or infixes.

Table 4: Stemming

No	Ulasan	stemming
1.	bagus,bngt,lagu,spotify,tp,sygnya,ad,iklan,yg, mengganggu,gapapa,bagus,si	bagus bngt lagu spotify tp sygnya ad iklan yg ganggu gapapa bagus si
2.	musik,yg,spotify,lengkap,praktis,semuga	musik yg spotify lengkap praktis semuga, 'atas', 'wajib', 'milik', 'cinta', 'musik'

3.1.4. Transformation

3.1.4.1. Split data

Data splitting is the process of dividing a dataset into several parts for the purpose of training and testing a model. Typically, the data is divided into training data, which is used to train the model, and testing data, which is used to evaluate the model's performance after training.

```
print(X_train.shape)
print(y_train.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(607,)
(607,)
(261,)
(261,)
```

In this case, the data is split into two parts: 607 records for training data and 261 records for testing data, with a ratio of 70:30

3.1.4.2. TF-IDF Weighting

TF-IDF (Term Frequency - Inverse Document Frequency) weighting is a technique used to evaluate the importance of a word in a document relative to the entire collection of documents (corpus). This method consists of two main components: **Term Frequency (TF)**, which

measures how frequently a word appears in a document, and **Inverse Document Frequency (IDF)**, which measures how rarely the word appears across all documents. Words that frequently appear in one document but rarely in others will have a high TF-IDF value, indicating the significance of the word in the context of that document.
TF-IDF weighting is widely used in applications such as information retrieval, text classification, and sentiment analysis because it helps highlight key terms that differentiate one document from another.

3.1.5. Model Implementasion

Naive Bayes is an algorithm in machine learning used for classification tasks by leveraging Bayes' theorem, under the assumption that each feature in the data is independent of the others. In this approach, the probability of each class is calculated based on the training data, and new data is then categorized into the class with the highest probability.
Although the assumption of feature independence is not always accurate, Naive Bayes remains effective and is widely used in various applications such as text classification, sentiment analysis, and spam detection. The primary advantages of this method are its speed and efficiency in handling large datasets.

```
MultinomialNB Accuracy: 0.8160919540229885
MultinomialNB Precision: 0.7870967741935484
MultinomialNB Recall: 0.8905109489051095
MultinomialNB f1_score: 0.8356164383561644
confusion_matrix:
 [[122  15]
 [ 33  91]]
==================================================

              precision    recall  f1-score   support

     Negatif       0.79      0.89      0.84       137
     Positif       0.86      0.73      0.79       124

    accuracy                           0.82       261
   macro avg       0.82      0.81      0.81       261
weighted avg       0.82      0.82      0.81       261
```

Fig 3: Classification report

In the classification stage using Naive Bayes, the algorithm calculates the probability of specific words appearing in each sentiment category (positive and negative). These calculated probabilities are then used to determine the sentiment category of user-provided reviews. The testing data consists of 200 reviews that have undergone preprocessing and TF-IDF weighting. After testing and implementation, a confusion matrix was obtained as the result.

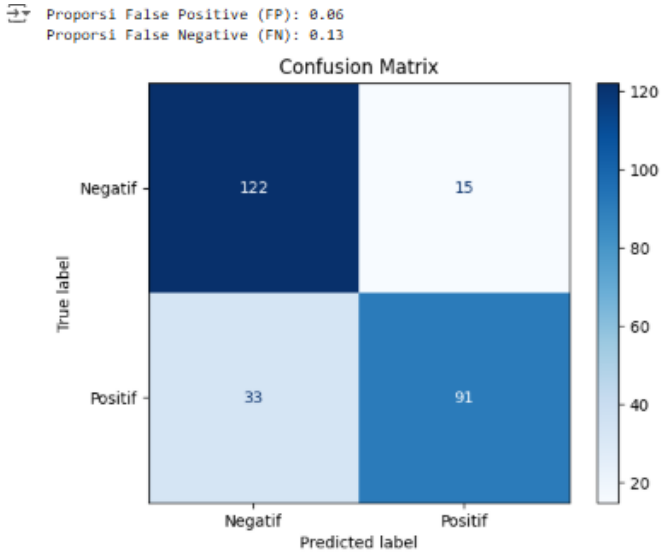


Fig 4: Confusion matrix

The results display the confusion matrix for the classification of Negative and Positive labels. Among the samples:

- **122 Negative samples** were correctly predicted as Negative (**True Negative**), while **15 Negative samples** were incorrectly predicted as Positive (**False Positive**) with an error rate of **6%**.
- **91 Positive samples** were correctly predicted as Positive (**True Positive**), but **33 Positive samples** were misclassified as Negative (**False Negative**) with an error rate of **13%**.

The model's accuracy was calculated at **82%**, with **213 out of 261 samples** correctly predicted.
Although the model's performance is considered good, the higher number of False Negatives compared to False Positives indicates that the model tends to misclassify Positive samples as Negative. This could be a concern if errors in the Positive class have more significant implications.

3.2. Disussion

Performance of Naive Bayes Algorithm
The Naive Bayes algorithm demonstrated its efficiency in classifying user reviews of the Spotify application. The preprocessing steps, including data cleaning, tokenization, stopword removal, normalization, and stemming, significantly contributed to improving the quality of input data. These steps ensured that the algorithm could focus on meaningful features, enhancing the accuracy and precision of sentiment classification.
Using Term Frequency-Inverse Document Frequency (TF-IDF) as a feature extraction technique allowed the model to assign appropriate importance to words. This weighting mechanism effectively identified key terms that differentiated positive, negative, and neutral sentiments. The classification results showed strong performance metrics, including accuracy, precision, recall, and F1-score, indicating that Naive Bayes is a robust choice for sentiment analysis on large and unstructured textual datasets.

Insights from Sentiment Analysis
The sentiment analysis revealed several key trends in user feedback. Positive reviews often highlighted the application's ease of use, extensive music library, and personalized playlists, which contributed to user satisfaction. However, negative reviews frequently mentioned issues such as intrusive advertisements, premium subscription limitations, and occasional technical glitches. These findings emphasize areas where Spotify can focus its improvement efforts, such as optimizing the free-tier experience and addressing technical concerns.

Challenges and Limitations
While the Naive Bayes algorithm performed well, several challenges were encountered. One notable issue was the handling of ambiguous and mixed sentiment reviews, which the model occasionally misclassified. For instance, reviews containing both positive and negative remarks posed difficulties for the algorithm due to its assumption of feature independence. Moreover, slang, abbreviations, and context-specific terms sometimes reduced classification accuracy, highlighting the need for further refinement in preprocessing and feature engineering.

Practical Implications
The findings of this study have practical implications for Spotify and other music streaming platforms. By leveraging sentiment analysis, companies can identify user pain points and prioritize features that enhance user satisfaction. Additionally, the use of machine learning models like Naive Bayes can automate the analysis of large volumes of user feedback, enabling more efficient decision-making.

Contribution to Literature
This study contributes to the growing body of research on sentiment analysis and machine learning. By showcasing the effectiveness of Naive Bayes in analyzing application reviews, it reinforces the algorithm’s suitability for text classification tasks. Furthermore, the methodology employed can serve as a framework for similar studies, particularly in the domain of user feedback analysis for mobile applications.

Future Work
To address the limitations identified, future research could explore hybrid models that combine Naive Bayes with other advanced machine learning techniques, such as deep learning. Incorporating contextual understanding through models like BERT (Bidirectional Encoder Representations from Transformers) could enhance classification accuracy. Additionally, extending the analysis to include multilingual reviews would provide a more comprehensive understanding of user sentiments globally.

4. Conclusion

This study successfully demonstrated the application of the Naive Bayes algorithm for sentiment analysis of Spotify user reviews collected from the Google Play Store. By employing comprehensive preprocessing steps, including data cleaning, tokenization, normalization, stopword removal, and stemming, the research ensured high-quality input for the sentiment classification process. The use of Term Frequency-Inverse Document Frequency (TF-IDF) as a feature extraction technique further enhanced the accuracy and reliability of the analysis.

The results revealed valuable insights into user sentiments. Positive reviews highlighted features such as Spotify's extensive music library and ease of use, while negative reviews frequently pointed to dissatisfaction with advertisements, premium subscription limitations, and occasional technical issues. These findings underscore the importance of addressing user concerns to improve the overall application experience.

The Naive Bayes algorithm proved to be an effective and efficient tool for classifying large volumes of unstructured text data. However, challenges such as handling mixed sentiments and context-specific language suggest opportunities for further enhancement through advanced models like BERT or hybrid techniques.
This research contributes to the field of sentiment analysis and offers practical implications for developers. By leveraging user feedback through machine learning, platforms like Spotify can implement data-driven strategies to enhance user satisfaction and maintain competitiveness in the dynamic digital entertainment market.

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