

Measuring Public Sentiment on Electric Cars in Indonesia: A Social Media Data Analysis

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ABSTRACT

The Industry 4.0 era has driven rapid growth in Indonesia's automotive industry, with increasing environmental awareness fueling demand for eco-friendly vehicles, such as electric cars. In 2023, electric car sales surged by 65%, reaching 17.06 thousand units. However, widespread adoption remains hindered by high costs and limited charging infrastructure. This study aims to analyze Indonesian public sentiment toward electric cars using the Naïve Bayes algorithm. The analysis shows that positive sentiment is dominant, reflecting broad support for this innovation, despite concerns over cost and infrastructure. The Naïve Bayes model achieved an accuracy of 80%, with a precision of 84%, recall of 90%, and an F1-score of 87%. These findings can help the industry devise more effective marketing and educational strategies to encourage the adoption of electric vehicles in Indonesia.

ABSTRAK

Era Industri 4.0 telah mendorong pertumbuhan pesat industri otomotif di Indonesia, dengan meningkatnya kesadaran lingkungan yang memicu permintaan kendaraan ramah lingkungan, seperti mobil listrik. Pada tahun 2023, penjualan mobil listrik meningkat 65%, mencapai 17,06 ribu unit, namun adopsi luas masih terhambat oleh harga yang tinggi dan infrastruktur pengisian daya yang terbatas. Penelitian ini bertujuan untuk menganalisis sentimen masyarakat Indonesia terhadap mobil listrik menggunakan algoritma Naïve Bayes. Hasil analisis menunjukkan bahwa sentimen positif lebih dominan, mencerminkan dukungan terhadap inovasi ini, meski ada kekhawatiran terkait biaya dan infrastruktur. Model Naïve Bayes mencapai akurasi 80%, precision 84%, recall 90%, dan F1-score 87%. Temuan ini dapat membantu industri dalam menyusun strategi pemasaran dan edukasi yang lebih efektif guna mendorong adopsi mobil listrik di Indonesia.

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INTRODUCTION

Technological developments, especially in Indonesia, have progressed in various fields, especially in the manufacturing sector. The industry 4.0 era has brought significant positive impacts, and the automotive industry has also utilized these developments to their advantage (Jati

et al., 2024). In recent years, Indonesia's automotive market has experienced significant growth due to technological advancements and increased environmental awareness. This has encouraged the automotive industry to look for smarter and more environmentally friendly solutions. For example, conventional vehicles that use internal combustion engines with fossil fuels have been dominant in the Indonesian automotive market for decades (Raksodewanto, 2020). Conventional vehicles are still chosen by many consumers due to factors such as habit, infrastructure availability, and more affordable prices when compared to electric cars. However, with the increasing awareness of climate change and concerns over the negative impact of exhaust emissions from conventional vehicles, electric cars are starting to emerge as one of the promising innovations for a sustainable mobility future (Parinduri et al., 2018) (Rayhan et al., 2024).

Electric cars were first introduced in late 1832 in America, but interest in them declined along with the development of more popular and affordable combustion engine cars in the 2000s (F.A, 2022), the automotive industry began to seriously consider the development of electric cars because they were considered more environmentally friendly by using Electric energy (Tulus Pangapoi Sidabutar, 2020). In Indonesia, the process of transitioning from fueled cars to the presence of electric cars triggered mixed opinions in the community. Some welcome it because of its environmentally friendly advantages, but there are still obstacles related to charging station infrastructure and readiness for increased demand for electrical energy (Yatriendi et al., 2022). because the use of electrical energy required by this electric vehicle is a lot, this electric vehicle has the disadvantage that it takes a long time to charge (Iskandar & Yulanto, 2021).

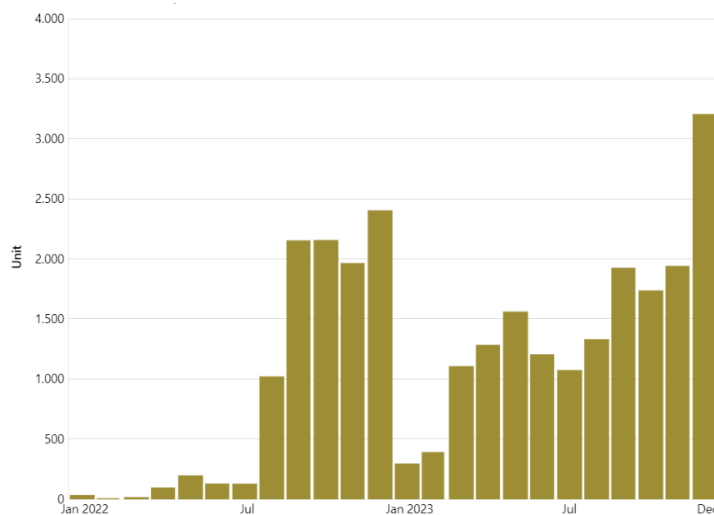


Figure 1. Electric Car Sales in 2023

Based on Figure 1. Monthly wholesale sales volume of Electric Cars in Indonesia, in December 2023, the number of wholesale sales of battery electric vehicles (BEVs) in Indonesia reached around 3.2 thousand units. This wholesale sales figure represents a 65% jump compared to November 2023, and is also about 33% higher compared to December 2022. In total, during the January-December 2023 period, wholesale sales of BEV electric cars in Indonesia reached 17.06 thousand units. This represents an increase of 65.2% when compared to the period in 2022, where sales were around 10.33 thousand units (Ahdiat, 2024).

Some people see electric cars as an effective solution to environmental problems by reducing pollution levels. They appreciate the existence of electric cars as a positive step in maintaining environmental sustainability. However, on the other hand, there are also groups of people who are concerned about the high price of electric cars. They consider the high price as one of the inhibiting factors in the widespread adoption of electric cars in the community. In addition, there is a lack of information and understanding by the public. Ignorance about electric car technology often results in an unfavorable view of this innovation. Some people may feel skeptical or even reluctant to switch to electric cars due to a lack of understanding of the advantages and

performance of electric cars compared to conventional cars that use fossil fuels (Envihsafkm, 2022) (Santoso et al., 2022).

Therefore, the solution is to analyze the sentiment of the Indonesian people towards electric cars using the naïve bayes algorithm, by utilizing Google Colab tools and web scraping techniques to collect sentiment data related to electric cars from the Twitter social media platform (Armand et al., 2023). Twitter is a social media platform that connects 556 million users from various parts of the world, including 24 million in Indonesia (Annur, 2023). Twitter users can share various types of content such as text, URL links, images, and videos. Links shared on Twitter can also direct users to external websites, which enriches the information shared (Nugraha & Nusantara, 2023). This platform stores a lot of comment data, so manually copying the data will take a long time. One technique used to retrieve text data from websites is through web scraping.

Web scraping is a method to collect information from websites automatically without the need to copy it manually, with the aim of finding specific information on targeted sections. Unlike web crawling which visits all sites connected to the main site, web scraping only extracts specific data from the desired site as needed (Satriajati et al., 2021). The results of web scraping can be reused by other systems or analyzed further. The data obtained from web scraping will be used for analysis, which is often used in the classification process (Ramlan et al., 2023).

In the context of opinion analysis, the Naïve Bayes method provides competitive results in the sentiment analysis process. Its main advantage lies in its ability to handle long texts, variations in sentence structure, and possibly a large number of features. It is also quite efficient in performing sentiment classification on large datasets (Dienwati et al., 2023). Naïve Bayes serves as a pre-processing technology in the feature classification process that improves scalability, accuracy, and efficiency (Widagdo et al., 2020). In addition, there are data cleaning techniques that remove irrelevant words and symbols and convert qualitative data into quantitative data. After that, user review data is classified to identify positive and negative reviews (Manik et al., 2021). Nowadays, sentiment analysis is a popular topic among studies due to its aim to present information from unstructured datasets. In this case, classification based on positive and negative sentiments is required (Ramadhan et al., 2022).

Based on previous research on Naïve Bayes Algorithm classification with 80:20 train and test scenarios. The best accuracy results in previous studies using the Naïve bayes method Accuracy 77%, Precision 78%, Recall 84%, F1-score 81%, have an accuracy value on the model that is less than optimal due to the results of less clean preprocessing in the form of duplicate data from the emoji conversion process because tweets mostly use emoji icons. So that in the development of this research, preprocessing for duplicate removal and cleaning processes and adding data to make it more optimal (Verawati & Jaelani, 2024).

The results of this study are expected to contribute to the understanding of people who want to own an electric car, the public will be more assisted in making the right decision when choosing an electric car as an alternative transportation apart from conventional cars. In addition, by understanding public sentiment, the electric car industry can improve marketing and education strategies, creating a more friendly environment is important, especially considering the important role of electric cars in reducing carbon emissions and dependence on fossil fuels.

RESEARCH METHODS

Naïve Bayes

Naïve Bayes classifier (NBC) is a classification method based on Bayes' theorem. The naïve Bayes method is famous for its simplicity and efficiency in text and data classification, which is commonly used for sentiment analysis. This approach is often applied to classification-based prediction problems. It is known that this algorithm has very high accuracy (Permana et al., 2021).

Data Preprocessing

The tweet data taken is still in raw form and needs to be processed before it can be processed further (Permana et al., 2021). The pre-processing stages include:

- a. Case Folding: Changing all capital letters to lowercase letters for uniform text format.
- b. Cleaning: Cleansing unnecessary elements such as URLs, usernames, etc.
- c. Tokenizing: Decapitates sentences into parts or words based on punctuation marks such as commas, periods, etc.
- d. Normalization: Normalization involves converting non-standard words into standard ones by using a dictionary containing pairs of non-standard and standard words.
- e. Stopword Removal: Removes words that do not contribute significantly to the understanding of the text such as conjunctions “which”, “will”, “in”, “on”, etc.

Research Flow

The research method used is CRISP-DM (Cross Industry Standard Process for Data Mining). This method applies 6 stages in processing a problem regarding data mining, namely Business Understanding, Data Understanding, Data preparation, Modeling, Evaluation, Deployment (Fitrianti et al., 2023).

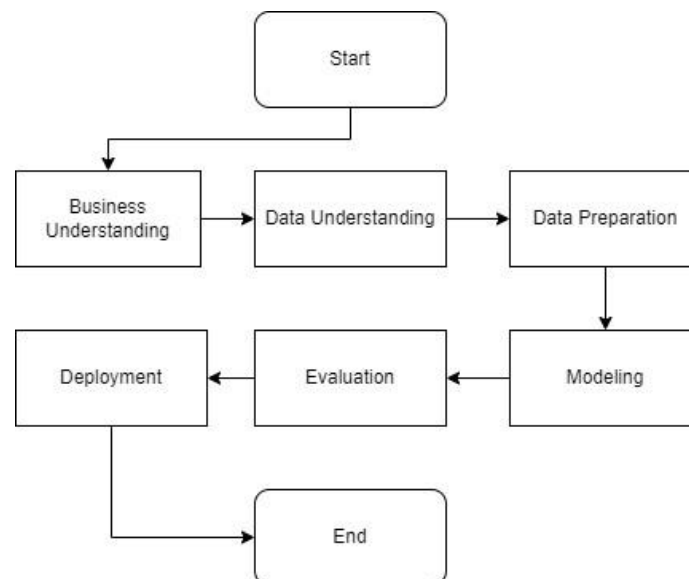


Figure 2. Research flow

In Figure 2, the following is an explanation of the 6 stages of CRISP-DM that will be used in this research, including:

Business Understanding

In this first stage, the analysis technique using the CRISP-DM method is carried out, this stage aims to understand in-depth research on the business field, including the data collection methods used to develop business strategies from the information obtained. This research is focused on providing insights that focus on discussing the issue of electric car problems that occur in Indonesian society which can be reviewed based on the comments of the Indonesian people through twitter application data (Suhanda et al., 2020).

Data Understanding

This study used 3053 review data from Twitter collected based on the views of Indonesians towards electric cars through the Google Colab scrapping tool, showing the effort involved in data

collection. Through the use of data scrapping, it is possible to access information from multiple sources and collect reviews that reflect the diverse views of the public. The collected attributes, such as creation date, number of comments, number of replies, number of retweets, number of favorites, and user names, provide information related to user interactions with the topic under study. With this significant amount of data, an in-depth analysis of public sentiment and opinion towards electric cars can be conducted with a higher degree of statistical expectation (Rahmatulloh & Gunawan, 2020).

Data Preparation

At this stage, an important stage in data analysis which aims to clean, prepare, and organize with the process of selecting data based on comments, and comment dates. After that, the data goes through stages in data preprocessing including cleaning, case folding, tokenization, and stemming of the data to be carried out (Rifaldi et al., 2023).

Modeling

In the modeling stage, this research implements the sentiment analysis algorithm, namely Naïve Bayes on the twitter application review dataset that has gone through the pre-processing stage. First, the dataset is divided into two parts, namely training data and test data. The training data is used to train the model, while the test data is used to test the performance of the model. Then, the Naïve Bayes algorithm was applied for model building, using the training data as training material. Evaluation is performed using the test data, and evaluation metrics such as accuracy, precision, recall, and F1-score are calculated to evaluate the performance of the Naïve Bayes model (Tinaliah & Elizabeth, 2022).

Evaluation

Evaluation is a step of the process that has been carried out in the previous stage, namely modeling. Further evaluation is carried out to determine whether the results of the modeling meet the research objectives or not. In this evaluation stage, an evaluation of the naïve bayes model will be produced, in addition there is a sentiment analysis in the form of positive, and negative results. and finally a wordcloud will also be created which displays words that often appear in reviews (Suhanda et al., 2020).

Deployment

At the deployment stage, the implementation of the naïve bayes model that has been done previously at the evaluation stage is carried out, with the use of this implementation it can be used to produce the right final decision score and meet the research objectives, as well as produce data visualization (Suhanda et al., 2020).

Google Colab

Google Colab surpasses Jupyter Notebook, RStudio, and Microsoft Azure Machine Learning Studio as a preferred tool for data analysis due to various advantages. It is cost-effective and easily accessible, eliminating the need for high local computing resources. Additionally, it offers complimentary GPU/TPU access, seamless integration with Google Drive and Docs, and facilitates interactive and collaborative data exploration (Fianty, Melissa Indah, Wongso & Johan, 2023) .

RESULTS AND DISCUSSION

Data Collection

This stage involves collecting data from twitter or now renamed X in the form of user tweets about electric cars. This data includes review texts, dates, and other relevant information.


```
data = 'data_tweet_mobil.csv'
search_keyword = 'mobil listrik until:2024-01-31 since:2024-01-01' #mulai ambil data dan since terakhir ambil data
limit = 500

!npx --yes tweet-harvest@2.2.7 -o "{data}" -s "{search_keyword}" -l {limit} --token ""
```

Figure 3. Data scrapping process

In Figure 3 the process is created with a data variable and filled with the file name 'data_tweet_mobil.csv' which will be used to store the search result data. Then, a search_keyword variable is created with the value 'electric car until:2024-01-31 since:2024-01-01', which is the search keyword to get tweets about electric cars from January 1, 2024 to January 31, 2024. The “until” parameter indicates the end date of the search, while the “since” parameter indicates the start date of the search, which is set as the last date of the previous data fetch to ensure there are no duplicates in the new data fetched. Furthermore, the limit variable is set with a value of 500, which indicates the maximum number of tweets to be retrieved.

[illegible]

Figure 4. Electric Car Dataset

In Figure 4 After the scraping process is complete and data has been successfully retrieved from Twitter based on the specified search keywords, the results will likely be stored in an excel file with the appropriate format. This csv file will contain columns that may include information such as tweet id, tweet text, tweet creation date, number of likes, number of retweets, and other information related to the tweet.

Data Preprocessing

In the next stage, preprocessing includes handling missing values, cleaning data to overcome noise and outliers, coding categorical variables into numerical form, and scaling or normalizing data to ensure uniformity and readability of data in the analysis model. ensuring the validity and overall quality of the data.

Cleaning

The Cleaning stage of this process helps clean the text of the twitter data before it is saved into the file mobil_listrik.CSV.) to perform a series of text cleaning steps specific to twitter data. remove twitter usernames that begin with the character “@” using the regular expression `re.sub(r'@[A-Za-z0-9_]+', '', text)`.

Case Folding

The cleaning stage is completed, followed by the case folding stage which aims to convert all characters in the text into lowercase letters. The first step of `case_folding` accepts one parameter `text`, which is the text that will be converted into lowercase letters.

Tokenization

At this stage, the tokenization process is carried out which aims to divide the text into tokens or individual words. The tokenize function accepts one parameter text, which is the text to be divided into tokens.

Normalization

In the previous stage of tokenization, the normalization stage was carried out in the data by replacing certain words with other predetermined words.

Stemming Data

The next process after the tokenization stage is done stemming data, the stemming process helps reduce the variety of words in the text so that words that have the same basic meaning will be represented by their basic form.

Labeling

The labeling process is done using the vader lexicon, to analyze the text by measuring the polarity of the sentiment, i.e. whether the text is positive, negative, or neutral. The Vader Lexicon contains a collection of words with sentiment values.

	full_text	Sentiment
0	masalah bukan macet beban apbn amp isu lingkun...	negative
1	om luar negara lebih maju indo gak pusing mobi...	positive
2	sering ajak normalisasi laku bisnis tindak reg...	positive
3	sulit terima bijak perintah juga main bursa ke...	positive
4	biar mobil listrik nya laku bu masa sih aja te...	positive

Figure 5. Labeling results

Figure 5 shows the results of the labeling that has been carried out. Then after the labeling results are complete, the next step is to visualize the sentiment using a bar chart to illustrate the positive and negative words that appear in the data.

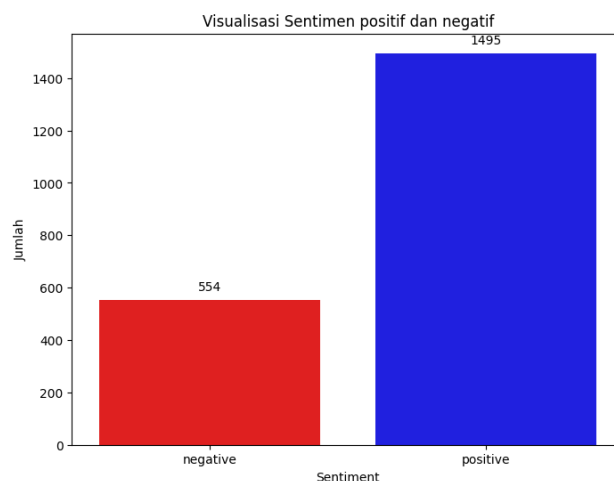


Figure 6. Bar chart visualization

In Figure 6, the results of the bar chart visualization show a comparison of the number of positive and negative words in the dataset related to sentiment analysis about electric cars. From

the visualization, it can be seen that the number of positive words represented in blue reaches 1495, while the number of negative words shown in red is only 554. This comparison indicates that texts expressing positive sentiments are far more abundant than those expressing negative sentiments in the context of electric cars.

This predominantly positive sentiment analysis reflects the generally favorable perception or opinion towards electric cars in the studied dataset. Positive sentiments towards electric cars can be related to several factors, such as environmental advantages, technological innovation, potential long-term cost savings, and positive responses from users or consumers.

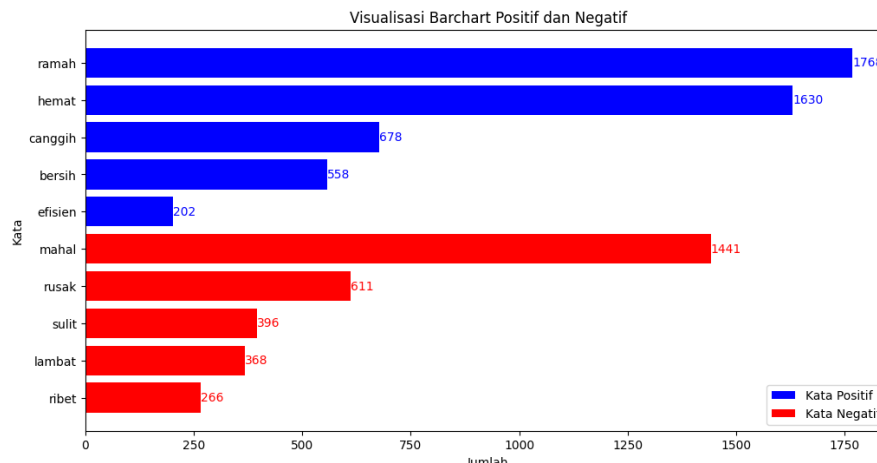


Figure 7. Visualization of positive and negative words

In Figure 7 visualization of positive words, there are words such as “friendly” and “economical”, the word “friendly” has a positive number of 1768 which indicates that there are positive aspects that exist, such as friendliness in service and the environment, besides that there is “economical” has a positive number of 1630 in the context of energy use and the cost of using electric cars. In addition to the negative word visualization, it can be seen that there are 2 words such as “less” and “expensive” that appear frequently in the text. The word “less” has a negative count of 611, indicating that the topics or issues discussed in the text are often related to dissatisfaction or shortcomings as well as prices that are considered high. The word “less” has a negative word count of 1441, referring to aspects that are inadequate or unsatisfactory, while the word “expensive” indicates that cost or price is a major concern for users or readers.

Modeling

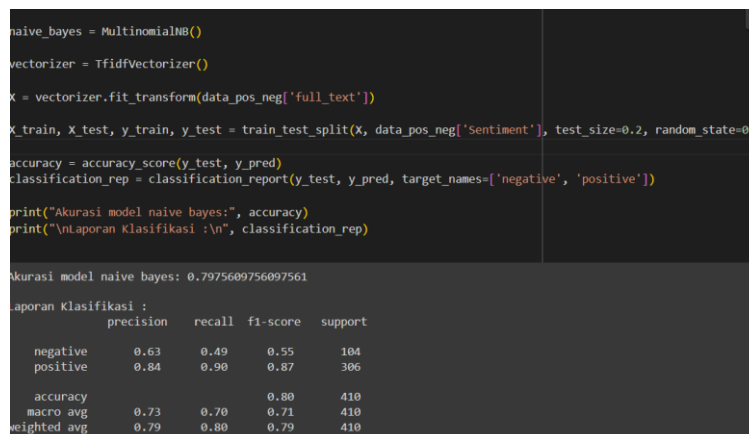


Figure 8. Figure Naïve Bayes Accuracy Process

At the modeling stage, the Naïve Bayes algorithm was used, after that, testing the Naïve Bayes algorithm with a ratio of the amount of test and training data of 80:20. In Figure 8, the Naive Bayes algorithm is modeled using training data (X_train, y_train). After training the model is used to predict sentiment on test data (X_test), the quality of which is then measured using an accuracy metric (accuracy_score). Apart from that, a classification report (classification_report) was also produced, the results of the classification report obtained from the Naïve Bayes model were accuracy of 80%, precision of 84%, recall of 90%, and F1-score of 87%.

Evaluation

In the next stage, an evaluation is carried out in one table based on the 80% training scenario and 20% testing, comparing with previous research. The following is a table of test results.

Table 1. Comparison of training data and testing data 80:20

Algorithm	Accuracy	Precision	Recall	F1-score
Naïve Bayes Priority	77%	78%	84%	81%
Naïve Bayes	80%	84%	90%	87%

In table 1 based on the results of previous research, in this study, Naïve Bayes algorithm classification was carried out with 80:20 training and test scenarios. The best accuracy results in previous studies using the Naïve Bayes method. Accuracy 77%, Precision 78%, Recall 84%, F1-score 81%. The accuracy results obtained by this study are greater than previous studies, where the accuracy results obtained in this study are 80% accuracy, 84% precision, 90% recall, and F1-score 87%. The difference in accuracy results is because this study has more data, and there are differences in the pre-processing process.

Deployment

In the final stage, namely deployment, a model is developed that has the ability to detect comment sentences or tweets that are able to classify new review sentences with positive or negative labels.

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.naive_bayes import MultinomialNB

new_text = input("\nMasukkan teks: ")
new_text_vec = vectorizer.transform([new_text])
predicted_sentiment = naive_bayes.predict(new_text_vec)

if predicted_sentiment[0] == 1:
    sentiment_label = "positif"
elif predicted_sentiment[0] == 0:
    sentiment_label = "negatif"
print("Hasil Analisis Sentimen untuk Teks Baru:", sentiment_label)

Masukkan teks: mobilnya casnya lama
Hasil Analisis Sentimen untuk Teks Baru: negatif
```

Figure 9. Code and results of model development

Figure 9 has some code that aims to analyze the sentiment of new text entered by the user using the naive Bayes classification model to predict the sentiment of new text based on the resulting feature vector. If sentiment is predicted as 1, the text is considered positive; if predicted

as 0, the text is considered negative. The results of the sentiment analysis are then printed in the form of a sentiment label, namely "positive" or "negative".

CONCLUSION

This study analyzed public sentiment towards electric cars in Indonesia using the Naïve Bayes algorithm. The findings indicate that Indonesian public sentiment is predominantly positive, as evidenced by the higher number of positive sentiment labels compared to negative ones. The Naïve Bayes model achieved an accuracy of 80%, with a precision of 84%, recall of 90%, and an F1-score of 87%, demonstrating its effectiveness in accurately classifying sentiments. The balanced performance of the Naïve Bayes model in identifying positive classes while minimizing classification errors highlights its suitability for sentiment analysis tasks. The sentiment visualization through bar charts further confirms that positive sentiments, such as the perception of electric cars being environmentally friendly and cost-effective, outweigh negative sentiments, which mostly focus on concerns about price and infrastructure readiness. These results suggest that while the public appreciates the environmental benefits of electric cars, there are still reservations about their adoption due to perceived high costs and limited charging facilities. This research provides valuable insights into public perceptions of electric cars, offering important guidance for the automotive industry. By understanding these sentiments, stakeholders can refine marketing strategies, address public concerns, and better promote the benefits of electric vehicles. This approach is essential to encourage wider adoption of electric cars, support the transition to sustainable mobility, and reduce carbon emissions in Indonesia.

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