

A Review on the Analysis of Public Opinion Regarding Natural Disasters

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Abstract. Natural disasters pose as one of the paramount challenges faced globally, exerting immense influence upon society, economy, and the environment. With the proliferation of social media, online public opinion has emerged as a pivotal source of information for studying natural disasters. Analysis of public opinion surrounding natural disasters holds significant implications in offering decision-making support and facilitating risk management. This review aims to recapitulate and analyze the recent advancements in the study of public opinion regarding natural disasters. Initially, It provides a summary of the relevant methods and techniques by delving into the modules of topic detection and topic tracking. Subsequently, it explores the applications of public opinion analysis, encompassing disaster monitoring and early warning, post-disaster assessment and emergency response, as well as the analysis of public opinion evolution. Finally, It elucidates the challenges and prospects in the field of public opinion analysis, encompassing aspects such as multimodal data fusion, enhancement of algorithmic efficacy, as well as cross-lingual and cross-cultural public opinion analysis. In conclusion, public opinion analysis can assist governments and relief agencies in gaining a deeper understanding of the public's cognition, emotions, and needs in relation to disasters, thereby enabling the formulation of more effective response measures.

Keywords: natural disasters; public opinion analysis; topic detection and tracking.

1. Introduction

Natural disasters stand as one of the formidable challenges confronting human society, inflicting significant impacts on socioeconomic factors, as well as the lives and property of individuals. With the widespread use of the internet, an abundance of public opinion information emerges during disastrous events, offering valuable resources for disaster response and management [1]. Natural disaster public opinion refers to the overall manifestation of public and media attention, emotional expressions, and societal reactions following a natural disaster. The analysis of natural disaster public opinion possesses some characteristics which include immediacy, complexity, emotionality, and timeliness. The analysis of natural disaster public opinion involves examining social media and news reports to understand the attitudes and reactions of the public towards natural disasters. Topic detection and topic tracking are two crucial aspects of public opinion analysis. They are closely intertwined [2]. Through topic detection, we can identify topics related to natural disasters and analyze them over time. By employing topic tracking, we can comprehend the changes in public attention and attitudes towards specific topics, thereby further analyzing the developmental trends of public opinion regarding natural disasters.

The analysis of public opinion regarding natural disasters plays a vital role in various application domains. Firstly, it is instrumental in public opinion monitoring and early warning. By conducting real-time monitoring and analysis of social media data, it enables a swift grasp of the development dynamics of disaster events, timely identification of potential risks and hazards. Secondly, it contributes to post-disaster assessment and emergency response. By analyzing public opinion data, decision-makers can promptly understand the public's level of concern related to disasters, thereby aiding in the formulation of effective disaster response strategies and emergency rescue measures. Additionally, it can also play a significant role in public opinion evolution analysis. By understanding the public's focal points and requirements, it becomes possible to identify public opinion evolution trends, leading to more scientific and effective decision-making. However, natural disaster public opinion analysis still faces several challenges and issues, including data

integration, improvement of algorithm effectiveness, cross-lingual and cross-cultural application. Future research can delve into and innovate in areas such as multimodal data source integration, Advancements in deep learning models and Cross-lingual public opinion analysis methods. This will drive the development of natural disaster public opinion analysis re-search, providing more effective tools and methods for practical applications, and enhancing society's disaster response and recovery capabilities.

2. The current status of domestic and international research

Research on public opinion analysis of natural disasters in China started relatively late but has garnered increasing attention in recent years [3-7]. Domestically, the research primarily focuses on the following aspects: 1. Study of the dissemination pathways of public opinion. The dissemination pathways of natural disaster public opinion primarily involve traditional media, social media, and personal communication. Traditional media serves as the main channel for the dissemination of public opinion during natural disasters, while social media and personal communication exhibit advantages in terms of speed and influence; 2. Research on methods for analyzing public opinion. Researchers primarily focus on utilizing techniques such as text mining, sentiment analysis, and network analysis to analyze and study disaster related information. 3. Study of influencing factors on public opinion during natural disasters. Factors influencing public opinion during natural disasters include the type of disaster, its scale, location, and timing. Research indicates that different types and scales of natural disasters have varying impacts on public opinion, and the location and timing of disasters also influence public opinion.

Research on public opinion analysis of natural disasters has a relatively early development in foreign countries and has established a certain research framework [8-13]. The overseas research primarily focuses on the following aspects: 1. Social network analysis of public opinion. Social network analysis involves the analysis of social network structures and relationships. The research on social network analysis primarily examines the information dissemination and interaction among the public on social networks; 2. Study of the dissemination mechanisms of natural disaster public opinion. Researchers analyze the dissemination pathways, speed, and scope of public opinion during natural disaster events to reveal the patterns and characteristics of its dissemination; 3. Research on sentiment analysis of public opinion. Sentiment analysis involves the classification and analysis of textual emotions. The research on sentiment analysis primarily focuses on the public's emotional expressions towards disasters; 4. Cross-cultural research on natural disaster public opinion. Cross-cultural research on natural disaster public opinion primarily examines the public's reactions towards disasters in different cultural backgrounds, hence the need to consider the influence of cultural factors when conducting relief efforts.

In general, there has been commendable progress in the study of public opinion on natural disasters. However, there still exist certain gaps and deficiencies, primarily encompassing challenges in data collection and processing, the lack of multimodal feature representation learning and in-depth research on multimodal sentiment analysis, as well as the disregard for regional disparities and cultural factors. Subsequent research can be focused on the following directions: 1. Enhancing methods for data collection and processing, encompassing the improvement of data quality and utilization of non-traditional data sources. 2. Employing techniques such as deep learning to map data from different modalities into a unified feature space, thereby undertaking research on multimodal feature representation learning and multimodal sentiment analysis. 3. Taking into account regional disparities and cultural factors, it is crucial to extensively engage in cross-lingual public opinion analysis and intercultural contextual comprehension.

3. Methods for topic detection and topic tracking on public opinion analysis

3.1 Topic detection methodology

Topic detection based on topic clustering is a text mining technique that aims to automatically identify potential topics and cluster related texts together. Blei et al. [14] introduced a time-based topic clustering algorithm that can discover the changing trends of topics in textual data over time. Zhang et al. [15] presented a deep learning based on text classification algorithm that transforms text data into vector representations for clustering purposes. Yang et al. [16] developed a topic clustering algorithm based on multi-domain data, enabling the clustering of text data from different domains and discovering commonalities and differences among them. Topic detection based on document semantics is a method that utilizes the semantic information within text to identify topics. Chen et al. [17] presented a semantic topic model based on word embeddings. This model combines word embeddings with topic models and utilizes word embedding information to represent word semantics, thereby better capturing the semantic information of documents. Wang et al. [18] introduced a semantic topic detection method that jointly models topics and word embeddings. This method models the topic-word semantic relevance and word-word semantic relevance to capture the topic distribution of documents. Qi et al. [19] applied spectral analysis to classify word weights based on temporal changes and used a Gaussian mixture model to model periodic features, aiming to improve the effectiveness of topic tracking. Topic detection based on graph vector space refers to the mapping of graph nodes into a low-dimensional vector space, enabling clustering and classification of the nodes. Hassan et al. [20] developed a topic detection algorithm called KeyGraph, which utilizes keyword co-occurrence information to construct a keyword graph. Lv et al. [21] divided topics into a three-level structure and conducted topic tracking research using the vector space model. Song et al. [22] categorized feature words into four types: time, location, person, and content, thus forming four vector spaces. Each space had independent weight calculation and similarity computation.

3.2 Topic tracking methodology

Topic tracking based on topic modeling is an analytical technique that utilizes text data to automatically identify and categorize topics within the text. Wang et al. [23] proposed the TM-LDA topic model, which learns topic parameter variations from historical data and predicts future data's topic distribution, effectively analyzing potential topic evolution processes. Zhang et al. [24] utilized the LDA model to construct a topic probability distribution vector for topic tracking, demonstrating superior performance compared to vector space models and monolingual models. Fang et al. [25] improved the LDA model for analyzing topic evolution processes based on dynamic topic numbers. Hong et al. [26] presented the ST-LDA single topic model, which enhances topic extraction for news and tweets in the topic space by removing noise from the traditional LDA model. Topic tracking based on vector space represents each time period's text as a vector and calculates the similarity between vectors of different time periods. Zhang et al. [27] represented topic models using a 3D document vector model and implemented topic tracking using K-nearest neighbors classification. Hu et al. [28] studied the distribution characteristics of topics and re-allocated the weights of each item belonging to the feature vector, achieving dynamic learning and updating of the topic model. Topic tracking based on statistical classification is a method that utilizes machine learning algorithms to classify and track text. Leek et al. [29] used boosting with a naive Bayes model to combine the results of multiple naive Bayes classifiers for topic tracking, with each classifier using a different similarity formula. Pan et al. [30] implemented news topic tracking using the least squares support vector machine method. They reduced the dimensionality of vector space features through latent semantic indexing analysis while preserving information.

4. The application of public opinion analysis on natural disasters

4.1 The monitoring and early warning of natural disasters

The analysis of public opinion regarding natural disasters holds significant value in the realms of natural disaster monitoring and early warning[31-32]. By examining public opinion information from various channels such as social media, news reports, and public feedback, it becomes possible for relevant authorities to get knowledge of the public's attitudes, emotions, and needs concerning natural disasters.

4.1.1 Public opinion monitoring and crisis management

The analysis of public opinion regarding natural disasters serves as a pivotal tool in the realm of crisis management. By actively monitoring and analyzing real-time public opinion information, it becomes possible to swiftly comprehend the public's reactions and demands concerning natural disaster events, thereby identifying potential crisis situations and promptly implementing measures for crisis intervention and management. This aids in mitigating panic, misinformation, and the spread of rumors, while providing accurate and reliable information to uphold societal order and ensure public safety.

4.1.2 Evaluation of warning effectiveness

The analysis of public opinion during natural disasters can be utilized to assess the effectiveness and impact of warning measures. By analyzing public opinion data, one can gain insights into the public's reception, understanding, and responsiveness to warning information. This aids in evaluating the efficacy of the warning system, identifying areas for improvement, and providing valuable lessons for future warning efforts.

4.1.3 Feedback monitoring and improvement measures

The analysis of public opinion during natural disasters can be utilized to monitor the feedback from the public regarding emergency response and post-disaster reconstruction measures. By analyzing evaluations and opinions within the public opinion data, pertinent departments can gain insights into public satisfaction levels, concerns, and suggestions regarding the implemented measures. This facilitates timely adjustments and improvements to emergency response and reconstruction measures, thereby enhancing the effectiveness and quality of post-disaster efforts.

4.2 Post-disaster evaluation and emergency response

The application of public opinion analysis in post-disaster assessment and emergency response facilitates a comprehensive understanding of public demands and feedback[33-34]. It aids in enhancing measures, improving the effectiveness of collaborative efforts and public engagement, ultimately leading to a more efficient and compassionate post-disaster recovery and reconstruction endeavor.

4.2.1 Post-disaster assessment

The utilization of natural disaster public opinion analysis allows for the evaluation of post-disaster rescue and response efforts. By analyzing the feedback and opinions of the affected public, one can comprehend the effectiveness of rescue operations, the satisfaction levels regarding the implemented measures, as well as identify potential issues and avenues for improvement. This process holds significant value in enhancing the efficiency and adaptability of future natural disaster monitoring and early warning systems.

4.2.2 Resource Allocation

Through the analysis of public opinion during natural disasters, we can gain insight into the scarcity of resources and urgent needs among residents in the disaster-stricken areas. Pertinent authorities can utilize the information extracted from public opinion data to allocate resources such as sustenance, pharmaceuticals, and rescue teams, effectively catering to the practical requirements

of the affected regions. This endeavor contributes to optimizing resource distribution, enhancing rescue efficiency, and alleviating the hardships faced by residents in disaster-stricken areas.

4.2.3 Emotional support and psychological counseling

The analysis of public opinion during natural disasters allows us to comprehend the emotional state and psychological needs of residents in the affected areas. By examining the emotional expressions and appeals for assistance within public opinion data, it becomes possible to provide emotional support and psychological counseling to the disaster-stricken regions. Relevant authorities can address the emotional needs of the affected individuals by offering psychological consultations, solace, and supportive services, assisting them in navigating the challenges of the post-disaster phase and restoring their psychological well-being.

4.3 Analysis of the evolution of public opinion during natural disasters

An important application of analyzing public opinion during natural disasters is to study the evolution[35-37]. It can help relevant authorities to understand the trends of public opinion, and enhance their capabilities in emergency response and post-disaster reconstruction.

4.3.1 Analysis of public opinion trends

By conducting an analysis of public opinion on natural disasters, it becomes possible to track and analyze the evolving trends. From the initial stages of a disaster to its subsequent developments, one can gain insights into the generation, transformation, and dissemination of public opinion information. This aids in understanding the dynamic progression of post-disaster public opinion, enabling timely adjustments to emergency response measures and information dissemination strategies.

4.3.2 Sentiment analysis

The analysis of public opinion concerning natural disasters facilitates the exploration of emotional attitudes and inclinations within the discourse. By analyzing the emotional expressions embedded in the data, one can gain an understanding of the public's emotional responses towards the disaster, encompassing concerns, apprehensions, hopes, and more. This aids relevant authorities in comprehending the emotional needs of the public, enabling them to provide emotional support and psychological assistance accordingly.

4.3.3 Analysis of online public opinion propagation pathways

The analysis of public opinion on natural disasters can unveil the pathways and modes through which information spreads within the online realm. By analyzing public opinion data from social media platforms and online forums, one can gain insights into the dissemination channels, propagation speed, and key influential nodes. This assists relevant authorities in selectively choosing information dissemination channels and methods, thereby enhancing the effectiveness of early warning systems and information communication.

5. The challenges and prospects of public opinion analysis on natural disasters

The field of public opinion analysis in the context of natural disasters encounters various challenges and presents promising prospects[38-41]. These include multimodal data fusion and processing, algorithmic performance evaluation and enhancement, and cross-lingual and cross-cultural public opinion analysis.

5.1 The challenges of public opinion analysis on natural disasters

5.1.1 Multimodal data fusion and processing

In the analysis of public opinion towards natural disasters, multimodal data fusion and processing are crucial aspects. Here are the challenges encountered in this field: 1. Diversity of data sources. Natural disaster public opinion data encompasses various forms of information. These data

sources possess distinct features and expressive formats, which make the fusion and processing of data complex. 2. Heterogeneity and incompleteness of data. The heterogeneity of multimodal data refers to the differences in representation and feature expression among different modalities. Incompleteness of data involves issues like missing data, noise, and errors within multimodal data. 3. Curse of dimensionality. Multi-modal data fusion can result in a significant increase in data dimensionality, thereby introducing complexity to data processing and analysis. Handling and modeling high dimensional data require addressing the curse of dimensionality and selecting appropriate feature to extract essential information.

5.1.2 Algorithmic performance evaluation and enhancement

Here are some challenges faced in the algorithmic performance evaluation and enhancement: 1. Difficulties in data annotation. To evaluate the effectiveness of algorithms, it is typically necessary to annotate a substantial amount of public opinion data, including emotions, topics and keywords. However, the annotation of such data is a laborious task, particularly when dealing with large-scale datasets; 2. Subjectivity and complexity. Public opinion surrounding natural disasters encompasses diverse content and expressions of emotions, which may involve subjective factors and complexity. Therefore, evaluating algorithmic effectiveness requires considering these factors and devising appropriate evaluation metrics and methods; 3. Data imbalance and variability. During natural disasters, public opinion data often exhibit imbalanced distributions. Moreover, as time elapses, the characteristics and distribution of public opinion data may undergo transformations, posing challenges to the evaluation and enhancement of algorithms.

5.1.3 Cross-lingual and cross-cultural public opinion analysis

Cross-lingual and cross-cultural analysis is an important research direction which faces several challenges: 1. Multilingual data processing. Natural disaster public opinion data may involve multiple languages, including different natural languages and dialects. Processing such multilingual data requires addressing language differences, semantic translation, and cultural background issues. Additionally, the data in different languages may be imbalanced, with some languages having a smaller volume of data, which can affect the effectiveness and generalization ability of cross-lingual public opinion analysis; 2. Cultural differences and contextual understanding. Cultural differences and contextual factors play a vital role in understanding and analyzing public opinion in the context of natural disasters. Different cultural backgrounds and contexts can lead to variations in the understanding and interpretation of public opinion. It is essential to fully consider cultural factors and contextual information to accurately analyze public opinion data; 3. Cross-cultural sentiment analysis. Different languages and cultures have distinct ways of expressing and interpreting emotions. Cross-cultural sentiment analysis needs to consider the emotional patterns and language expressions in different cultures to accurately capture and analyze the sentiment information in public opinion data.

5.2 The prospects of public opinion analysis on natural disasters

In the future, with the continuous advancement of technology, we can expect to make further progress in the field of natural disaster public opinion analysis. Here are some prospects: 1. Design of multimodal fusion algorithms. Developing fusion algorithms tailored to multimodal data enables the integration of information from different modalities, leading to more comprehensive and accurate public opinion analysis results. 2. Advancements in deep learning models. With ongoing advancements in deep learning technology, more powerful and efficient models can be expected to be applied in natural disaster public opinion analysis, enhancing algorithm performance; 3. Cross-lingual public opinion analysis methods. Developing effective cross-lingual public opinion analysis methods that leverage machine translation, cross-lingual information retrieval, and text alignment technologies can facilitate the transformation and matching of public opinion data across different languages.

6. Conclusion

The analysis of public opinion towards natural disasters is a complex and pivotal field that has made significant progress within the interdisciplinary realms of social science, computer science, and data science. This research holds paramount value in comprehending the public's attitudes, needs, and emotions concerning natural disasters. This comprehensive review presents a holistic research framework, analyzing and summarizing the background and significance of public opinion analysis regarding natural disasters. In terms of topic detection and tracking methods, this review explores three dimensions: topic detection based on thematic clustering, topic detection based on document semantics, and topic detection based on graph vector spaces. Additionally, it examines topic tracking methods encompassing topic tracking based on topic models, topic tracking based on vector spaces, and topic tracking based on statistical classification. The advancement of public opinion analysis for natural disasters equips decision-makers with accurate and real-time information support, promoting the effectiveness and sustainable development of disaster management and response. Future research efforts should be dedicated to addressing challenges such as multimodal data integration, algorithm precision, cross-lingual and cross-cultural analysis. By doing so, we can further advance and apply public opinion analysis, making a greater contribution to societal safety and public well-being.

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