Performance Analysis of Public Sentiment Towards Electric Vehicles in Indonesia on Social Media X Using Word2Vec and Graph Neural Network

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***Abstract*— The issue of climate change and air pollution represents a significant global challenge that demands critical attention. In 2017, the transportation sector in Indonesia accounted for approximately 46.58% of total energy consumption and contributed 53% of total exhaust emissions. Despite an 82.8% public interest in Electric Vehicles (EVs), doubts and concerns persist regarding the viability of battery technology, the availability of supporting infrastructure, and the cost of ownership. This study conducted a sentiment analysis of public perceptions of Electric Vehicles. The approaches employed in this study are Word2Vec and Graph Neural Network (GNN). The combination of Word2Vec and GNN was selected due to its advantages in understanding the semantic meaning of text and enhancing accuracy through the utilization of relational information between words. The objective of this sentiment analysis is to gain insights into public perceptions of Electric Vehicles (EVs) in Indonesia. The results of Word2Vec and GNN achieved an F1-score of 78.81% with an embedding size of 100, a window size of 9, and 200 epochs, higher than other comparable methods, including Word2Vec and CNN (70.50%), SVM (69.28%) and Naive Bayes (61.52%). The most effective model could serve as a reference for future studies on public acceptance of EVs.**

***Keywords*—sentiment analysis, electric vehicle (EVs), Word2Vec, graph neural network (GNN), social media x**

I. INTRODUCTION

Climate change and air pollution are global challenges that require urgent and effective solutions. Indonesia's energy consumption continues to rise annually. In 2017, the transportation sector accounted for the largest proportion of energy consumption, at 46.58%, with most of this energy derived from fuel oil. Furthermore, approximately 53% of the total emissions in Indonesia are attributed to the transportation sector [14]. Given that 82.8% of the public expresses interest in electric vehicles (EVs), with 67.29% indicating a willingness to purchase an EV in the future and 15.51% intending to do so in the near term, the Indonesian government faces both a significant challenge and opportunity in transitioning from internal combustion engines (ICEs) to EVs [1].

The use of electric vehicles (EVs) powered by rechargeable batteries represents a potential alternative for transitioning from fossil fuels to environmentally friendly energy sources. EVs produce minimal emissions during usage, with carbon emissions of only 67.8 grams per kilometer. This represents a significant reduction compared to internal combustion engines (ICEs), which emit 179.1 grams of carbon per kilometer [2]. Therefore, the potential of EVs to reduce Indonesia's total emissions and air pollution is significant. A comparison of emissions from Electric Vehicles (EVs) and Internal Combustion Engines (ICEs) suggests that EVs could offer an effective solution for reducing air pollution and dependence on fossil fuels, thereby accelerating the transition to renewable energy sources.

Despite the environmental benefits of Electric Vehicles (EVs), public perceptions and concerns continue to be a significant barrier to their adoption. A recent survey found that 62.27% of the public expressed concerns about battery lifespan, while 61.13% cited infrastructure limitations as a major issue. Furthermore, 57.8% of the public perceive the cost of Electric Vehicles (EVs) as relatively high, 37% express concerns about safety, 29.2% hesitate due to the limited availability of sales, 26.2% cite the lack of variety in available models as a decision factor, along with several other considerations. Public acceptance of Electric Vehicles (EVs) remains low, as evidenced by findings from the Research and Development Agency of ESDM in 2021, which indicated that only 22.3% of respondents demonstrated an understanding of EVs [1]. Social media platforms, particularly X, have emerged as a primary source of information about EVs, with a large volume of content being created and shared on these platforms.

A previous study on the sentiment analysis of electric cars was conducted using a combination of Word2Vec and Bidirectional Long Short-Term Memory (Bi-LSTM) with an embedding size of 200, resulting in an F1-score of 95.49% [15]. The findings indicated a positive perception of electric cars among the Indonesian public. In the analysis of Weibo comments, a combination of Graph Neural Network (GNN) and Long Short-Term Memory (LSTM) achieved an F1 score of 95.22%, with the results indicating that most comments on Weibo were positive [16]. The sentiment analysis of the installation of American military bases in Ghana using the Word2Vec word embedding method with the Skip Gram model resulted in an F1-score of 81%, indicating a predominance of negative perceptions among the public [17].

The results of the research, which achieved high F1-score outcomes, suggest that the integration of Word2Vec with a GNN in sentiment analysis is an effective approach. Word2Vec excels at understanding word meanings, discerning sentiments, and categorizing topics, while GNNs enhance accuracy by leveraging the relationships between words based on interactions in social media. Consequently, a sentiment analysis of public perceptions of electric vehicles (EVs) in Indonesia was conducted on social media X using the Word2Vec and GNN methods.

II. Literature Review

The research on sentiment analysis related to Electric Vehicles (EVs) [15], uses Word2Vec optimization on the Bi-LSTM model. The Word2Vec model is used to generate a word vector representation that can enhance the accuracy of sentiment classification, while using Bi-LSTM to interpret public sentiment and improve the accuracy of sentiment classification. The application of Word2Vec Optimization on the Bi-LSTM model resulted in an accuracy of 96.31% and an F1-score of 95.49%.

Moreover, the sentiment analysis research on the establishment of American military bases in Ghana implements word embedding methods, particularly Word2Vec [17]. The Word2Vec model generates word vectors that facilitate the comprehension of public sentiment. The dataset employed is extracted from Twitter data pertaining to the subject of the ”U.S. Military Base in Ghana,” including trending hashtags such as #PutGhanaFirst, #StopUSMilitaryBaseInGhana, and other relevant hashtags. The application of U.S. Military Base in Ghana with Word2Vec model resulted in an accuracy rate of 81% and an F1-score of 81%.

The following research presents a sentiment analysis of Weibo comments [16], implemented using Graph Neural Network (GNN) and Long Short-Term Memory (LSTM) methodologies. The Graph Neural Network (GNN) method is employed to extract semantic and structural features from the text by leveraging the semantic graph, whereas the Long Short-Term Memory (LSTM) is developed into a Bi-LSTM to capture information bidirectionally and effectively address the limitations of the LSTM model. The dataset used in this study is drawn from the Weibo_senti_100k dataset, which comprises 120,000 Weibo comments. The method resulted in an accuracy of 95.25% and an F1-score of 95.22%.

In the research on measuring social sentiment towards electric vehicle technology using the Naive Bayes method, the Naive Bayes method is used to classify public sentiment by calculating the probability of a particular class of analyzed tweets and comments. The research dataset is drawn from social media X data with keywords related to electric vehicles, including ”Electric Car,” ”Tesla,” ”Electric Vehicle,” ”Gesits,” and ”Electric Motor.” The accuracy result achieved by using the Naive Bayes method is 94% [18].

Moreover, sentiment analysis research on movie reviews was also performed using the Word2Vec method and Support Vector Machine (SVM) [19]. The Word2Vec method of the Skip Gram model was used to perform feature extraction on English language movie review data, while a Support Vector Machine (SVM) was used to classify the data. The dataset used was drawn from an international movie review forum website containing 10,000 movie reviews. The accuracy achieved using these methods was 78.75%, with an F1-score of 78.74%.

III. Methods and Implementation

A. System Design

The system designed in this study consists of multiple stages, which can be observed in the system design flowchart shown in Fig. 1.

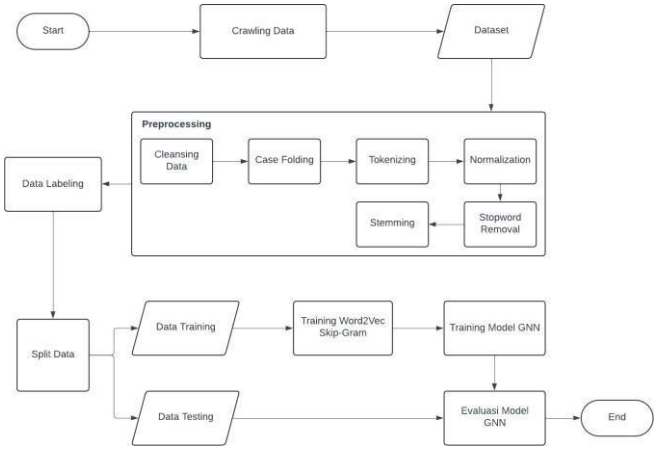

Fig. 1. System design flowchart.

B. Crawling Data and Labelling

In this study, data were extracted from the social media platform X. Keywords relevant to electric vehicles were used, including ”electric vehicles,” ”electric cars,” ”Hyundai electric cars,” ”electric Transjakarta,” ”electric car SPKLU,” ”electric car batteries,” and ”electric motors.” The results of the data crawling are 6,285 data, which will later be grouped into negative and positive sentiments.

The dataset is divided into two sentiment categories: positive (labeled as 1) and negative (labeled as 0). The labeling process is conducted using the Valence Aware Dictionary and Sentiment Reasoner (VADER), a lexicon and rule-based sentiment analysis tool designed specifically for the analysis of text polarity on social media [25]. VADER evaluates text polarity based on a predefined lexicon and contextual rules, such as words with negative meanings (e.g., ”bad,” ”old fashioned,” ”pushover”) and words with positive meanings (e.g., ”advanced, ”innovative,” ”good”). This process resulted in 3,856 data with negative sentiment and 2,087 data with positive sentiment. Table I presents examples of data labelled as positive and negative sentiments. In the table, the positive sentiment category contains words like *dukungan* (support), *bantuan* (help), and *mempercepat* (accelerate), while the negative sentiment category includes words like *kemunduran* (setback) and error.

TABLE I. Data Labeling

Sentimen	Label	Tweets
Positif	1	Dukungan pemerintah dan bantuan kredit mempercepat adopsi kendaraan listrik serta mengurangi dampak lingkungan.