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Aspect-based Sentiment Analysis on Electric Motorcycles: Users' Perspective

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Abstract. Electric Vehicles (EVs) adoption is emerging especially electric motorcycles due to their lower price. Research has shown that the majority of people have positive sentiments towards EVs but most of the sentiments were from people who did not already own or use EVs, but rather from people who reacted / commented towards a product that is recently being launched/announced. This research aims to evaluate users' opinions regarding the positive and negative aspects of electric motorcycles they had purchased / used. This information will be beneficial for the manufacturers and marketers as an evaluation for their products; and it is also beneficial for prospective buyers as a buying consideration. This research uses Aspect-Based Sentiment Analysis applied on 844 electric motorcycles review data from www.bikewale.com website. Results showed that the notable positive sentiments are related to smooth riding experience and low maintenance. Whereas notable negative sentiments are related to poor build quality and product malfunctions. The other aspects of electric motorcycles received mixed sentiments such as related to vehicle speed and customer service. The research findings, limitations, and future research direction are discussed.

Keywords: aspect-based sentiment analysis, electric vehicle, electric motorcycle, users' perspective

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1. Introduction

Electric Vehicles (EVs) are emerging and vehicle manufacturers have released their products to the public, more specifically electric cars and electric motorcycles (EMs). Having lower price tags, electric motorcycle ownership has gained a more rapid growth than electric cars. When purchasing electric motorcycles, the public has their own expectation about the products, especially related to their expected / promised

advantages. After the purchase has been made and the product being used, the owner / user will have their real-life experience and opinion about the product. The users will now see the real advantages and disadvantages of the product. This research aims to evaluate users' opinions regarding the positive and negative aspects of electric motorcycles they had purchased / used. This information will be beneficial for both the manufacturer, marketers, and prospective buyers [1]. As for prospective buyers, it will inform them about the actual advantages and disadvantages of the product. As for marketers, it is useful for determining what features should be advertised. Whereas for the manufacturers, it serves as an evaluation of which aspects of the product are already good / well-received by the buyer and which aspects need improvement. Previous research commonly focused on EV buying motivation / considerations [2], and not on the actual advantages and disadvantages of EVs. Therefore this research aims to identify the real-life advantages and disadvantages of EVs as mentioned by people who already bought / used the vehicle. To identify the real-life advantages and disadvantages of EVs, aspect-based sentiment analysis is used as the research approach.

Sentiment Analysis (SA) is one of the Natural Language Processing (NLP) tasks where people's opinions/perceptions (positive or negative) toward certain entities such as products and services are extracted and analyzed [3]–[5]. There are three levels of SA: document-level SA, sentence-level SA, and aspect-based SA (ABSA) [6]. The document-level and sentence-level SA can only classify each document/sentence into a class and is incapable of finding the more fine-grained sentiment for a specific aspect of interest, such as the comfort and the speed of a vehicle. The document-level and sentence-level SA will struggle to classify a document/sentence that contains both positive and negative sentiments such as "The range is good but it's too pricey.". They will miss the details for each positive and negative sentiments. In this case, ABSA has the advantage to identify the aspects of the product that are perceived as positive or negative by the users / customers. One of the data sources that can be used for SA / ABSA is based on review data that is available online [7], [8]. In this research, ABSA is applied to EM review data to extract the positive and negative aspects of the already-owned EM.

The three most commonly used approaches in ABSA are lexicon-based, traditional machine learning, and deep learning approach [6]. This research will use the lexicon-based approach, which uses a predefined dictionary of words and phrases that are associated with a positive or negative sentiment polarity. The ABSA in this research will use a lexicon-based sentiment analysis tool called VADER (Valence Aware Dictionary and sEntiment Reasoner) where the sentiment classification is based on positive or negative keywords such as "great", "good", "worst", and "poor" [9].

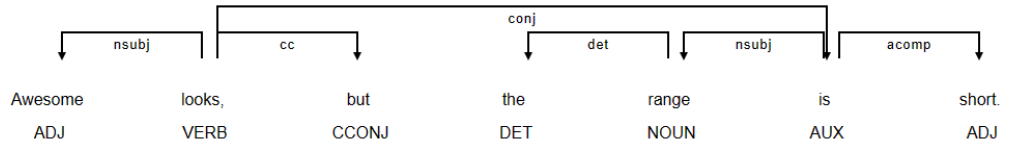
Research has shown that the public generally has positive sentiments towards EV [10], [11]. Sentiment analysis regarding EVs has been carried out based on social media data [1], [10]–[12]. The limitation of such data source is that it cannot guarantee that the person is already using the EVs. For example, research by Anwar (2023) [11] showed that most of the sentiments from social media are those from people who did not already own or use EVs, but rather people's reaction towards a product that is recently being launched/announced [11], [12]. Also, the aspect being discussed is usually unrelated to the aspect of the product itself, but rather on other aspects such as EVs being environmentally friendly [11] and EV price [12]. Other research also showed that multiple users may give their opinions on different aspects of EVs, for example, potential customers talk about the price, brands of EVs, driving range, and charging time [13]. These kinds of sentiment analysis results do not reflect the real-world experience in using the product, which the information is much needed especially for people who are planning to buy an EV. To extract the specific aspects of the product that need paying attention in buying consideration, we need to use Aspect-Based Sentiment Analysis (ABSA) instead of document-level sentiment analysis. Therefore, this research will focus on conducting ABSA on EV reviews from people who already use or own an EV. Other research that used Chinese EV review data had performed sentiment analysis but on document-level [14].

2. Methods

The research methods are shown in Figure 1. The electric motorcycle review data was collected from www.bikewale.com, an Indian website that provides information related to motorcycles including specifications, price, and reviews from the users. In this research, the data being used is the review text. The review data is collected across multiple electric motorcycle brands and models to inform us of general sentiments related to Electric Motorcycles. The text will undergo dependency parsing (identifying grammatical relationships between words in a sentence) and noun phrase extraction using

the SpaCy [15] module in Python. SpaCy is known to be the fastest NLP parser available while and has the highest state-of-the-art accuracy [16]–[18]. The parser used in SpaCy is a transition-based dependency parser. It uses the large English pipeline named "en_core_web_lg" which was trained using three datasets namely the OntoNotes Release 5.0 (University of Pennsylvania), ClearNLP (Emory University), and WordNet 3.0 (Princeton University) [15]. The accuracy of the Part-of-speech tagger component is 0.97, 0.92 for Sentence segmentation precision, and 0.90 for Labeled dependencies [15]. The extracted noun phrases are then classified into positive and negative sentiments using the VADER SentimentIntensityAnalyzer [9] submodule in the nltk [19] module in Python. VADER is chosen because of its rule-based approach which brings four major advantages: transparency, domain-independence, no training requirement, and speed. First, due to its rule-based nature, VADER is transparent and allows us to understand why a particular phrase was assigned to a positive or negative sentiment. Second, the traditional Machine Learning and Deep Learning model requires training on labeled and specific domain datasets, whereas VADER does not require training and is domain-independent which will work on any domain. Lastly, VADER is faster and more lightweight than the Deep Learning model. Finally, the frequency of each noun phrase is calculated to extract the aspect-based sentiment and the result is interpreted. The experiments were carried out using Python 3.7 and Jupyter Notebook [20]. An example of the research process is shown in Table 1.

Table 1. Example of dependency parsing, noun phrase extraction, and sentiment classification

Phase	**Example**
Review text	Awesome looks, but the range is short..
Dependency parsing	
Extracted noun phrases	"awesome looks", "short range"
Sentiment classification	"awesome looks" -> positive sentiment "short range" -> negative sentiment

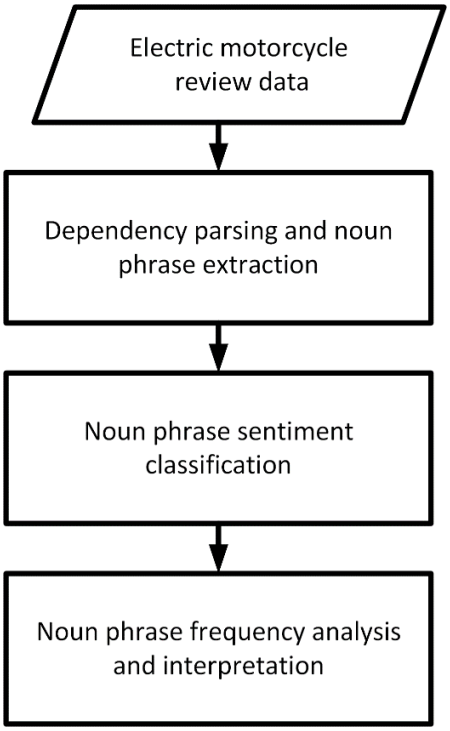


Figure 1. Research Methods

3. Results and Discussion

The data acquisition resulted in a total of 844 rows of review data from multiple EM brands and models with 79% of the reviews being from owners. The rest of them are either people who use other people's EM or just give a comment about a particular EM product. The length of the reviews is up to 5500 characters or 970 words with an average of 462 characters or 89 words. On the document-level sentiment analysis, our data showed that most of the reviews are positive (72%). The results of the positive and negative aspects are shown in Table 2 and Table 3 respectively. The frequency of aspects mentioned in the review can reflect the importance of each aspect which can inform the manufacturer, marketer, or consumer about which aspects need paying attention [21].

Table 2 shows that the notable positive sentiments are related to a smooth riding experience and low maintenance. Research has shown that riding comfort is related to sound and vibration [22]. This is reasonable since EV uses an electric motor which produces minimal sound and vibration. The result related to EV's low maintenance is in line with other research results which mentioned that one of the advantages of EVs is low maintenance [23]. EVs are also known to have lower maintenance costs compared to internal combustion engine (ICE) vehicles, although it has higher initial costs [24]. The low maintenance of EVs comes from the use of battery and electric motors [25] instead of the more complicated drivetrain system in combustion-based vehicles.

On the other hand, the notable negative sentiments are related to poor build quality and product malfunction. The low build quality may come from the competition of the manufacturer to offer lower prices since EVs are generally more expensive due to battery cost [26]. Even though many people mentioned the poor build quality, there are quite a lot of people who mentioned that the build quality is good. This can be explained by the fact that they reviewed different brands and models. Related to EV malfunction, it can be mitigated by using a Fault Detection system especially if it is related to the battery and electric motor as they are the most critical components [27]. Other aspects such as customer service

and EM speed received mixed sentiments. This variation may also be attributed to people reviewing different brands/models.

Contrary to other research results, our result does not mention the sentiment towards charging stations [28]. It might be explained by that EM can be charged at home and is used for shorter travel distances than cars, thus it does not need public charging stations. Charging EM at home is generally much easier to do, much less costly to install, and does not need higher power than an EV car charger.

Other research in EV (car) sentiments analysis using LDA found that the most important topics/aspects the customers consider when planning to purchase an EV are: dynamics (top speed, acceleration, etc), technology (driving range, charge time, etc), safety (braking properties, operating stability, etc), comfort (suspension, seat, etc), and cost [29]. The result of our research agreed on four out of the five aspects, excluding safety. The lack of findings about the safety aspect in our research aspect might be explained by that the EM owner is less concerned about the vehicle safety relative to other aspects of the vehicle, or that the safety of electric motorcycles is less of a concern than those of electric cars. Nevertheless, future research may need to explore the safety aspect of EM as it is an important aspect to consider, especially regarding government policy related to vehicle safety. Other ABSA research on ICE cars use has found that most of its users are satisfied with several positive aspects of the vehicle such as driving comfort, good fuel economy / mileage, reliability, value for money, quiet ride, good acceleration, well-designed, solid build, etc [30]. Many of these aspects have also been captured in our research. Manufacturers may use this information to target the specific aspect they need to maintain / improve the quality of.

Compared to the previous research [29], this research found three new important aspects related to EVs: build quality, product malfunction, and customer service. All of these aspects have mixed sentiments but generally tend to be on the negative side. All of this negativity might be attributed to price competition among manufacturers/companies. Therefore, based on this research result, the manufacturer/company needs to pay attention to product build quality and electric system reliability; whereas marketers/dealers should focus on giving good service to their customers.

The limitation of this research is that this research is based on short-term reviews where most of the reviews (70%) are from owners who give reviews within 1 year of EM usage/ownership. Future research may need to perform follow-up research with a longer period of ownership, such as 3-5 years of use, especially regarding the battery performance because the battery capacity might be degraded after 3-5 years of use. Some of the electric motorcycle parts may also degrade and need replacement after a certain period of usage time. This information is also important to consider for people planning to buy an EV.

Table 2. List of positive aspects and its corresponding frequency

Positive aspects	Frequency
Good/smooth riding experience	22
Good service	13
Low maintenance	11
High speed	11
Good quality	10
Good mileage	8
Amazing look	4
Large boot space	3
Functional buttons	2
Affordable price	2
Removable battery option	2

Table 3. List of negative aspects and its corresponding frequency

Negative aspects	Frequency
Poor build quality	57
Bad experience	15
Many problems	11
Bad customer service	11
Low speed	6
Bad salesperson	5
Bad servicing	4
Suddenly stops	3
Frequent price hikes	2

4. Conclusion

This research aims to uncover users' opinions on the positive and negative aspects of electric motorcycle usage based on user reviews. Results showed that the notable positive sentiments are related to a smooth riding experience and low maintenance. Whereas notable negative sentiments are related to poor build quality and product malfunctions. The other aspects of EM received mixed sentiments such as related to vehicle speed and customer service. Based on the results, manufacturers should improve the overall build quality of their products and the quality of their electrical systems. As for the marketers, they should provide better customer service in handling prospective buyers, handling customer complaints, and giving after-sales services. As for the prospective buyers, they should carefully choose which brand / model has a good build quality and good customer service. The limitation of the study is that this research uses short-term reviews in which most of the reviews (70%) are from owners who give reviews within 1 year of using/owning the electric motorcycles. Future research may need to perform a follow-up research on a longer ownership period, such as 3-5 years of use, as people's opinions may change over time and some of the components especially the battery may degrade in performance and become a significant issue. Future research may focus on exploring some aspects related to longer-term reviews such as battery degradation, vehicle performance degradation, and component degradation.

References

[1] R. Jena, "An empirical case study on Indian consumers' sentiment towards electric vehicles: A big data analytics approach," *Ind. Mark. Manag.*, vol. 90, pp. 605–616, 2020.

[2] M. T. Anwar, M. P. Utami, L. Ambarwati, and A. W. Arohman, "Identifying Social Media Conversation Topics Regarding Electric Vehicles in Indonesia Using Latent Dirichlet Allocation," in *2022 IEEE International Conference on Cybernetics and Computational Intelligence (CyberneticsCom)*, 2022, pp. 102–106.

[3] M. Birjali, M. Kasri, and A. Beni-Hssane, "A comprehensive survey on sentiment analysis: Approaches, challenges and trends," *Knowledge-Based Syst.*, vol. 226, p. 107134, 2021.

[4] I. Chaturvedi, E. Cambria, R. E. Welsch, and F. Herrera, "Distinguishing between facts and opinions for sentiment analysis: Survey and challenges," *Inf. Fusion*, vol. 44, pp. 65–77, 2018.

[5] M. T. Anwar, L. Ambarwati, D. Agustin, and others, "Analyzing Public Opinion Based on Emotion Labeling Using Transformers," in *2021 2nd International Conference on Innovative and Creative Information Technology (ICITech)*, 2021, pp. 74–78.

[6] H. Liu, I. Chatterjee, M. Zhou, X. S. Lu, and A. Abusorrah, "Aspect-based sentiment analysis: A survey of deep learning methods," *IEEE Trans. Comput. Soc. Syst.*, vol. 7, no. 6, pp. 1358–1375, 2020.

[7] Y. Yiran and S. Srivastava, "Aspect-based Sentiment Analysis on mobile phone reviews with LDA," in *Proceedings of the 2019 4th International Conference on Machine Learning*

Technologies, 2019, pp. 101–105.
[8] Y. Zhang, J. Du, X. Ma, H. Wen, and G. Fortino, "Aspect-based sentiment analysis for user reviews," *Cognit. Comput.*, vol. 13, no. 5, pp. 1114–1127, 2021.
[9] C. Hutto and E. Gilbert, "Vader: A parsimonious rule-based model for sentiment analysis of social media text," in *Proceedings of the international AAAI conference on web and social media*, 2014, vol. 8, no. 1, pp. 216–225.
[10] F. J. Costello and K. C. Lee, "Exploring the Sentiment Analysis of Electric Vehicles Social Media Data by Using Feature Selection Methods.," *J. Digit. Converg.*, vol. 18, no. 2, 2020.
[11] M. T. Anwar, "Analisis Sentimen Masyarakat Indonesia Terhadap Produk Kendaraan Listrik Menggunakan VADER," *JATISI (Jurnal Tek. Inform. dan Sist. Informasi)*, vol. 10, no. 1, pp. 783–792, 2023.
[12] D. P. Demirer and A. Büyükeke, "Analysing perceptions towards electric cars using text mining and sentiment analysis: A case study of the newly introduced TOGG in Turkey," *Appl. Mark. Anal.*, vol. 7, no. 4, pp. 386–399, 2022.
[13] T. Ruan and Q. Lv, "Public perception of electric vehicles on reddit over the past decade," *Commun. Transp. Res.*, vol. 2, p. 100070, 2022.
[14] M. Wang, H. You, H. Ma, X. Sun, and Z. Wang, "Sentiment Analysis of Online New Energy Vehicle Reviews," *Appl. Sci.*, vol. 13, no. 14, p. 8176, 2023.
[15] H. Matthew, I. Montani, S. Van Landeghem, and A. Boyd, "spaCy: Industrial-strength Natural Language Processing in Python," 2020, doi: 10.5281/zenodo.1212303.
[16] N. Colic, "Dependency parsing for relation extraction in biomedical literature," *Master's thesis, Univ. Zurich, Switz.*, 2016.
[17] N. Colic and F. Rinaldi, "Improving spaCy dependency annotation and PoS tagging web service using independent NER services," *Genomics \& informatics*, vol. 17, no. 2, 2019.
[18] M. Honnibal and M. Johnson, "An improved non-monotonic transition system for dependency parsing," in *Proceedings of the 2015 conference on empirical methods in natural language processing*, 2015, pp. 1373–1378.
[19] S. Bird, E. Klein, and E. Loper, *Natural language processing with Python: analyzing text with the natural language toolkit*. " O'Reilly Media, Inc.," 2009.
[20] T. Kluyver *et al.*, "Jupyter Notebooks -- a publishing format for reproducible computational workflows," in *Positioning and Power in Academic Publishing: Players, Agents and Agendas*, 2016, pp. 87–90.
[21] B. Gong, R. Liu, X. Zhang, C.-T. Chang, and Z. Liu, "Sentiment analysis of online reviews for electric vehicles using the SMAA-2 method and interval type-2 fuzzy sets," *Appl. Soft Comput.*, vol. 147, p. 110745, 2023.
[22] X. Wang, A.-L. Osvalder, and P. Höstmad, "Influence of sound and vibration on perceived overall ride comfort—A comparison between an electric vehicle and a combustion engine vehicle," *SAE Int. J. Veh. Dyn. Stability, NVH*, vol. 7, no. 10-07-02–0010, pp. 153–171, 2023.
[23] A. Thattil, S. Vachhani, D. Raval, P. Patel, and P. Sharma, "Comparative study of using different electric motors for EV," *Int. Res. J. Eng. Technol.*, vol. 6, no. 4, pp. 4601–4604, 2019.
[24] I. Veza, M. Z. Asy'ari, M. Idris, V. Epin, I. M. R. Fattah, and M. Spraggon, "Electric vehicle (EV) and driving towards sustainability: Comparison between EV, HEV, PHEV, and ICE vehicles to achieve net zero emissions by 2050 from EV," *Alexandria Eng. J.*, vol. 82, pp. 459–467, 2023.
[25] K. A. Nitesh and Ravichandra, "A study on battery controller design for the estimation of state of charge (SoC) in battery management system for electric vehicle (EV)/hybrid EV (HEV)," *SN Comput. Sci.*, vol. 2, no. 3, p. 197, 2021.
[26] A. König, L. Nicoletti, D. Schröder, S. Wolff, A. Waclaw, and M. Lienkamp, "An overview of parameter and cost for battery electric vehicles," *World Electr. Veh. J.*, vol. 12, no. 1, p. 21, 2021.
[27] M. Z. Khaneghah, M. Alzayed, and H. Chaoui, "Fault detection and diagnosis of the electric

motor drive and battery system of electric vehicles," *Machines*, vol. 11, no. 7, p. 713, 2023.
[28] O. I. Asensio, K. Alvarez, A. Dror, E. Wenzel, and C. Hollauer, "Evaluating popular sentiment of electric vehicle owners in the United States with real-time data from mobile platforms."
[29] X. Ren, S. Sun, and R. Yuan, "A study on selection strategies for battery electric vehicles based on sentiments, analysis, and the MCDM model," *Math. Probl. Eng.*, vol. 2021, pp. 1–23, 2021.
[30] M. T. Anwar, D. Trisanto, A. Juniar, and F. A. Sase, "Aspect-based Sentiment Analysis on Car Reviews Using SpaCy Dependency Parsing and VADER," *Adv. Sustain. Sci. Eng. Technol.*, vol. 5, no. 1, p. 230109, 2023.