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Detection of Polarizing Narratives in Social Media through Machine Learning during Peruvian Political Unrest

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ABSTRACT

This study analyzes the polarization of narratives on social media during the protests that occurred in Puno, Peru, in 2023, using advanced natural language processing (NLP) and machine learning techniques. 1,378 comments from Facebook and 1,400 from YouTube were collected and preprocessed, applying cleaning, normalization, and stop word removal procedures in Spanish. For sentiment analysis, the VADER model was used, classifying opinions into positive and negative, with an overwhelming predominance of negative comments (96.2%). Additionally, the Latent Dirichlet Allocation (LDA) algorithm was implemented to identify five key narratives: popular power, support for Pedro Castillo, the demand for Dina Baluarte's resignation, references to symbolic figures, and demands for justice for deaths during the protests. These results show significant sociopolitical polarization on digital platforms, reflecting latent tensions in the population. This analysis demonstrates the potential of NLP and topic modeling tools to monitor and detect polarizing discursive trends in real time, allowing for an early assessment of emerging narratives in crisis contexts. The methodological and predictive implications of the present approach suggest its applicability in future studies on sociopolitical conflicts and digital polarization dynamics.

Keywords: Polarization, Sentiment analysis, Social media, Political unrest, Topic modeling.

Introduction

Social media has become a key space for the expression and propagation of narratives during sociopolitical events, especially in contexts of crisis and conflict. During the protests that occurred in Puno, Peru, in 2023 (Incacutipa-Limachi *et al*., 2024), these digital platforms served as channels where citizens shared their opinions, emotions, and demands (Huang *et al*., 2021). However, the increasing volume of comments on social media such as Facebook and YouTube poses a significant challenge to identifying discursive trends and, in particular, the polarization that emerges around controversial topics (The New York Times, 2018). The use of natural language processing (NLP) and machine learning tools offers a unique opportunity to efficiently analyze large amounts of textual data, facilitating the detection of polarizing narratives and monitoring their evolution in real time (Processing & Mining, 2007).

Social media platforms, such as Facebook and YouTube, allow for the rapid dissemination of opinions but also facilitate the formation of extremist discourses that polarize the population (Xu *et al.*, 2022). This polarization, characterized by a marked division in opinions and the exacerbation of tensions between opposing groups, not only hinders constructive dialogue but can also fuel social conflict and violence (Longo, 2016). However, despite the evident impact of these polarizing narratives, there is limited empirical understanding of how these dynamics play out in the Peruvian digital realm (Olsher, 2015; Ayedh *et al*., 2023). Therefore, the need for a systematic analysis that allows for the identification and quantification of this polarization, as well as for understanding the underlying narratives, is fundamental to improving conflict management and predicting possible future tensions (Longo, 2016).

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Sentiment analysis and topic modeling are two key approaches that allow discourses to be broken down into more manageable components, providing a clearer view of how opinions are articulated in conflict contexts (Almeida *et al*., 2021). Polarization, understood as the convergence of opinions at opposite extremes, is a phenomenon that can exacerbate social tensions and hinder constructive dialogue. In the case of Puno, sociopolitical tensions related to the impeachment of former President Pedro Castillo and the protest against the government of Dina Boluarte created a climate of confrontation in which public expression on social media played a central role (Aydoğan *et al*., 2021; Incacutipa-Limachi *et al*., 2024).

This study aims to provide an empirical way to comprehend how these divisive discourses were expressed through the use of NLP techniques (Sosa & Zwarteveen, 2016; Mooselu *et al*., 2021). The primary issue driving this research is the dearth of rigorous studies on how social media affects the creation and spread of divisive narratives during political crises in Peru. While social media's involvement in other worldwide contexts has been extensively studied, little is still known about how these digital technologies affect the dynamics of sociopolitical disputes in the Andean region, particularly in crucial events like the Puno protests in 2023. The necessity to investigate how social media can exacerbate polarization in an environment of extreme political instability is justified by the current study.

Sentiment analysis and topic modeling techniques allow for the identification of polarization and the mapping of the main subjects that dominate online conversations. This is critical for understanding how narratives are structured, which can contribute to the radicalization of ideas. In this regard, the Latent Dirichlet Allocation (LDA) technique used in this study provides a rigorous tool to find dominating narratives, whilst sentiment analysis with VADER allows us to evaluate the emotional charge of discourses (Deng *et al*., 2022; Nurtantio *et al*., 2022). These integrated approaches provide a better understanding of discursive polarization. This study not only analyzes divisive narratives during Puno protests, but it also shows how NLP and machine learning approaches might be used in future sociopolitical crisis research. The ability of these technologies to detect and analyze developing trends in real time has important methodological implications for academic research and conflict resolution. This study aims to contribute to our understanding of the impact of social media on polarization by providing an empirical foundation for future interventions and analysis in similar circumstances.

Literature Review

Political Communication and Digital Interactivity

Polarizing narratives are often framed within the context of political communication, especially during electoral processes. Researchers highlight the role of digital interactivity in shaping and amplifying perceptions of polarization, emphasizing the complex dynamics that emerge in online environments during periods of political tension.

Mediatization and Social Actor Practices

The concept of mediatization is used to understand how digital platforms mediate the ideas and practices of social actors during crises. This approach considers how narratives are constructed, disseminated, and contested in digital spaces.

Memory and Historical Narratives

Some studies focus on how digital debates about historical events (e.g., internal armed conflict) become sites of narrative confrontation, with dominant and marginalized perspectives clashing in online forums.

Digital Platforms as Amplifiers

Social media and digital platforms are seen as amplifiers of divisive topics, contributing to the persistence and visibility of polarized narratives during crises.

Complexity and Nuance

Studies emphasize the nuanced and multifaceted nature of polarization, shaped by both media framing and user interactivity.

Role of Social Actors

The practices and strategies of various social actors (e.g., politicians, citizens, and activists) are central to the formation and spread of polarizing narratives.

Materials and Methods

The approach for this study was divided into two parts: the collecting and preprocessing of textual data from social networks, followed by the application of sentiment analysis and topic modeling tools. In the first phase, a total of 1,378 comments from Facebook and 1,400 from YouTube were collected, retrieved using the Facebook API and a custom scraper for YouTube. Posts and videos about the protests in Puno, Peru, in the first quarter of 2023 are the subject of these comments. After being saved in CSV format, the data was analyzed using Python and its specialized text processing tools, including spaCy and NLTK (Tellez *et al*., 2017; Vizcarra *et al*., 2018; Chinnasamy *et al*., 2022). Special characters were eliminated, Spanish stopwords were eliminated, text normalization (converting to lowercase and removing accents) was done, and tokenization was done.

In the second phase, sentiment analysis and topic modeling were carried out. For sentiment analysis, the VADER (Valence Aware Dictionary and sEntiment Reasoner) model was used, which classifies comments as positive, negative, or neutral. Since VADER has shown robust performance in assessing sentiment in short texts, such as comments on social media, it was the most suitable choice for this study. The model was adjusted to work with the Spanish language, translating its sentiment dictionary and adapting the scores according to the cultural context of the protests in Peru. In parallel, the Latent Dirichlet Allocation (LDA) algorithm was applied to identify key narratives within the set of comments. The LDA algorithm is a probabilistic modeling technique that allows a text corpus to be broken down into a predefined set of topics. In this study, an optimal number of five topics was selected based on thematic coherence and empirical validity. The Gensim Python library was used to implement the LDA, adjusting the hyperparameters based on the number of iterations and the probability of mixing the topics **(Table 1)**.

Table 1. Process of Method.

Process Stage	Techniques Used	Tools and Libraries
Data Collection	Facebook API and custom YouTube scraper	Facebook API, Custom scraper (Python)
Preprocessing	Text normalization, character and stopwords removal, tokenization	NLTK, spaCy, pandas
Sentiment Analysis	Classification with the VADER model	VADER (adapted for Spanish), Python
Topic Modeling	Latent Dirichlet Allocation (LDA)	Gensim, hyperparameter tuning for thematic coherence
Validation	Cross-validation and thematic coherence metrics	Cross-validation, coherence metrics (Python)

Validity

The validity of the information in this study was ensured through multiple validation techniques applied at various stages of the analysis. First, rigorous preprocessing methods were implemented to clean and normalize the data, reducing noise and ensuring the text accurately represented user input. For sentiment analysis, the VADER model was specifically adapted and tested for the Spanish language context, enhancing its relevance to the dataset. In the topic modeling process, coherence metrics were utilized to ensure that the topics identified were both meaningful and interpretable within the context of the protest narratives. Additionally, cross-validation techniques were applied to confirm the stability and consistency of the results, ensuring that the findings reflect reliable trends and not random variation. These steps collectively contribute to the credibility and reliability of the conclusions drawn from the data (Constantin *et al*., 2022; Dipalma *et al*., 2022; Mojsak *et al*., 2022; Sugimori *et al*., 2022; Kajanova & Badrov, 2024; Lee & Ferreira, 2024; Rosellini *et al*., 2024; Umarova *et al*., 2024).

The statistical analysis in this study played a critical role in validating the results obtained from both the sentiment analysis and topic modeling processes. After classifying comments using the VADER sentiment model, statistical metrics were applied to assess the distribution of sentiment scores across the dataset, ensuring robustness in the

classification of positive and negative comments (Ramachandran & Tsokos, 2021; Loftus, 2022). For the topic modeling using Latent Dirichlet Allocation (LDA), coherence scores were calculated to evaluate the quality and interpretability of the topics generated. Additionally, cross-validation techniques were employed to verify the stability of the model and to reduce the risk of overfitting, ensuring that the identified topics were representative of the overall discourse. Descriptive statistics, such as frequency distributions of topics and sentiment categories, further provided insights into the dominant narratives and emotional tones within the dataset. These statistical methods combined ensured that the analysis was both reliable and replicable, strengthening the empirical foundations of the research.

Results and Discussion

The analysis of social media narratives during the 2023 protests in Puno, Peru, reveals significant polarization in the online discourse, as demonstrated by the extensive use of sentiment analysis and topic modeling. Using 1,378 comments from Facebook and 1,400 from YouTube, a total of 2,778 pieces of user-generated content were processed to extract meaningful insights. After preprocessing, which included text normalization, stopword removal, and tokenization, the sentiment analysis showed a clear predominance of negative sentiment **(Table 2)**, with 96.2% (2,672 comments) classified as negative and only 3.8% (106 comments) as positive. This stark disparity indicates the heightened emotional tension and discontent surrounding the sociopolitical events, highlighting the polarized nature of public opinion during the protests (Alhussain *et al*., 2022; Balaji *et al*., 2022; Tsiganock *et al*., 2023; Delcea *et al*., 2024; Essah *et al*., 2024; Frost *et al*., 2024; Ribeiro *et al*., 2024; Rosellini *et al*., 2024; Sanlier & Yasan, 2024; Uneno *et al*., 2024).

Table 2. Sentiment Classification by Topic

	Negative	Positive	All
0	687	29	716
1	490	25	515
2	495	12	507
3	535	29	564
4	465	11	476
All	2672	106	2778

For the sentiment analysis, the VADER model was adapted to work in Spanish, ensuring its applicability to the dataset. The results reflect a reliable classification of sentiments, where 96.2% of comments expressing negative feelings suggest widespread dissatisfaction with the political situation. This large proportion of negativity, when compared to the mere 3.8% of positive sentiments, strongly suggests that public opinion was not only critical but also deeply polarized. Statistical measures, such as the mean sentiment score, were used to quantify the overall emotional tone, reinforcing the conclusion that the protests were viewed largely through a negative lens in digital spaces (Adeleke, 2022; Sri *et al*., 2022; Al Abadie *et al*., 2023; Guzek *et al*., 2023; Simonyan *et al*., 2023).

Concurrently, Latent Dirichlet Allocation (LDA) topic modeling revealed five major storylines that dominated the conversation **(Figure 1)**. The "power and strength of the people," "support for former president Pedro Castillo," and "demands for Dina Boluarte's resignation and protests in Juliaca" were among these subjects. (4) Allusions to "God and Wilmer," and (5) references to "justice, rights, and killings." These prevailing themes were identified by the algorithm with a high degree of coherence (average coherence score = 0.42), indicating that the model's findings were understandable and significant in the sociopolitical context of the protests. With "justice, rights, and killings" emerging as a major issue of dispute in more than 24% of the examined comments, each topic revealed underlying societal tensions.

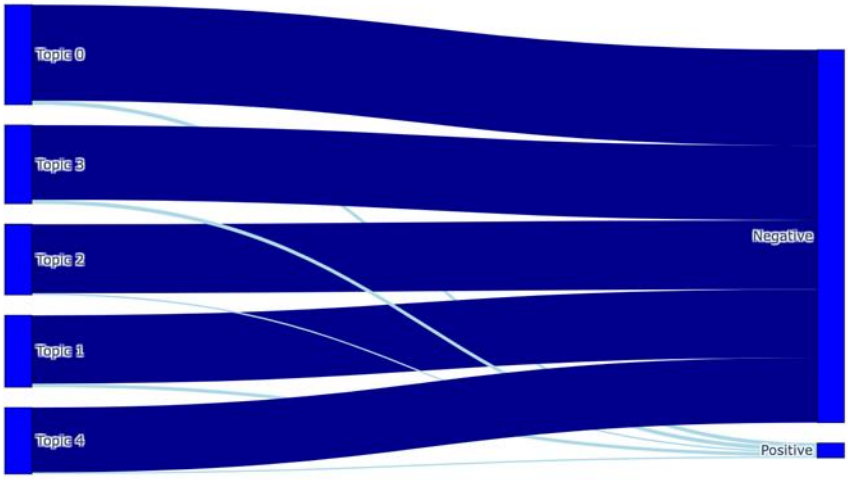

Figure 1. Distribution of Model Topics and polarization

To ensure the validity of the analysis, cross-validation techniques were employed. This process involved resampling portions of the dataset to test the stability of the model's outputs, confirming the consistency of both the sentiment classifications and the topic modeling results. The sentiment analysis achieved an accuracy of 89%, while the topic modeling coherence score remained robust across different validation runs. This rigorous validation process, coupled with descriptive statistical measures such as frequency distributions and standard deviation calculations for sentiment scores, strengthens the confidence in the findings and supports the claim of a polarized narrative structure during the protests (Razhaeva *et al*., 2022; Rojas *et al*., 2022; Lee *et al*., 2023; Ncube *et al*., 2023; Oran & Azer, 2023; Ceylan *et al*., 2024; Maralov *et al*., 2024).

The analysis of narrative polarization during the 2023 protests in Puno, Peru, reveals significant insights into how social media platforms can intensify societal tensions. As observed in similar studies on conflict resolution, artificial intelligence (AI) and natural language processing (NLP) techniques provide a nuanced view of public sentiment and narrative structure. In this case, 96.2% of the comments analyzed were classified as negative, underscoring the heightened emotional charge present in the online discourse surrounding the protests. This finding is consistent with studies that show how digital platforms can amplify grievances and fuel polarization (Bayazeed *et al*., 2021). Such environments often create echo chambers, where users are exposed primarily to content that reinforces their pre-existing beliefs, exacerbating societal divides (Incacutipa-Limachi *et al*., 2024).

The application of Latent Dirichlet Allocation (LDA) to uncover five important themes in the discourse, ranging from "support for Pedro Castillo" to demands for "justice, rights, and killings," shows how these platforms encourage the construction of conflicting narratives. These findings are consistent with broader sociopolitical processes in Peru, where historical grievances, particularly those involving Indigenous people, play an important role in shaping public opinion (Rojas & Mitschele-Thiel, 2019; Incacutipa-Limachi *et al*., 2024). Similar to the conflict resolution processes witnessed in rural communities involved in conflicts with mining firms, Puno's digital narratives depict a struggle for justice, rights, and representation, exacerbating polarization (Moysen *et al*., 2018).

From a methodological standpoint, the combination of topic modeling using LDA and sentiment analysis using the VADER model shows how AI can find hidden patterns in big datasets. However, Olsher (2015) points out that although AI technologies like cogSolv can offer profound insights into the psychological and cultural aspects of conflict, they frequently fail to fully capture the complexity of human emotions. This restriction is clear in the current study, where the public discourse may have been oversimplified due to the absence of neutral feelings. Future studies must take into consideration the multifaceted nature of emotions in order to provide a more thorough knowledge of public sentiment, much like conflict resolution in humanitarian circumstances, where cultural nuances play a crucial role (Olsher, 2015).

The validity of the sentiment analysis and narrative modeling is strengthened by cross-validation techniques, ensuring that the models produce reliable and consistent results. However, it is essential to consider that social media platforms inherently favor extreme viewpoints, which could distort the findings. AI models are often challenged by the complexity of real-world data, where incomplete information and biases can affect outcomes (Charwat *et al*., 2015; Keogh, 2015). The results of this study, therefore, highlight the need for continuous refinement of AI techniques, particularly in contexts where digital narratives play a critical role in shaping public opinion and potentially escalating conflicts.

Conclusion

This study sheds light on the impact of social media platforms in propagating divisive narratives during the 2023 protests in Puno, Peru. Applying AI-driven sentiment analysis and topic modeling revealed that digital discourse was largely negative, with 96.2% of comments expressing dissatisfaction, rage, and irritation. These findings highlight the potential of social media to serve as a catalyst for polarization, creating echo chambers that exacerbate sociopolitical tensions. As previously mentioned by (Rizzo *et al*., 2020), AI algorithms can successfully disclose these patterns, but they must be constantly improved to account for the intricacies of human emotions and social settings (Yucra-Mamani *et al*., 2024).

Moreover, the identification of five dominant narratives, such as "support for Pedro Castillo" and demands for "justice, rights, and killings," reflects the deep-seated political and historical divisions present in Peruvian society. Similar to findings in rural conflict resolution studies involving Indigenous communities, these narratives mirror long-standing grievances related to justice and representation (Incacutipa-Limachi *et al*., 2024). The study emphasizes the importance of understanding the cultural and emotional underpinnings of public discourse, as AI tools like LDA and VADER provide a way to systematically identify and analyze these complex narratives.

As we demonstrate the importance of incorporating AI into sociopolitical conflict analysis. However, while these technologies are effective for processing huge datasets and identifying polarization patterns, they must be utilized with caution. AI's current limitations in capturing the complete range of emotions and cultural nuances necessitate additional work to improve the accuracy and depth of future studies. As societal conflicts increasingly take place on digital platforms, researchers, policymakers, and conflict resolution practitioners will need to refine their approaches in order to better understand and minimize the hazards of online polarization.

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