The Application of Deep Learning in Social Media Sentiment Analysis and Public Opinion Prediction

Yusen Wang
Southwest Jiaotong University· University Of Leeds ,Chengdu , China

Abstract

The rapid development of social media has generated a vast amount of unstructured text data, providing abundant resources for sentiment analysis and public opinion prediction. Deep learning, with its capabilities of automatic feature extraction, sequence modeling and multimodal fusion, has become the core technical path in this field. This paper systematically reviews the theoretical basis and application progress of deep learning in social media sentiment analysis and public opinion prediction, covering aspects such as sentiment classification, fine-grained recognition, real-time monitoring, trend prediction, crisis warning and cross-platform correlation analysis. It discusses key technologies such as pre-trained language models, attention mechanisms and knowledge graphs, and analyzes the current challenges and future development trends.

Keywords: Deep Learning; Sentiment Analysis; Public Opinion Prediction; Social Media.

1. Introduction

1.1 Research Background and Significance

The rapid development of Internet technology has led to the unprecedented prosperity of social media. Platforms such as Weibo, WeChat, Twitter, and Facebook have become the core arenas for the public to obtain information, express opinions, and participate in social discussions. According to statistics, the number of global social media users has exceeded several billion, and billions of user-generated content continuously flows on these platforms, forming massive unstructured text data [1]. These data contain rich emotional expressions and trends, and are precious resources for understanding public mentality and grasping social pulse. Sentiment analysis, as one of the core tasks in the field of natural language processing, aims to automatically identify and classify sentiment tendencies from text, while public opinion prediction further deduces the dynamic evolution patterns of public emotions. Together, these constitute the cornerstone of social media big data analysis, and have irreplaceable strategic value for government decision-making, enterprise operation, and social governance [2].

At the government governance level, sentiment analysis and public opinion prediction can help decision-making departments promptly grasp the public's attitude and feedback towards public policies, thereby optimizing policy formulation and communication strategies. At the enterprise operation level, brand managers can use these technologies to promptly capture consumers' real evaluations of products and services, and respond quickly to market changes. In the public security and social governance field, the rapid perception and accurate prediction of emergency public opinion are important technical supports for ensuring social stability. Therefore, in-depth research on the application of deep learning in social media sentiment analysis and public opinion prediction not only has significant academic value, but also has far-reaching practical significance for promoting the intelligent transformation of social governance.

1.2 Current Status and Challenges of Social Media Public Opinion Analysis

Social media public opinion exhibits significant characteristics such as non-structuredness, dynamic changes, and strong real-time nature, which bring multiple challenges to the analysis work. The data volume is extremely large and growing rapidly, and traditional methods are difficult to complete effective processing within a limited time [3]. Social media texts are often short and casual, with ambiguous semantics, filled with internet buzzwords, abbreviations, irony, puns, etc., and fixed rules are difficult to quickly capture their true emotional meaning. For example, new internet words such as "jiejiezi" and "tanQ" keep emerging, and their meanings rapidly shift with the context, posing extremely high requirements for the language understanding ability of the analysis system. At the same time, the existence of false information and online trolls poses a serious threat to the objectivity of the public opinion environment, and public emotions are easily affected and fluctuate violently by emergencies, requiring the analysis system to have high real-time and adaptive capabilities [4].

In the application field, public opinion analysis has widely penetrated into government decision-making, enterprise brand management, crisis communication, public security, financial markets, and other fields. However, existing analysis methods still have bottlenecks such as insufficient accuracy, slow response, and difficulty in capturing deep semantics when dealing with large-scale complex data. How to respond in real time while maintaining good analysis, how to find real emotional signals in a noisy environment, and how to collect and output reliable public comments from multimodal data are all important problems that need to be solved quickly[5].

Traditional public opinion analysis methods use hand-made rules or simple machine learning models, but they are not good

enough in the face of the complexity of social media data. By constructing a multi-layer neural network, deep learning can extract a high-level representation from the original data alone without doing a lot of manual work to create features[6]. It finds that the powerful ability of nonlinear relationship enables the model to see the meaningful connection that traditional methods can't find, its sequential modeling ability enables it to deal with the time dependence of the text well, and its real-time processing ability meets the speed requirement of monitoring public opinion. With the arrival of pre-training language models, the models can adapt to different fields and only need a little labeled data, which greatly expands their application possibilities[7]. Deep learning is completely changing the way we analyze social media emotions and predict public opinion, bringing unprecedented in-depth analysis and processing efficiency to this field.

2. The Theoretical Foundation of Deep Learning and Sentiment Analysis

2.1 Basic Concepts of Deep Learning

Deep learning is based on artificial neural network. It constructs a deep network structure with multiple hidden layers to abstract the characteristics of data layer by layer. The input layer receives the original data, the hidden layer extracts higher-level feature representation through a series of nonlinear transformations, and the output layer generates the final classification or prediction results. Deep learning training is based on error back propagation algorithm and gradient descent algorithm. By continuously optimizing the network parameters, the model can automatically extract and learn the inherent patterns in the data. Its main feature is its strong representation learning ability, and it can automatically discover the basic functional information that is crucial to downstream tasks from the original data [8].

2.2 Task Dimensions of Sentiment Analysis

Emotional analysis refers to the use of computers to discover and understand emotions, attitudes and feelings in texts. From the task point of view, emotion classification is the simplest task: it tells you whether a text is positive, negative or neutral. Sentiment Intensity Analysis measures the intensity of emotions. Topic mining and sensory-related tasks find the main themes around the text emotion. Detailed emotional analysis goes beyond three basic categories and focuses on more specific emotions, such as anger, happiness, sadness and fear.

2.3 Intrinsic Relationship between Deep Learning and Sentiment Analysis

Traditional affective analysis methods use affective dictionaries and hand-made grammar rules, or observe how words appear together. When we talk about the language of social media, it is new and complicated, and these methods don't work. The deep learning model can learn the text features by itself, understand complex sentences with changes and contradictions, and find the deep meaning. Convolutional neural network is good at finding important words in a small place. Recurrent neural networks and their variants can include links between long sentences and words. The attention mechanism helps the model to see the most important part of the feeling. Pre-training the language model makes the analysis more accurate.

3. Application of Deep Learning in Social Media Sentiment Analysis

3.1 Automatic Extraction and Representation of Text Features

Social media texts have highly unstructured characteristics. Traditional methods rely on manually designed feature engineering, which is difficult to capture the deep semantic information. Deep learning converts words into low-dimensional dense vectors through word embedding technology, and words with similar semantics are close to each other in the vector space. Pre-trained language models, through pre-training on large-scale corpora, have acquired rich general language knowledge and can deeply understand the semantic associations and syntactic structures between words, providing high-quality feature initialization for downstream sentiment analysis tasks, representing a qualitative leap compared to traditional methods.

3.2 Multi-dimensional Sentiment Recognition and Fine-grained Analysis

The emotional expressions in social media present a complex multi-dimensional and multi-level appearance. Deep learning models can simultaneously handle multi-dimensional tasks such as sentiment classification, sentiment intensity estimation, and fine-grained sentiment recognition. In brand management scenarios, enterprises not only need to know whether users have positive or negative evaluations of the product, but also need to understand the specific reasons for dissatisfaction and the intensity of emotions. In the public safety field, fine-grained sentiment analysis can identify complex emotions such as sadness and panic from discussions on emergencies, providing precise entry points for psychological assistance and public opinion intervention.

3.3 Multi-modal Sentiment Fusion Analysis

The dissemination of information in social media is no longer limited to pure text. Multi-modal content such as images, videos, and audio also carry rich emotional information. Convolutional neural networks can extract visual features and identify the emotional cues contained therein, and deep learning models can determine the emotional state of speakers through acoustic features. By fusing text sentiment, visual sentiment, and voice sentiment, a more comprehensive and accurate sentiment judgment can be obtained, demonstrating great potential in intelligent customer service, brand image management, and other scenarios.

3.4 Real-time Sentiment Monitoring and Dynamic Tracking

The high immediacy of social media public opinion requires analysis systems to have real-time processing capabilities. Deep learning models, combined with distributed computing frameworks and stream processing technologies, can achieve real-time sentiment analysis of massive data. Through message queue systems, the collected data is transmitted in real time to the processing module, and the distribution of sentiments in different time periods is statistically analyzed, and the trend of public opinion changes is analyzed. When negative public opinion suddenly erupts, the real-time monitoring system can identify the sudden change in sentiment tendency in the shortest time, trigger the warning mechanism, and enable decision-makers to respond promptly and intervene in time.

4. Application of Deep Learning in Public Opinion Prediction

4.1 Mining of Public Opinion Transmission Patterns and Trend Prediction

The prerequisite of public opinion prediction is a deep understanding of communication mode. Information dissemination on social media shows a complex network communication mode, which is influenced by many factors such as user characteristics, theme characteristics and media characteristics. The deep learning model can automatically discover implicit patterns and key influencing nodes in the communication process by analyzing historical public opinion data. Recurrent neural network and its variants can capture the time-varying characteristics of public opinion propagation and make a relatively accurate prediction of future public opinion trends. In the financial field, by analyzing the correlation between news sentiment and market data, deep learning model can help to make investment decisions. In the field of public policy, public opinion prediction is helpful for the government to predict the possible public response caused by policy announcements.

4.2 Anomaly Detection and Crisis Warning

The deep learning model can find abnormal data points different from other data points by looking at a large number of public opinion data. Anomaly detection model uses statistical methods and machine learning techniques to immediately view sudden emotional changes or strange topics in a large number of data. When the intensity or popularity of an emotion exceeds a set threshold, an automatic alarm will be triggered. In natural disasters and public safety incidents, early warning can help relevant departments to quickly understand the public's emotions and key points, so as to take correct actions. The alarm system assisted by deep learning can shorten the response time to one minute, thus making public opinion management more effective.

4.3 Cross-platform Public Opinion Correlation Analysis

Discussions on the same event on different platforms are interrelated and influence each other. The deep learning model can integrate data from multiple sources, such as Weibo, WeChat, Twitter and news websites, so as to establish an overall view of public opinion. The combination of knowledge graphics and deep learning enables the model to show the relationship between different topics and discover cross-platform public opinion chains. Therefore, enterprises can understand the reputation differences of their brands on different platforms and formulate targeted strategies. The government can capture the differences in the acceptance of a policy in different public opinion fields and optimize the way to spread the policy.

5. Key Technical Architecture

5.1 Pre-trained Language Model and Transfer Learning

Pre-training language model is the main technical engine that allows deep learning to analyze emotion. Models like BERT are represented by bi-directional encoders. By pre-training a large number of unlabeled data, the common language can be well understood. They show good results in tasks such as emotional analysis. The emergence of transfer learning strategy helps us to need less labeled data. By fine-tuning a small amount of tag data from social media, the pre-training model can quickly adapt to the task of emotion analysis in a specific field, so that we can easily use it in different fields and platforms.

5.2 Attention Mechanism and Context Understanding

Attention mechanism allows the model to dynamically view the part of the text that contains the most emotional information, which makes the model easier to understand. Transformer architecture uses self-awareness mechanism to interact with all the information in the text, and completely solves the problem of remote dependence. In sentiment analysis, the Transformer model can look at several important points in the text at the same time, and fully judge the overall sentiment, which is very useful for dealing with texts with multiple topics that are often seen on social media.

5.3 Knowledge Graph and the Combination of Sentiment Analysis

Knowledge map provides well-organized background knowledge support for deep learning emotion analysis. By putting entities, relationships and attributes into the graph structure, the knowledge graph helps the model to understand the special objects and their relationships in the text, thus improving the accuracy and depth of emotional analysis. By combining the viewpoint extraction technology of knowledge map, we can automatically extract the main viewpoints and audience's positions from a large number of social media texts, showing the internal laws of communication. Public opinion This is an important direction of deep learning emotional analysis.

6. Challenges and Future Prospects

6.1 Data Quality and Privacy Ethics

Social media data is full of boring, false content and spam, which directly affects the training and accuracy of model prediction. How to clean and remove data noise correctly is the first step to improve the analysis quality. For privacy and morality, public opinion analysis uses a lot of user-created content. How to use the value of data while protecting users' privacy and abiding by laws and regulations is a very important thing. Data bias is also not to be ignored. Models may produce discriminatory results during training, and this needs to be prevented through technical means and institutional norms.

6.2 Model Explainability and Bias Issues

The "black box" characteristic of deep learning models is an important obstacle restricting their wide application. In scenarios where transparency of decision-making is required, the non-explainability of the models may lead to decision-makers' lack of trust in the analysis results. At present, due to technologies such as attention visualization, the interpretability of the model has been improved, but there is still a big gap compared with complete transparency. Ensuring the fairness of the model in different groups and backgrounds is an important direction for future research.

6.3 Future Development Trends

Looking ahead, multi-mode integration will become the mainstream. The joint analysis of various information such as text, image and voice will greatly improve the understanding of public opinions. Interdisciplinary integration will continue to deepen, and the combination of sociological and psychological theories with deep learning will add more human wisdom to public opinion analysis. Semi-supervised learning and unsupervised learning will help to effectively solve the problem of lack of labeled data. Lightweight model technology will extend sentiment analysis to mobile devices and embedded devices, and multilingual sentiment analysis will promote the understanding of global public opinion and provide new possibilities for cross-cultural public opinion research.

Conclusion

The rapid development of deep learning technology has opened up a brand-new realm for social media sentiment analysis and public opinion prediction. From automatic feature extraction to multi-dimensional sentiment recognition, from real-time monitoring to trend prediction, from anomaly detection to cross-platform correlation analysis, deep learning, with its powerful representation learning ability and flexible architecture design, is profoundly reshaping the technical paradigm and application pattern of public opinion analysis. Although challenges such as data quality, privacy ethics, and model interpretability still exist, with the continuous advancement of technology, deep learning will undoubtedly play a more extensive and far-reaching role in the field of social media public opinion analysis, providing more intelligent and efficient information support for scientific decision-making by the government, precise operation by enterprises, and harmonious governance of society.

REFERENCES

[1] Comito, C., Caroprese, L., & Zumpano, E. (2023). Multimodal fake news detection on social media: a survey of deep learning techniques. Social Network Analysis and Mining, 13(1), 101.

[2] Hajiali, M. (2020). Big data and sentiment analysis: A comprehensive and systematic literature review. Concurrency and Computation: Practice and Experience, 32(14), e5671.

[3] Sukheja, S., Chopra, S., & Vijayalakshmi, M. (2020, March). Sentiment analysis using deep learning–a survey. In 2020 international conference on computer science, engineering and applications (ICCSEA) (pp. 1-4). IEEE.

[4] Gao, J., Li, P., Chen, Z., & Zhang, J. (2020). A survey on deep learning for multimodal data fusion. Neural computation, 32(5), 829-864.

[5] Nguyen, H., Veluchamy, A., Diop, M., & Iqbal, R. (2018). Comparative study of sentiment analysis with product reviews using machine learning and lexicon-based approaches. SMU Data Science Review, 1(4), 7.

[6] Alyafeai, Z., AlShaibani, M. S., & Ahmad, I. (2020). A survey on transfer learning in natural language processing. arXiv preprint arXiv:2007.04239.

[7] Zhou, Y., Kang, X., & Ren, F. (2023). Prompt consistency for multi-label textual emotion detection. IEEE Transactions on Affective Computing, 15(1), 121-129.

[8] Hayat, M. K., Daud, A., Alshdadi, A. A., Banjar, A., Abbasi, R. A., Bao, Y., & Dawood, H. (2019). Towards deep learning prospects: insights for social media analytics. IEEE access, 7, 36958-36979