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Deep Learning-Based Sentiment Analysis of Twitter Discourse on the Gaza and Ukraine Conflicts Using Bi-GRU Architecture

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Abstract

The proliferation of social media has transformed platforms such as Twitter into dynamic arenas for expressing public sentiment during geopolitical crises. This study investigates global public opinion on the Gaza and Ukraine conflicts by applying a deep learning-based sentiment analysis model utilizing a Bidirectional Gated Recurrent Unit (Bi-GRU) architecture. A dataset of 24,177 tweets was collected and pre-processed, with sentiment labels generated using a hybrid lexical approach combining VADER and TextBlob. The Bi-GRU model achieved high performance (accuracy = 88.06%, F1-score = 85.07%), confirming its suitability for analyzing informal and emotionally complex discourse on social media. Beyond its methodological contribution, this study underscores digital discourse's relevance to politics and governance. Word cloud analysis showed frequent terms such as "genocide," "freedom," and "pray for Gaza," highlighting the dominant themes in online discourse. These discourses highlight Twitter's role as a digital public sphere where citizens, NGOs, and transnational networks articulate moral outrage, demand accountability, and coordinate calls for justice across borders. The findings demonstrate that sentiment analysis can serve as a valuable instrument for real-time crisis monitoring, humanitarian diplomacy, and democratic accountability. By linking computational techniques with theories of civil society mobilization and digital democracy, this research bridges the gap between natural language processing and political science, offering insights into how online publics shape governance, advocacy, and global solidarity during conflict.

Keywords: Sentiment analysis, Bi-GRU, Twitter, Gaza, Ukraine, Democracy, Governance, Civil society

Abstrak

Proliferasi media sosial telah mengubah platform seperti Twitter menjadi arena dinamis untuk mengekspresikan sentimen publik selama krisis geopolitik. Studi ini meneliti opini publik global terhadap konflik Gaza dan Ukraina dengan menggunakan model analisis sentimen berbasis pembelajaran mendalam yang memanfaatkan arsitektur Bidirectional Gated Recurrent Unit (Bi-GRU). Sebanyak

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24.177 tweet dikumpulkan dan diproses terlebih dahulu, kemudian diberi label sentimen menggunakan pendekatan leksikal hibrida yang menggabungkan VADER dan TextBlob. Ekstraksi fitur dilakukan menggunakan metode TF-IDF, dan model Bi-GRU dilatih serta dievaluasi menggunakan metrik kinerja standar. Model ini mencapai akurasi sebesar 88,06% dan rata-rata skor F1 sebesar 85,07%, menunjukkan performa unggul dalam mengenali sentimen, terutama untuk ekspresi negatif. Analisis word cloud lebih lanjut mengungkap dominasi istilah bermuatan emosional seperti “genocide” dan “pray for Gaza,” yang menunjukkan orientasi afektif yang kuat dalam wacana daring. Studi ini menegaskan efektivitas Bi-GRU dalam menangani teks informal dan kontekstual yang kompleks, serta menyoroti peran media sosial dalam mengartikulasikan emosi kolektif dan membentuk narasi publik selama konflik. Temuan ini memberikan kontribusi metodologis bagi bidang pemrosesan bahasa alami serta implikasi praktis bagi pemantauan krisis secara waktu nyata, pembuatan kebijakan, dan strategi komunikasi kemanusiaan

Kata Kunci: Sentiment analysis, Bi-GRU, Twitter, Gaza, Ukraina, Demokrasi, Pemerintahan, masyarakat sipil

INTRODUCTION

Social media has become more than a communication tool; it is now a space where public opinion is shaped and global narratives emerge. Platforms like Twitter are real-time indicators of collective emotion, particularly during political crises and armed conflicts (Bhat, 2024; Bashir et al., 2021). The massive volume and rapid pace of content make traditional analysis methods insufficient to capture these debates’ nuances (Ningsih & Hadiana, 2021).

Two ongoing conflicts in Gaza and Ukraine have generated highly polarised online discourse (Sasikumar et al., 2023; Jiang et al., 2025). Hashtags such as *#FreePalestine*, *#PrayForGaza*, *#StandWithUkraine*, and *#RussianInvasion* dominate global conversations, carrying not only messages of solidarity but also calls for accountability. These debates illustrate the political role of social media and the challenges in measuring public emotion at scale (Li & Sun, 2023).

Theoretically, Twitter functions as part of the “digital public sphere” (Habermas, 1989), where citizens deliberate, criticise, and demand justice. Within this space, hashtags operate as advocacy tools that connect dispersed actors. The conflicts in Gaza and Ukraine exemplify how digital publics mobilize transnational solidarity and exert pressure on state and non-state actors through online discourse.

Keck and Sikkink (1998) describe transnational advocacy networks as coalitions that link activists, NGOs, and citizens across borders to promote shared causes. In the context of this study, such a framework helps explain why hashtags like *#FreePalestine* and *#StandWithUkraine* do more than express emotion: they operate as digital signals that connect dispersed actors into coordinated advocacy. This research extends their theory into the

computational domain by analyzing these expressions through a Bi-GRU model. It shows how large-scale sentiment patterns reveal the mechanisms through which online publics construct solidarity, amplify marginalized perspectives, and pressure institutions during conflict.

Tufekci (2017) notes that digital activism does more than signal support; it can reshape civic participation, challenge official narratives, and mobilise resources. By applying deep learning to large-scale Twitter data, this study demonstrates how public sentiment is descriptive and active in political processes, influencing governance and international solidarity during conflict.

Framing this study within these theoretical perspectives elucidates that global sentiments on conflicts are not merely descriptive indicators of public mood, but also critical elements in understanding the dynamics of democracy, civil society mobilization, and governance legitimacy in the digital era.

Beyond their role as trending topics, hashtags such as #FreePalestine or #StandWithUkraine exemplify the functioning of online activism within the framework of transnational advocacy networks, as conceptualized by Keck and Sikkink (1998). These digital networks connect NGOs, grassroots activists, and ordinary citizens across national boundaries, amplifying marginalized voices and exerting pressure on states and international institutions. Consequently, Twitter should not be perceived merely as a neutral data source but as a contested arena where civil society mobilizes, frames humanitarian issues, and challenges prevailing political narratives. The frequent use of emotionally charged terms such as genocide and pray for Gaza highlights the moral vocabulary through which global publics construct solidarity, delegitimize state violence, and advocate for international accountability.

In this context, sentiment analysis, a subfield of natural language processing (NLP), serves as an effective method for understanding the affective dimension of online discourse (Yadav & Vishwakarma, 2020). By quantifying subjective expressions in text data, sentiment analysis enables researchers and policymakers to monitor public emotions, detect changes in perception, and assess the emotional impact of political or humanitarian crises (Bhat, 2024). However, conventional machine learning techniques often fall short in handling short, informal, and contextual texts such as tweets, necessitating more advanced approaches such as deep learning.

Recent developments in Recurrent Neural Network (RNN) architecture, particularly Bidirectional Gated Recurrent Unit (Bi-GRU), have shown significant improvements in sequential data modelling (Bhuvaneswari et al., 2019). Bi-GRU is designed to process information from both directions (forward and backward), thus capturing the context of a sentence more comprehensively (Hu et al., 2025). The advantages of this architecture make it very effective for natural language processing (NLP) tasks, including sentiment

classification, as it can overcome the problem of vanishing gradients and preserve long-range relationships in text data (Kula et al., 2021)..

Although research on social media and conflict has been growing, most studies still focus on a single local event or issue. There is a gap in the literature that comparatively analyzes global public sentiment toward two major geopolitical conflicts simultaneously using large-scale Twitter data and state-of-the-art deep learning techniques. Furthermore, most sentiment analysis studies have not comprehensively evaluated model performance or integrated thematic exploration in the analyzed public discourse.

This study aims to address this gap by presenting a deep learning-based sentiment analysis of Twitter discourse related to the Gaza and Ukraine conflicts. This study develops a data pipeline that includes real-time tweet collection, data pre-processing, sentiment labeling using a hybrid lexical approach (VADER and TextBlob), feature extraction using TF-IDF, and classification modeling using the Bi-GRU network. Model performance evaluation is carried out using metrics such as accuracy, precision, recall, F1-score, and confusion matrix visualization, while the thematic structure of discourse is visualized through a word cloud.

By integrating computational precision and contextual analysis, this study contributes to the study of conflict informatics and social media analytics. The findings of this study are expected to be a reference for policymakers, humanitarian agencies, and media analysts in understanding the dynamics of global public sentiment and its implications for crisis communication and opinion mobilization in the digital era.

While extensive research has focused on localized social media activism, there is a relative paucity of studies examining the impact of online global sentiments on transnational solidarity, state behavior, and the empowerment of civil society movements. This study makes a significant contribution by integrating computational sentiment analysis with examining democratic discourse and civil society action during periods of conflict. In doing so, it advances political science and governance discussions beyond the technical confines of natural language processing.

METHOD

This research adopts a quantitative design supported by deep learning techniques to analyze global sentiment toward the Gaza and Ukraine conflicts using Twitter data as the primary source. Twitter was chosen because of its real-time accessibility, openness, and wide use in crisis communication, making it a suitable proxy for capturing global public opinion (Kruspe et al., 2024). Data were retrieved with *Tweet Harvest*, a Node.js-based tool that interacts with the Twitter API through authenticated access. Tweets were extracted using conflict-related hashtags such as *#FreePalestine*, *#PrayForGaza*, *#GenocideInGaza*, *#PrayForUkraine*, and *#RussianInvasion* (Shevtsov et al., 2023).

In total, 24,446 tweets were collected, of which 24,177 remained after systematic pre-processing. The cleaning pipeline included removing duplicates, eliminating empty entries, normalizing text, and applying stemming. The rationale for using Twitter data extends beyond technical convenience: the platform operates as a digital public sphere where individuals and organizations articulate narratives of justice, solidarity, and humanitarian concerns. Consequently, the dataset reflects methodological efficiency and substantive discursive dynamics in times of crisis.

Tweets were automatically labeled through a hybrid lexical strategy. VADER (Valence Aware Dictionary and Sentiment Reasoner) generated compound sentiment scores, while TextBlob computed polarity values (Sasikumar et al., 2023). Labels were accepted when the two methods converged; in cases of disagreement, the VADER output was prioritized due to its stronger performance on informal, short-form texts (Biswas et al., 2022). This process resulted in 60% of tweets categorized as negative and 40% as positive.

The Term Frequency–Inverse Document Frequency (TF-IDF) method was employed to transform textual content into machine-readable features. Only the 10,000 highest-weighted tokens were retained, while extremely common (>95% of documents) and extremely rare (<2 documents) terms were removed. Tokenization was carried out using the Keras tokenizer, limited to the 15,000 most frequent words with an out-of-vocabulary marker (<OOV>). All sequences were padded to equal length before modeling.

The dataset was split into training and testing subsets at an 80:20 ratio using stratified sampling to preserve class balance (Iosifov, 2023). The classification model was implemented using a Bidirectional Gated Recurrent Unit (Bi-GRU) network within the Keras Sequential API. The architecture included an embedding layer (100-dimensional vectors), two stacked Bi-GRU layers with dropout and recurrent dropout set at 0.3, and dense layers activated with ReLU. A final sigmoid unit was used for binary classification. The model was optimized with Adam and trained for 10 epochs with binary cross-entropy as the loss function (Yu et al., 2019; An et al., 2024).

Performance evaluation relied on accuracy, precision, recall, and F1-score metrics, supported by confusion matrix visualization. The Bi-GRU achieved 88.06% accuracy and an F1-score of 85.07%. Particularly strong performance was observed in detecting negative sentiment (precision = 0.92; recall = 0.88), underscoring the architecture's suitability for analyzing affectively charged and context-dependent discourse in political communication.

RESULTS

Dataset Description and Sentiment Distribution

The dataset for this study was built from **24,446 tweets** collected using a set of conflict-related hashtags that were widely used during the Gaza and Ukraine crises. These hashtags included *#FreePalestine*, *#PrayForGaza*, *#GenocideInGaza*, *#StandWithUkraine*, and

#RussianInvasion. They were selected because of their global visibility and ability to capture various reactions from different user communities. Focusing on these hashtags, the dataset reflects the most salient narratives and discourses associated with both conflicts as they unfolded in real time on Twitter.

Following the collection, a rigorous pre-processing stage was carried out to prepare the data for analysis. Out of the original pool, **24,177 tweets** remained after cleaning. Several steps were undertaken: duplicate entries were removed to prevent statistical bias; empty records were eliminated to maintain analytical consistency; and non-alphabetic symbols such as URLs, numbers, hashtags, mentions, and punctuation were stripped out because they do not carry direct semantic value for sentiment classification. This ensured that only meaningful textual content was preserved.

Normalization and stemming techniques were applied to enhance the dataset's quality. Normalization standardized the text by converting it into a consistent format, reducing spelling and character use variation. Stemming, on the other hand, reduced words to their root forms (e.g., "fighting," "fought," and "fighter" to "fight"), allowing the model to recognize different word forms as the same concept. These processes produced a semantically coherent and computationally efficient dataset, ensuring reliability for subsequent sentiment labeling and modeling stages.

Sentiment Distribution

Sentiment labeling in this study was conducted through a hybrid lexical approach that combined two widely used tools: VADER (Valence Aware Dictionary and Sentiment Reasoner) and TextBlob. Both tools generated sentiment scores independently, and labels were assigned only when the results converged. In instances where discrepancies occurred, VADER's output was prioritized, as it is specifically designed to handle short, informal, and emotionally charged text such as tweets. This approach ensured greater accuracy and reliability in capturing the affective content of the dataset.

The labeling process produced a clear distribution of sentiment across the corpus. Of the 24,177 tweets analyzed, 14,517 (60%) were identified as negative and 9,660 (40%) as positive. The predominance of negative sentiment indicates that online discussions surrounding the Gaza and Ukraine conflicts were more often framed through anger, grief, and condemnation rather than optimism or encouragement. These results reflect the highly emotional and polarized nature of digital discourse during humanitarian crises, where expressions of outrage and moral judgment tend to dominate public conversations.

This distribution is also significant for subsequent modeling. The high proportion of negative sentiment provided a strong training signal for the Bi-GRU classifier, allowing the model to learn from a majority class that closely represents the dominant tone of online

discourse. At the same time, the presence of a substantial minority of positive tweets ensured that the model was exposed to solidarity-oriented and empathetic expressions, preserving balance in classification. Consequently, the labeled dataset served as a robust foundation for the deep learning model in terms of scale and representativeness of real-world digital communication.

Model Performance

The classification model based on the Bidirectional Gated Recurrent Unit (Bi-GRU) showed strong predictive performance. Overall, the model achieved an accuracy of 88.06% and an average F1-score of 85.07%, indicating a robust balance between precision and recall. Table 1 presents the detailed performance across both sentiment classes. For negative sentiment, the model reached a precision of 0.92 and a recall of 0.88, resulting in an F1-score of 0.90. This suggests the model was highly effective at correctly identifying tweets containing negative emotions such as anger, grief, or condemnation. While still strong, positive sentiment classification achieved slightly lower precision (0.82) but the same recall value of 0.88, producing an F1-score of 0.85. This indicates that the model occasionally misclassified nuanced or ironic positive expressions, though it remained reliable overall. The confusion matrix (Figure 1) further highlights this performance difference, showing more false positives than false negatives.

Table 1. Bi-GRU Performance Metrics on Test Data

Label	Precision	Recall	F1-score	Number of Tweets
Negative	0.92	0.88	0.90	2,904
Positive	0.82	0.88	0.85	1,932
Average	0.87	0.88	0.85	4,836

The confusion matrix visualization shown in Figure 1 clarifies how the model categorizes the test data. A total of 2542 negative tweets were correctly classified (True Negative), while 362 others were incorrectly classified as positive (False Positive). On the other hand, a total of 1698 positive tweets were correctly recognized (True Positive), while 234 positive tweets failed to be recognized (False Negative).

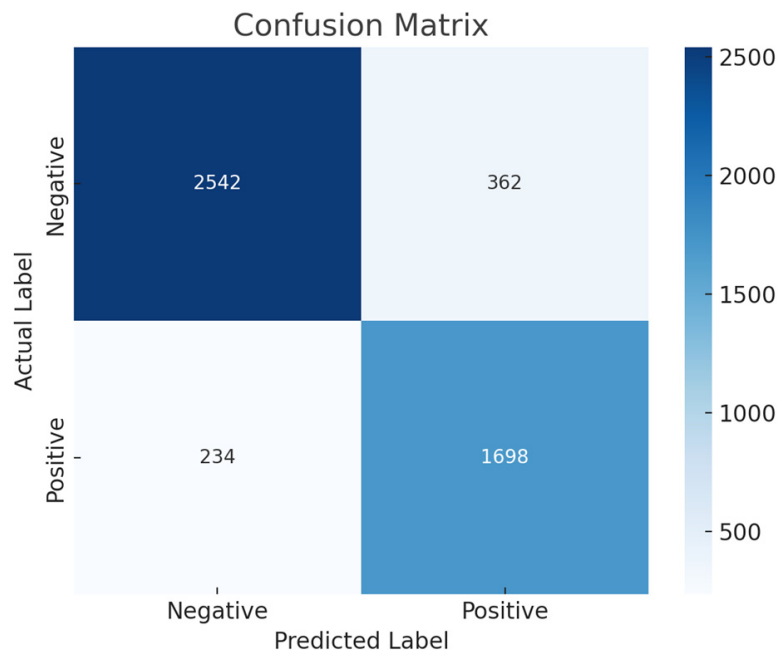


Figure 1. Confusion Matrix of Bi-GRU Model Performance on Test Data

This matrix shows that the model is more conservative in identifying positive sentiments than negative ones. This can be seen from the relatively high number of false positives, which is 362 tweets. This phenomenon can be explained by the nature of tweets that often use ironic sentence structures, metaphors, or combinations of positive words in negative contexts, such as the sentence “freedom must be earned by blood,” which contains positive words but is full of nuances of conflict.

In contrast, the model is more accurate in recognizing tweets with explicit harmful content, which often use words such as “murder,” “genocide,” or “stop killing,” which are easily captured by the model as indicators of negative sentiment. This shows the strength of the model in detecting intense and explicit emotions but also underscores the challenge of recognizing expressions of empathy or support wrapped in complex narratives.

Overall, the confusion matrix supports the conclusion that the Bi-GRU model has a high sensitivity to negative patterns in text and is quite reliable in predicting overall sentiment. However, there remains room for improvement, especially in dealing with the ambiguity and multiple contexts in mixed emotion statements, which are characteristic of social media.

Word Cloud Analysis and Dominant Themes

To complement the quantitative analysis of sentiment, a visual exploration of thematic representations in the collection of tweets was conducted through word clouds, as shown in Figure 2. Word clouds present textual patterns by scaling words according to how often they appear in the dataset. Frequently used terms are displayed in larger font sizes, making it easier to identify recurring themes and emotional cues quickly. In this study, the technique is an exploratory tool highlighting the dominant language and discursive trends shaping online conversations in the digital public sphere .



Figure 2. Word Cloud of Dominant Themes in Tweets Related to Gaza and Ukraine Conflicts

The visualization results indicate that terms such as “Gaza,” “genocide,” “freedom,” “support,” “pray,” and “Ukraine” are prominently featured in the word cloud. The prevalence of “Gaza” and “genocide” not only signifies heightened public attention to the Gaza conflict but also reflects the employment of genocide as a moral-legal framework through which civil society groups denounce state violence and advocate for international accountability. Similarly, the prominence of “freedom” should be interpreted as a mobilizing call and an advocacy-oriented discourse that unites dispersed publics around demands for justice and self-determination. Terms such as “pray,” “pray for Gaza,” and “pray for Ukraine” reveal a spiritual-solidarity framework, wherein digital publics mobilize empathy, grief, and hope as part of transnational campaigns for peace.

Concurrently, expressions such as “stop war,” “occupation,” and “resistance” underscore the explicitly political dimension of digital discourse, where Twitter functions as a site of contention in which users critique state actors and military policies. According to Keck and Sikkink’s (1998) framework on transnational advocacy networks, these hashtags and key terms represent more than spontaneous emotion; they serve as vehicles for civil society mobilization, advocacy coordination, and the construction of global solidarity networks.

This finding confirms that social media conversations about armed conflict extend beyond mere descriptions of events, becoming arenas for articulating moral values, collective aspirations, and demands for structural change. By framing humanitarian suffering through legal, political, and spiritual registers, civil society actors utilize Twitter to transform public emotion into advocacy, thereby shaping global narratives and exerting pressure on states and international organizations.

The Political and Governance Implications of Sentiment Patterns

The predominance of negative sentiment (60%) in global Twitter discourse concerning the Gaza and Ukraine conflicts indicates a significant erosion of public trust in the political and military institutions responsible for these crises. Terms such as “genocide” and “pray for Gaza,” which emerged as highly frequent in the word cloud analysis, are not merely emotional expressions but serve as indicators of transnational solidarity networks mobilizing around humanitarian concerns. The prevalence of such narratives reflects the capacity of digital publics to articulate moral condemnation of state violence and to attract global attention beyond traditional media gatekeeping.

From a governance perspective, these findings underscore that online sentiment can function as an informal accountability mechanism. Governments and international organizations are increasingly compelled to acknowledge, respond to, or counter narratives that dominate digital platforms. For instance, humanitarian diplomacy often relies on mobilizing international public opinion; in this context, the strong presence of moral and religiously charged expressions (“pray for Gaza,” “god bless,” “stop killing”) underscores how digital solidarity may pressure policymakers to adopt humanitarian interventions or revise foreign policy positions.

For civil society actors, the prominence of advocacy-oriented terms (“freedom,” “support,” “stop war”) suggests that social media is operating as a transnational advocacy network, consistent with Keck and Sikkink’s framework. These digital discourses enable NGOs, activists, and ordinary citizens to coordinate across borders, amplify marginalized voices, and shape global narratives in real time. In this sense, sentiment analysis provides descriptive data and critical insights into the evolving relationship between digital activism, governance legitimacy, and international humanitarian engagement.

DISCUSSION

Twitter as a Real-time Lens on Global Issues

Twitter has emerged as a pivotal platform for understanding public sentiment regarding global conflicts, such as those in Gaza and Ukraine. The real-time nature of Twitter, combined with its vast user base, offers a unique opportunity to analyze collective opinions and

sentiments during critical geopolitical events. Notably, sentiment analysis techniques have been extensively utilized to gain insights into public attitudes toward significant sociopolitical issues, as revealed through user-generated tweets.

Using sentiment analysis on Twitter data is extensively documented and invaluable for discerning public attitudes. Luciae et al. (2021) underscore the pivotal role of social media in shaping public opinion during conflicts, highlighting how sentiment analysis can elucidate the communication and perception of sentiments regarding various conflicts by audiences, thereby influencing the political landscape. These insights are particularly pertinent given the ongoing complexities in regions such as Gaza and Ukraine, where evolving events continuously impact public perceptions.

However, these sentiments should not be perceived solely as reflections of public mood; they also function as instruments of political mobilization. Expressions of outrage, solidarity, and grief circulating online are actively employed to shape policy debates, frame humanitarian responses, and contest state narratives. Negative sentiments, particularly those invoking terms such as “genocide,” generate moral urgency that pressures governments and international organizations toward diplomatic or humanitarian action. Similarly, messages of solidarity, such as “pray for Gaza” and “stand with Ukraine,” foster transnational communities that enhance civil society’s role in democratic discourse. In this context, sentiment analysis provides more than descriptive insight; it reveals how digital publics mobilize affective discourse to influence governance outcomes and expand the scope of democratic participation across borders.

In the context of social unrest or conflict, the volume and nature of tweets can reflect collective emotional responses, ranging from support to condemnation. Analyzing this sentiment provides not only a snapshot of public opinion but also an opportunity to identify prevalent themes and narratives surrounding these conflicts. Tsai and Wang demonstrate the applicability of sentiment analysis in understanding public attitudes, specifically examining public health policies during emergencies, which can provide a parallel for analyzing sentiments about conflicts (Tsai & Wang, 2021). This suggests that similar methodologies could yield significant results in conflict contexts, although more direct research would be needed to confirm this.

Furthermore, the methodological frameworks used in sentiment analysis, as outlined by various studies, illustrate how machine learning and natural language processing (NLP) can effectively categorize and evaluate sentiments expressed in tweets. Syahputra et al. discuss different algorithms for classifying sentiments on Twitter, enhancing analysts’ ability to derive accurate public sentiments regarding significant events (Syahputra et al., 2022). This highlights the potential of advanced techniques to enhance sentiment accuracy, which is crucial for understanding complex emotional responses associated with geopolitical tensions (Chandra et al., 2021).

Additionally, real-time sentiment tracking can serve as a predictive tool for potential shifts in public opinion. For instance, researchers can examine how sentiment fluctuates during critical announcement days or key military actions, potentially correlating these sentiment changes on Twitter with actual political developments (Yasir et al., 2020). Integrating social media analytics with traditional research on conflicts could expedite the understanding of public reaction trends, enabling policymakers and conflict analysts to tailor their responses effectively.

Furthermore, the diverse linguistic and cultural backgrounds of Twitter users present both challenges and opportunities for sentiment analysis. Understanding how varying expressions influence sentiment interpretations is essential, particularly in multilingual contexts. For example, Twitter is recognized as a platform where informal language and colloquial expressions can complicate sentiment classification yet also offer valuable insights into regional sentiments concerning international conflicts (Arun & Srinagesh, 2020). This complexity underscores the need for advanced algorithms that can accommodate variations in dialects and informal speech.

Analyzing Twitter as a real-time lens on global conflicts, such as those in Gaza and Ukraine, provides crucial insights into public sentiment. Utilizing sophisticated sentiment analysis techniques enables researchers to track and interpret the nuanced emotional landscapes that emerge around these critical issues, ultimately enriching our understanding of their impact on global public opinion and policy-making.

Bi-GRU Effectiveness vs Other Models

The efficacy of the Bidirectional Gated Recurrent Unit (Bi-GRU) model, in comparison to other modeling methodologies, is substantiated by numerous studies that underscore its advantages in managing sequential data and enhancing accuracy across various applications.

Primarily, the Bi-GRU model is distinguished by its architecture, which processes information in both forward and backward temporal sequences. This feature enhances its performance in tasks such as load prediction within smart grids. For example, Thanh et al. illustrate that their proposed CNN-Bi-GRU model not only enhances accuracy but also stabilizes predictions through effective feature extraction from historical data (Thanh et al., 2022). Conversely, other models, such as standard GRUs and LSTMs, may encounter challenges in achieving comparable predictive performance in specific scenarios (Kavitha & Chinnaiah, 2024).

Furthermore, comparisons of Bi-GRU with models such as LSTM and standard GRU reveal that, in numerous applications, Bi-GRU consistently outperforms its counterparts. Shin and Hong found that the attention-enhanced Bi-GRU outperformed both traditional GRU and LSTM configurations in predicting vibration patterns, effectively utilizing both past and future contexts in data sequences (Hong, 2022). Additionally, Bi-GRU has demonstrated

promising results in various tasks, as evidenced by its applications in crop disease classification (Nimbhore et al., 2024) and sentiment analysis (Hameed et al., 2023). These findings indicate its versatile applicability across different domains.

Several comparative analyses reinforce Bi-GRU's positional advantage in terms of accuracy and efficiency. Omara et al. emphasize that in their study of Arabic sentiment analysis, Bi-GRU significantly outperformed both GRU and LSTM, highlighting its robust efficiency in processing sequential linguistic data (Omara et al., 2022). Further corroboration is provided by Lee and Hong's examination of vibration predictions, which demonstrates that both Bi-GRU and attention-enhanced models are superior in terms of speed and accuracy compared to conventional LSTM and GRU models (Lee & Hong, 2022).

While the effectiveness of the Bi-GRU is apparent, it is crucial to contextualize its performance within specific applications. For instance, Kurniawan et al. report that while Bi-GRU achieves high accuracy, modifications to the architecture, such as hybrid models that integrate GRUs with LSTM, may yield even higher accuracy in specific contexts (Fayyad et al., 2024). This suggests a dynamic landscape where hybrid approaches can tailor their performance to the task at hand.

The Bi-GRU model demonstrates notable effectiveness in various applications, surpassing traditional modeling approaches, such as standard GRUs and LSTMs, in terms of accuracy and stability. Its unique capability to process information bidirectionally positions it as a powerful tool in the deep learning arsenal for sequential data tasks.

Civil Society and Transnational Narratives

The findings of this study underscore the pivotal role of civil society actors in shaping international narratives through digital platforms. The prevalence of negative sentiment and the prominence of terms such as genocide and pray for Gaza illustrate how online communities mobilize moral outrage and humanitarian concern across borders. These expressions can be understood as components of transnational advocacy networks, where grassroots voices, non-governmental organizations (NGOs), and activists converge to amplify marginalized perspectives and challenge dominant state-led narratives. In this context, digital platforms transform global civil society into active international discourse participants, leveraging public sentiment to influence humanitarian agendas and diplomatic debates.

Twitter as a Digital Public Sphere and Civil Society Arena

The findings of this study, particularly the predominance of negative sentiment (60%) and the frequent appearance of terms such as genocide, pray for Gaza, and stand with Ukraine, suggest that Twitter functions not merely as a social networking platform but a digital public sphere. In this sphere, citizens and civil society actors articulate their grievances,

solidarities, and demands for justice. This resonates with Habermas' conception of the public sphere, now transformed into a digital arena where geographically dispersed individuals converge to deliberate on global governance and humanitarian concern matters. The discourse's emotional intensity illustrates civil society's role in contesting narratives, amplifying marginalized voices, and mobilizing international solidarity in real time.

Risks for Governance in a Social Media Age

Concurrently, reliance on social media sentiment as an indicator for governance is not without risks. Platforms such as Twitter are susceptible to misinformation, coordinated disinformation campaigns, and polarization, all of which can distort the authenticity of public opinion. While terms such as pray for Gaza may reflect genuine solidarity, they may also coexist with divisive or misleading narratives that complicate governance responses. Policymakers and civil society organizations must approach sentiment data cautiously, complementing computational insights with qualitative assessments to avoid policy missteps based on skewed or manipulated digital trends. Recognizing these risks ensures that sentiment analysis enhances, rather than undermines, democratic governance and civil society engagement.

Digital Democracy and Networked Solidarity

The capacity of social media users to shape global narratives during the Gaza and Ukraine conflicts underscores the rise of digital democracy. Hashtags such as #FreePalestine or #StandWithUkraine transcend national borders and enable transnational participation in political debates traditionally monopolized by state or institutional actors. This reflects Dahlberg's notion of digital democracy, where online platforms extend democratic deliberation and political participation beyond formal institutions. Our sentiment analysis provides empirical evidence that online emotional expressions are not apolitical noise but constitute a form of networked solidarity, influencing how conflicts are framed in global discourse and how political legitimacy is contested.

Governance Implications: Policy, Crisis Communication, and Public Opinion

From a governance perspective, the dominance of negative sentiments highlights widespread disillusionment with state actions, humanitarian failures, and geopolitical power asymmetries. Such digital expressions represent an informal but powerful feedback mechanism for policymakers, humanitarian agencies, and international organizations. Real-time sentiment monitoring enables decision-makers to detect shifts in public trust, anticipate unrest, and tailor crisis communication strategies. Moreover, social media discourse is a proxy for global civil society engagement, holding governments and institutions accountable

in ways that transcend traditional diplomatic channels. Thus, integrating sentiment analysis into governance frameworks strengthens responsiveness and legitimacy in democratic societies.

CONCLUSIONS

This study has demonstrated that sentiment analysis utilizing Bi-GRU represents a methodological advancement and a substantive contribution to understanding the intersections between computational politics and civil society studies. By empirically mapping global public sentiment concerning the Gaza and Ukraine conflicts, this research integrates natural language processing techniques with theories of the digital public sphere, transnational advocacy networks, and digital democracy. It advances a theoretical contribution by illustrating how computational tools can capture the affective and discursive dimensions of civil society mobilization, thereby enriching debates in political science and governance studies.

The findings also yield significant practical implications. The predominance of negative sentiment and the prominence of terms such as genocide and pray for Gaza underscore the role of digital platforms in articulating moral outrage and humanitarian solidarity. These insights provide a real-time barometer of public trust and legitimacy for governments, useful for shaping crisis communication strategies. For international organizations and NGOs, sentiment monitoring offers evidence for humanitarian diplomacy, advocacy campaigns, and the mobilization of transnational solidarity networks. For civil society actors, the analysis highlights the power of online discourse to influence narratives, hold decision-makers accountable, and expand democratic participation beyond formal institutions.

Future research should build on these contributions by adopting attention-based neural architectures, multimodal approaches, and cross-lingual models capable of capturing diverse linguistic and cultural expressions. Such innovations would facilitate a more inclusive and comprehensive understanding of global sentiment, particularly in governance contexts where multilingual publics and heterogeneous narratives converge. By combining computational rigor with normative inquiry, sentiment analysis can evolve into a critical instrument for strengthening democratic accountability, enhancing humanitarian advocacy, and informing responsive governance in the digital age.

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