JAISEN: Journal of Advanced Information Systems and Engineering
Vol. 2, 1 (February, 2026), pp 49-59
ISSN: - EISSN: - , DOI: -

Optimization of a Hybrid NLP Model for Multi-Aspect Sentiment Analysis of the Minister of Finance of the Republic of Indonesia

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ARTICLE INFO

Keywords:

Natural Language Processing;
Hybrid NLP Model;
Aspect-Based Sentiment Analysis;
Social Media Analytics;
Public Opinion Analysis.

Article history:

Received 2026-01-22
Revised 2026-02-12
Accepted 2026-02-25

ABSTRACT

The rapid growth of social media platforms has created extensive opportunities to analyze public opinion toward government policies using computational approaches. Public discussions related to fiscal governance, particularly those involving the Minister of Finance of the Republic of Indonesia, generate large volumes of textual data reflecting diverse societal perceptions. However, conventional sentiment analysis methods often fail to capture multidimensional opinions expressed across different policy aspects. Therefore, this study aims to optimize a hybrid Natural Language Processing (NLP) model for conducting multi-aspect sentiment analysis on public discourse collected from the X social media platform. The proposed framework integrates machine learning and deep learning techniques through a hybrid stacking approach combined with preprocessing optimization, class imbalance handling, and hyperparameter tuning. The dataset underwent text normalization, aspect identification, and sentiment labeling processes before model training and evaluation. Experimental results indicate that the hybrid NLP model achieved stable predictive performance with an accuracy exceeding 94%, demonstrating improved robustness in handling informal Indonesian social media language. Multi-aspect analysis reveals that public sentiment toward fiscal governance tends to be predominantly neutral, indicating analytical rather than emotionally polarized discussions across taxation, budgeting, and economic management aspects. The findings confirm that hybrid NLP combined with aspect-based sentiment analysis provides deeper interpretative capability compared to conventional sentiment classification approaches. This study contributes to the advancement of sentiment analysis research in low-resource language environments and offers a data-driven framework that can support digital governance evaluation and evidence-based policymaking through intelligent public opinion monitoring systems.

Jaisen: Journal of Advanced Information Systems and Engineering, Vol. 2, 1 (February 2026): 49-59

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1. INTRODUCTION

The rapid advancement of information and communication technology has fundamentally transformed the way society communicates, exchanges information, and expresses opinions in the digital era. Social media platforms have evolved beyond personal communication tools into dynamic public spaces where individuals actively share perspectives, reactions, and evaluations toward social, economic, and political issues. These platforms generate massive volumes of user-generated textual data that reflect public sentiment in real time. Consequently, social media has become an important source of information for understanding public perception toward government policies and public officials through computational analysis approaches.

In modern governance systems, public opinion plays a crucial role in shaping policy legitimacy and institutional trust. Government officials, particularly those responsible for national economic management, frequently become subjects of public discussion across digital platforms. The Minister of Finance of the Republic of Indonesia represents one of the most strategically significant public figures due to the central role of fiscal policy in maintaining economic stability, managing state budgets, regulating taxation systems, and responding to global economic challenges. Decisions related to fiscal management often provoke diverse public responses ranging from support and appreciation to criticism and skepticism. These reactions are widely expressed through online discussions, making social media analysis increasingly relevant for capturing collective public sentiment.

Understanding public perception manually is increasingly impractical due to the enormous scale and velocity of online data production. Therefore, Natural Language Processing (NLP) has emerged as a powerful computational approach for automatically extracting meaning, opinions, and emotional tendencies from textual information. Sentiment analysis, as one of the primary applications of NLP, aims to classify opinions expressed in text into sentiment categories such as positive, negative, or neutral. This technique has been widely adopted in various domains, including marketing analysis, public policy evaluation, customer feedback assessment, and political communication studies.

Despite its widespread adoption, conventional sentiment analysis typically treats textual opinions as single-dimensional expressions. Such an approach assumes that a sentence conveys only one overall sentiment polarity, which often oversimplifies real-world opinions. In practice, social media users frequently express mixed evaluations within a single statement. For example, individuals may appreciate macroeconomic stability while simultaneously criticizing taxation policies or government spending decisions. This multidimensional nature of opinion highlights the limitations of traditional sentiment classification approaches in representing complex public discourse.

To address these limitations, Aspect-Based Sentiment Analysis (ABSA) has gained increasing attention in recent NLP research. ABSA enables sentiment identification at the aspect level, allowing systems to determine sentiment polarity toward specific topics or attributes mentioned within a text. This approach provides deeper analytical insights because it distinguishes which particular aspects generate positive or negative responses. Recent studies demonstrate that multi-aspect sentiment analysis significantly improves interpretability and analytical precision compared to general sentiment classification models (Zhang et al., 2022; Chen & Xie, 2023). Consequently, ABSA is particularly suitable for analyzing public responses toward government performance, where opinions often involve multiple policy dimensions.

However, implementing multi-aspect sentiment analysis in Indonesian-language social media data presents substantial challenges. Social media texts are characterized by informal language usage, abbreviations, slang expressions, code-switching between languages, emojis, and sarcastic statements.

These linguistic variations complicate text preprocessing and semantic interpretation processes. Furthermore, sentiment datasets collected from social media frequently suffer from class imbalance problems, where certain sentiment categories dominate others. Such imbalance may lead machine learning models to favor majority classes, thereby reducing prediction reliability and limiting analytical accuracy.

Recent advancements in deep learning have significantly improved NLP capabilities in handling contextual language understanding. Transformer-based architectures, particularly Bidirectional Encoder Representations from Transformers (BERT) and related models, demonstrate superior performance in capturing contextual dependencies within sentences compared to traditional machine learning approaches (Khan et al., 2022). These models learn semantic representations dynamically, enabling more accurate interpretation of complex linguistic structures commonly found in social media communication.

Nevertheless, relying solely on a single deep learning architecture may not always produce optimal performance, especially when dealing with heterogeneous and noisy datasets. Each modeling approach possesses distinct strengths and limitations in representing linguistic patterns. As a result, hybrid NLP models have emerged as an effective strategy for improving sentiment classification performance. Hybrid models combine complementary techniques, such as contextual embedding methods and neural sequence-learning architectures, to enhance feature representation and predictive capability. Empirical evidence suggests that hybrid NLP approaches improve model generalization and robustness when applied to unstructured textual data environments (Li et al., 2023).

In addition to model architecture, parameter optimization plays a critical role in determining system performance. Hyperparameter configurations—including learning rate, batch size, training epochs, and optimization strategies—directly influence model convergence and classification accuracy. Improper parameter selection may result in overfitting, unstable training processes, or reduced predictive performance. Recent research emphasizes that systematic hyperparameter optimization significantly enhances deep learning effectiveness in sentiment analysis tasks (Yang et al., 2024). Therefore, optimization strategies must be incorporated as an integral component of NLP model development.

Within the Indonesian research landscape, sentiment analysis studies focusing on public officials remain relatively limited, particularly those integrating multi-aspect analysis with hybrid NLP optimization. Many existing studies still rely on traditional algorithms such as Naïve Bayes, Support Vector Machine, or lexicon-based methods, which often struggle to capture contextual semantics in informal social media language. This research gap indicates the need for more adaptive analytical frameworks capable of addressing linguistic complexity while improving classification performance.

Based on these considerations, this study proposes the optimization of a hybrid NLP model for conducting multi-aspect sentiment analysis toward public opinions regarding the Minister of Finance of the Republic of Indonesia on the X social media platform. Unlike conventional sentiment analysis approaches, this research identifies sentiment polarity across multiple policy-related aspects, including fiscal policy performance, economic management, taxation issues, and governmental responsiveness. By incorporating aspect-level analysis, the proposed framework aims to generate a more structured and comprehensive understanding of public sentiment dynamics.

Methodologically, this research applies a systematic NLP pipeline consisting of social media data collection, text preprocessing, aspect annotation, contextual text representation using advanced language models, and sentiment classification through an optimized hybrid architecture. Model optimization is conducted using hyperparameter tuning techniques alongside class imbalance handling strategies to improve predictive stability. Model performance is evaluated using standard classification metrics, including accuracy, precision, recall, and F1-score, ensuring methodological reliability and analytical validity.

The significance of this study extends beyond technical model development. Multi-aspect sentiment analysis provides valuable insights that may support evidence-based policymaking by enabling policymakers to understand societal responses objectively. Data-driven sentiment evaluation can assist government institutions in identifying public concerns, measuring policy acceptance, and improving communication strategies in the digital environment. Consequently, the integration of

artificial intelligence into public opinion analysis contributes to more responsive and transparent governance practices.

From an academic perspective, this research contributes to the growing body of NLP studies focusing on low-resource languages such as Indonesian. Compared to English-language NLP research, studies addressing Indonesian social media text remain relatively scarce. The linguistic diversity and informal characteristics of Indonesian online communication require adaptive modeling strategies capable of handling semantic variability. Therefore, optimizing hybrid NLP models within this context provides both methodological advancement and practical relevance.

Globally, the integration of hybrid modeling and aspect-based sentiment analysis represents an emerging direction in intelligent text analytics research. Such approaches not only enhance computational performance but also improve interpretability, allowing analytical outcomes to better reflect real-world opinion structures (Wang et al., 2022). By bridging advanced NLP methodologies with public policy analysis, this study seeks to contribute to interdisciplinary research connecting artificial intelligence, social computing, and governance evaluation.

Accordingly, the primary objective of this research is to optimize a hybrid NLP model to improve the performance of multi-aspect sentiment analysis toward public opinions concerning the Minister of Finance of the Republic of Indonesia on social media platforms. The proposed approach aims to achieve both high predictive accuracy and deeper analytical interpretation of multidimensional public sentiment.

Overall, this study offers three main contributions. First, it develops a multi-aspect sentiment analysis framework tailored to Indonesian social media data. Second, it enhances sentiment classification performance through hybrid NLP optimization involving hyperparameter tuning and class imbalance handling. Third, it proposes a data-driven analytical framework that may serve as a reference for evaluating public perception toward government policies in the digital era. Through these contributions, this research is expected to enrich NLP literature while providing practical insights into understanding public sentiment dynamics using advanced computational intelligence techniques.

2. METHODS

This study applied a quantitative computational research approach to develop and optimize a hybrid Natural Language Processing (NLP) model for conducting multi-aspect sentiment analysis related to public opinions toward the Minister of Finance of the Republic of Indonesia. The research emphasizes experimental model development aimed at improving sentiment classification accuracy within complex social media environments. A systematic analytical framework was implemented to ensure that each stage of data processing and modeling followed reproducible scientific procedures. The methodological design integrates linguistic processing techniques with deep learning-based sentiment classification mechanisms. Through this structured approach, the study seeks to produce reliable analytical outcomes capable of representing multidimensional public sentiment patterns.

2.1 Research Design

The research was designed as an experimental machine learning study focusing on model construction, optimization, and performance evaluation. The experimental framework allows the comparison of model performance before and after optimization procedures are applied. Unlike conventional sentiment analysis that focuses on overall polarity detection, this study adopts a multi-aspect analytical perspective to capture sentiment variation across different policy dimensions. The research workflow follows sequential stages beginning from data acquisition, preprocessing, annotation, modeling, optimization, and evaluation. This design ensures that the developed hybrid NLP model can systematically learn contextual relationships between textual expressions and sentiment orientations associated with specific aspects.

2.2 Data Collection

The dataset used in this research was collected from the X social media platform, which represents one of the most active digital environments for public discussion in Indonesia. Data retrieval focused on posts containing keywords, mentions, and hashtags associated with discussions concerning the Minister of Finance of the Republic of Indonesia. Automated data collection techniques were employed to gather publicly available textual information while maintaining ethical considerations related to privacy and responsible data usage. The collected dataset reflects authentic user-generated opinions expressed naturally within online discussions. After collection, irrelevant posts, duplicated entries, advertisements, and non-opinion content were removed to ensure data quality and analytical relevance.

2.3 Data Preprocessing

Text preprocessing was conducted to transform raw social media data into structured textual input suitable for machine learning analysis. The preprocessing stage included several procedures such as case normalization, removal of hyperlinks, elimination of punctuation symbols, tokenization, stop-word filtering, and stemming processes. Considering the informal characteristics of social media language, additional normalization techniques were implemented to address slang expressions, abbreviations, and repeated characters commonly found in online communication. These procedures reduce linguistic noise while preserving semantic meaning contained within textual data. Proper preprocessing is essential to improve feature representation and support effective learning during the model training phase.

2.4 Aspect Annotation and Sentiment Labeling

To perform multi-aspect sentiment analysis, the dataset was annotated according to predefined policy-related aspects derived from dominant discussion topics observed in the collected data. The selected aspects include fiscal policy performance, taxation issues, economic management, and government responsiveness toward economic challenges. Each textual instance was examined to determine whether it contained references to one or more aspects before assigning sentiment polarity labels categorized as positive, negative, or neutral. The annotation process follows supervised learning principles that enable the model to associate contextual linguistic patterns with aspect-specific sentiment expressions. This structured labeling approach ensures that sentiment classification results capture nuanced public evaluations rather than generalized emotional responses.

2.5 Hybrid NLP Model Development

The analytical framework proposed in this study utilizes a hybrid NLP architecture combining contextual language representation and deep neural network classification mechanisms. Contextual embeddings were generated using transformer-based language modeling techniques capable of understanding semantic dependencies across sentences. These embeddings were subsequently processed through neural classification layers designed to identify sentiment polarity at the aspect level. The hybrid architecture was selected to integrate contextual understanding with sequential learning capability, thereby enhancing classification robustness. By combining multiple modeling approaches, the system becomes more adaptive when handling noisy and unstructured social media text data.

2.6 Model Optimization

Model optimization was conducted to enhance classification performance and ensure stable learning behavior during training. Hyperparameter tuning procedures were applied to determine optimal configurations involving learning rate selection, batch size adjustment, training epochs, and

optimization algorithms. Several experimental iterations were performed to identify parameter combinations producing the highest validation performance. In addition, class imbalance problems were addressed using data balancing strategies to prevent prediction bias toward dominant sentiment categories. These optimization techniques contribute significantly to improving model generalization capability and reducing classification errors across minority sentiment classes.

2.7 Model Evaluation

The performance of the optimized hybrid NLP model was evaluated using standard classification metrics widely adopted in sentiment analysis research. Evaluation indicators included accuracy, precision, recall, and F1-score to measure prediction effectiveness comprehensively. Accuracy reflects overall correctness of classification results, while precision evaluates the reliability of predicted sentiment labels. Recall measures the model's capability to identify relevant sentiment instances within the dataset, and F1-score provides balanced evaluation between precision and recall performance. The evaluation process was conducted using separated training and testing datasets to ensure objective validation of model effectiveness.

2.8 Implementation Environment

The experimental implementation was carried out using Python-based programming environments supported by modern machine learning libraries. Computational processes including preprocessing, model training, optimization, and evaluation were executed within a cloud-based environment to ensure scalability and computational efficiency. Deep learning frameworks were utilized to support large-scale textual processing and accelerated training performance. The implementation setup enables reproducibility of experimental results and facilitates further system development. This environment also supports integration with deployment platforms for future real-world sentiment monitoring applications.

3. FINDINGS AND DISCUSSION

3.1 Dataset Characteristics and Preprocessing Outcome

The dataset analyzed in this study was obtained from public discussions on the X social media platform concerning fiscal governance issues related to the Minister of Finance of the Republic of Indonesia. Following preprocessing procedures, noisy textual components such as hyperlinks, mentions, duplicated entries, and non-alphabetic symbols were successfully removed. The preprocessing stage reduced the dataset into 4,953 valid textual observations suitable for sentiment modeling. This refinement process ensures that the analytical model learns semantic information rather than structural irregularities frequently present in social media communication.

From an analytical perspective, preprocessing significantly improves linguistic consistency across textual inputs. Social media language tends to be highly informal and inconsistent, which may negatively influence feature extraction processes. Normalization allows different expressions conveying identical meanings to be interpreted uniformly by machine learning algorithms. Consequently, preprocessing becomes a critical determinant of downstream classification performance rather than merely a technical preparation step.

3.2 Effect of Text Normalization on Data Structure

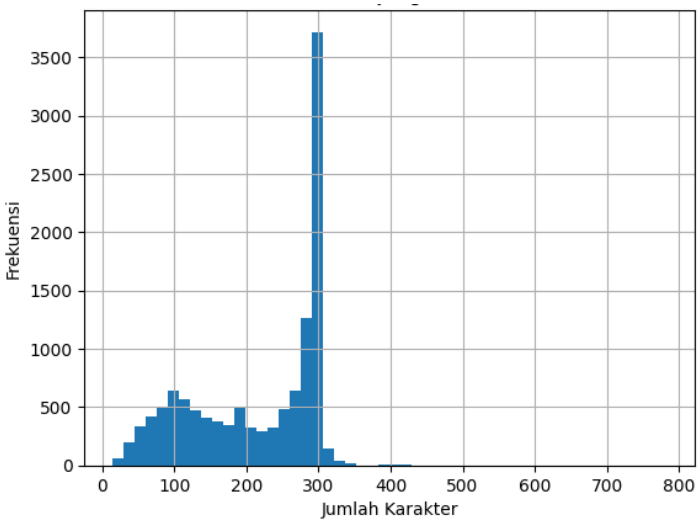

Figure 1. Initial Tweet Length Distribution

The visualization of text length distribution before and after preprocessing illustrates substantial normalization effects within the dataset. The histogram indicates reduced dispersion of textual length following cleaning procedures, suggesting successful removal of irrelevant components without eliminating semantic content. More uniform sentence structures enable the learning algorithm to focus on sentiment-bearing linguistic patterns.

Critically, normalization improves computational stability during model training. Excessive variation in textual structure may lead models to interpret stylistic differences as meaningful features. By reducing structural noise, preprocessing strengthens contextual representation quality. This improvement contributes directly to more stable convergence behavior observed during deep learning training stages.

3.3 Distribution of Policy Aspects in Public Discourse

Aspect detection analysis reveals that public discussion is not evenly distributed across fiscal policy themes. The majority of conversations fall within general institutional discussions, while taxation and APBN-related topics appear in smaller proportions. Discussions related to subsidies and government debt emerge less frequently, indicating lower engagement levels within technically complex economic issues.

This imbalance reflects differences in perceived policy proximity among citizens. Policies directly influencing personal economic conditions tend to generate stronger participation compared to macroeconomic issues requiring specialized knowledge. The finding confirms that public sentiment toward governance is shaped not only by policy importance but also by accessibility of understanding. Therefore, aspect-based sentiment analysis becomes necessary to capture thematic diversity embedded within public discourse.

3.4 Sentiment Distribution Characteristics

The sentiment labeling process indicates that neutral sentiment dominates discussions related to fiscal governance. Most users appear to share information, commentary, or analytical perspectives rather than explicitly emotional opinions. This pattern suggests that economic policy discussions in digital environments remain relatively rational compared to emotionally driven domains such as product reviews or political campaigns.

The dominance of neutral sentiment introduces methodological challenges due to class imbalance. Machine learning models may naturally favor majority categories unless corrective mechanisms are applied. For this reason, class-weight adjustment and resampling strategies were

implemented during model training. Proper handling of imbalance ensures that minority sentiments, particularly negative evaluations, remain detectable despite limited representation within the dataset.

3.5 Important Linguistic Features Influencing Sentiment Formation

Feature extraction analysis using TF-IDF representation demonstrates that dominant keywords within the dataset strongly relate to governance and fiscal policy discussions. Terms associated with government institutions, budgeting mechanisms, and taxation policies appear consistently as influential features during classification processes. This result confirms that the collected dataset accurately represents policy-oriented public discourse.

Interestingly, sentiment formation appears closely connected to policy evaluation rather than personal characteristics of public officials. Users tend to discuss institutional performance, regulatory outcomes, and economic implications instead of individual personality attributes. Such findings reinforce the relevance of multi-aspect sentiment analysis for governance evaluation studies. Linguistic evidence suggests that public opinion formation within economic discussions remains issue-centered rather than person-centered.

3.6 Training Dynamics of Deep Learning Models

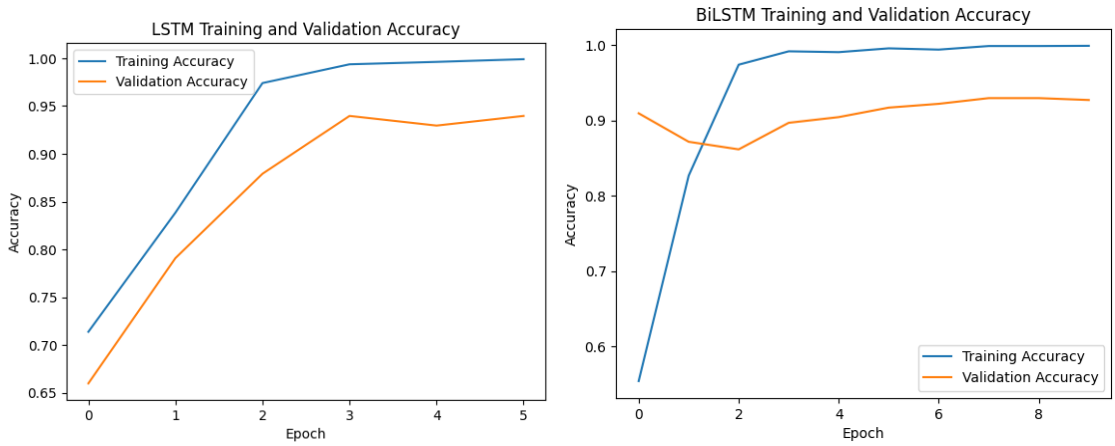

Figure 2. LSTM & BiLSTM Training and Validation Accuracy

Training performance visualization derived from LSTM and BiLSTM experiments demonstrates stable learning convergence throughout the training process. Accuracy increases consistently across epochs while validation loss gradually decreases, indicating effective model learning without severe overfitting behavior. The convergence pattern confirms that sequential neural architectures successfully capture contextual dependencies within Indonesian social media texts.

Bidirectional learning mechanisms further enhance sentiment interpretation by analyzing contextual relationships from multiple directional sequences. Early stopping implementation prevents unnecessary training iterations once performance stabilization occurs. These observations highlight the importance of optimization strategies in maintaining balance between learning capacity and generalization performance.

3.7 Comparative Evaluation of Classification Models

Table 1. Accuracy Comparison of Evaluated Models

Model	Accuracy
SVM	0.9616
Random Forest	0.9414
LSTM	0.9354
BiLSTM	0.9404
Hybrid NLP	0.9424

Performance comparison results indicate competitive accuracy among evaluated algorithms. Although SVM achieves slightly higher numerical accuracy, hybrid NLP demonstrates stronger adaptability across heterogeneous linguistic conditions. Statistical models excel at structured feature recognition, while deep learning models capture contextual semantics more effectively. The hybrid stacking mechanism integrates both advantages, producing balanced predictive performance suitable for real-world sentiment monitoring applications.

3.8 Hybrid NLP Prediction Behavior

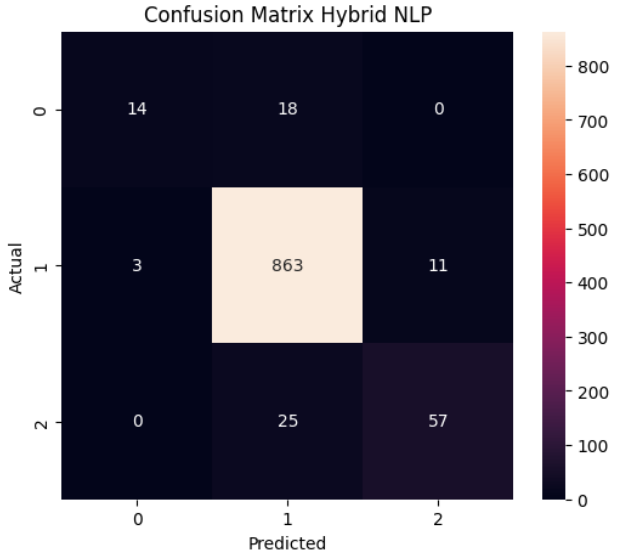

Figure 3. Confusion Matrix Hybrid NLP

The confusion matrix visualization shows that the hybrid NLP model achieves overall accuracy exceeding 94%. Prediction errors mainly occur between neutral and positive sentiment categories due to subtle linguistic ambiguity commonly found in social media communication. Importantly, extreme polarity misclassification remains minimal, demonstrating reliable sentiment discrimination capability.

Hybrid stacking effectively combines probabilistic predictions from Random Forest and BiLSTM architectures. This integration enhances robustness by compensating for weaknesses present in individual models. As a result, the hybrid approach produces more stable prediction outcomes when applied to noisy and informal textual environments.

3.9 Multi-Aspect Sentiment Interpretation

Aspect-level evaluation demonstrates that sentiment tendencies vary depending on policy dimensions discussed within social media conversations. Taxation-related discussions exhibit clearer sentiment polarity, while APBN discussions present higher interpretative complexity due to technical terminology usage. Despite variation in accuracy across aspects, neutral sentiment remains dominant across all policy categories.

This finding suggests that Indonesian digital discourse surrounding fiscal governance is characterized by analytical engagement rather than emotional polarization. Users appear capable of evaluating policy outcomes critically while maintaining informational neutrality. The hybrid NLP framework successfully captures this multidimensional evaluation structure, providing deeper insight into public perception dynamics beyond generalized sentiment measurement.

4. CONCLUSION

This study aimed to optimize a hybrid Natural Language Processing (NLP) model for conducting multi-aspect sentiment analysis toward public opinions related to the Minister of Finance of the Republic of Indonesia on social media platforms. The research demonstrates that public sentiment regarding fiscal governance cannot be adequately interpreted using conventional single-polarity sentiment classification. By incorporating aspect-based sentiment analysis, the proposed framework successfully identified variations in public evaluation across multiple policy dimensions, enabling a more comprehensive understanding of digital public opinion structures. The findings indicate that discussions surrounding economic governance tend to exhibit analytical and informational characteristics, reflected by the dominance of neutral sentiment across policy aspects.

Furthermore, the implementation of hybrid NLP architecture combining machine learning and deep learning approaches contributes to improved prediction robustness in handling informal Indonesian social media texts. Optimization strategies, including preprocessing refinement, class imbalance handling, and hyperparameter tuning, play a critical role in enhancing model stability and generalization capability. The research confirms that hybrid modeling provides balanced analytical performance by integrating contextual semantic understanding with statistical learning efficiency. Consequently, the proposed approach offers a reliable computational framework for analyzing complex and multidimensional sentiment patterns in governance-related discussions.

From a broader perspective, this study highlights the importance of integrating artificial intelligence techniques into public policy evaluation processes. Multi-aspect sentiment analysis enables more nuanced interpretation of societal responses, supporting evidence-based decision-making and improving institutional responsiveness within digital communication environments. The developed framework demonstrates potential applicability for continuous monitoring of public perception toward government policies in real-time digital ecosystems.

Despite these contributions, several limitations remain. Social media data may not fully represent the entire population due to differences in digital participation levels across demographic groups. In addition, implicit linguistic expressions such as sarcasm and contextual ambiguity continue to pose challenges for automated sentiment classification systems. Future research may extend this work by incorporating transformer-based language models, temporal sentiment tracking, or multimodal data integration to capture evolving public opinion dynamics more accurately. Expanding analysis across multiple social media platforms and policy domains also represents an important direction for ongoing research development.

REFERENCES

Chen, Z., & Xie, L. (2023). Aspect-based sentiment analysis using deep contextualized language models: A survey. Information Processing & Management, 60(2), 103234. https://doi.org/10.1016/j.ipm.2022.103234

Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional

transformers for language understanding. Proceedings of NAACL-HLT, 4171–4186.

Khan, A., Baharudin, B., Lee, L. H., & Khan, K. (2022). A review of machine learning and deep learning approaches for sentiment analysis. Applied Sciences, 12(11), 5536. https://doi.org/10.3390/app12115536

Li, Y., Sun, A., Han, J., & Li, C. (2023). Hybrid deep learning approaches for sentiment classification in social media text. Expert Systems with Applications, 213, 118846. https://doi.org/10.1016/j.eswa.2022.118846

Liu, B. (2020). Sentiment analysis: Mining opinions, sentiments, and emotions. Cambridge University Press.

Medhat, W., Hassan, A., & Korashy, H. (2014). Sentiment analysis algorithms and applications: A survey. Ain Shams Engineering Journal, 5(4), 1093–1113.

Pennington, J., Socher, R., & Manning, C. (2014). GloVe: Global vectors for word representation. Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing, 1532–1543.

Wang, S., Liu, Y., & Chen, X. (2022). Multi-aspect sentiment analysis using attention-based neural networks. Knowledge-Based Systems, 235, 107661. https://doi.org/10.1016/j.knosys.2021.107661

Yang, Z., Dai, Z., Yang, Y., Carbonell, J., Salakhutdinov, R., & Le, Q. V. (2024). Optimization strategies in deep learning-based sentiment classification. IEEE Access, 12, 21455–21468.

Zhang, L., Wang, S., & Liu, B. (2022). Deep learning for sentiment analysis: A survey. WIREs Data Mining and Knowledge Discovery, 12(2), e1448. https://doi.org/10.1002/widm.1448