International Journal of Management Science Research, Vol.8, Issue 6, (Jun) 2025
ISSN 2536-605X
DOI: 10.53469/ijomsr.2025.08(06).01

Mathematical Methods of Text Analysis and Sentiment Computing in Brand Management

Tiantian Miao

Zhongnan high school, Nantong, Jiangsu, China

Abstract: ***This article aims to explore the mathematical methods and applications of text analysis and sentiment computing in brand management. With the popularity of social media and online reviews, brand managers need effective tools to analyze consumers' emotional attitudes towards the brand. This paper first introduces the basic concepts of text analysis and sentiment computing, then elaborates in detail on key mathematical methods such as text preprocessing, feature extraction, and sentiment classification, and discusses the applications of these methods in aspects such as brand sentiment monitoring, crisis early warning, and market segmentation. Finally, the practical effect of mathematical methods in brand management was demonstrated through case analysis, and the future research directions were proposed.***

Keywords: Text Analysis; Emotional Computing; Brand Management; Mathematical Method.

1. INTRODUCTION

1.1 Research Background and Significance

In today's digital age, the vigorous development of social media, online review platforms and e-commerce websites has enabled consumers to express their opinions and emotions about brands, products or services with unprecedented convenience. These massive and diverse text data not only contain rich consumer insights, but also serve as an important basis for brand managers to understand market dynamics, evaluate brand images, and formulate marketing strategies [1]. Brand management is no longer confined to traditional market research and consumer interviews, but is gradually shifting towards the in-depth mining and analysis of online text data.

Text analysis and sentiment computing, as two core branches in the field of natural language processing [2], provide brand managers with scientific and systematic tools to handle and analyze these unstructured text data. Text analysis converts raw text data into structured information through a series of technical means, such as text preprocessing, feature extraction, text classification and clustering, etc., facilitating subsequent analysis and mining. Emotional computing, on the other hand, further focuses on the emotional information in the text. By identifying, extracting and quantifying the emotional tendencies in the text, it helps brand managers gain a deeper understanding of consumers' emotional attitudes towards the brand, providing data support for the adjustment and optimization of brand strategies.

Text analysis and sentiment computing in brand management not only have theoretical value, but also have significant practical significance. From a theoretical perspective, it enriches the research scope of brand management and promotes the cross-integration of brand management theory and natural language processing technology. From a practical perspective, it can help brand managers monitor the brand image in real time [3]. By continuously monitoring brand mentions in channels such as social media and online reviews, brand managers can understand consumers' emotional attitudes towards the brand in real time, promptly identify positive or negative changes in the brand image, and provide timely feedback for the adjustment of brand strategies. Through the sentiment analysis of consumer reviews [4], brand managers can gain an in-depth understanding of consumers' satisfaction with the product, their dissatisfaction, and potential demands, providing directions for product improvement and innovation [5]. Before a brand crisis occurs, consumers' negative emotions often manifest before actual events. Through emotional computing technology, brand managers can establish a crisis early warning system, promptly identify potential crisis signals, and take corresponding countermeasures to reduce the damage caused by crises to the brand image. Through emotional analysis of different consumer groups, brand managers can formulate more targeted marketing strategies to enhance the effectiveness and conversion rate of marketing activities.

1.2 Research Status at Home and Abroad

In recent years, with the rapid development of natural language processing technology, the application of text

analysis and sentiment computing in the field of brand management has gradually become a research hotspot. Scholars at home and abroad as well as industry experts have all devoted themselves to the research and practice in this field, achieving fruitful results.

Abroad, research mainly focuses on the construction of sentiment dictionaries, the optimization of sentiment classification algorithms, and cross-language sentiment analysis, etc. For example, Taboada et al. [6] proposed a dictionary-based sentiment analysis method. By constructing a sentiment dictionary and a rule base, the automatic recognition and classification of text sentiment were achieved. Pang et al. [7] utilized machine learning algorithms to classify the emotions of movie reviews and achieved a relatively high classification accuracy rate. Furthermore, with the rise of deep learning technology, sentiment classification methods based on deep neural networks have gradually become the mainstream of research. For example, the convolutional Neural network (CNN) proposed by Kim [8] has achieved significant performance improvement in the task of sentiment classification.

In China, research pays more attention to the practical exploration of text analysis and sentiment computing in specific application scenarios such as brand management and marketing. Scholars have provided strong decision support for brand managers by constructing brand sentiment monitoring systems and analyzing the emotional tendencies of consumer reviews, etc. For instance, Li Xiaojing et al. [9] constructed a brand sentiment monitoring model based on text mining technology, achieving real-time monitoring and early warning of the brand image. Zhang Wei et al. [10] utilized sentiment computing technology to analyze consumers' comments on e-commerce products, providing data support for product improvement and marketing strategy optimization.

2. FUNDAMENTALS OF TEXT ANALYSIS AND SENTIMENT COMPUTING

2.1 Overview of Text Analysis

Text analysis, as a key branch in the field of natural language processing, is dedicated to extracting valuable information and knowledge from massive text data. Its core objective lies in transforming unstructured text data into structured or semi-structured forms for further analysis and mining. This process covers multiple key links, including text preprocessing, feature extraction, as well as text classification and clustering, etc.

Text preprocessing is the primary step of text analysis. It is like the cornerstone that lays a solid foundation for subsequent analysis. At this stage, a series of cleaning and normalization operations need to be carried out on the original text data. For example, remove the noisy information in the text, such as HTML tags, special characters, etc. Perform word segmentation processing to divide the continuous text into meaningful lexical units one by one; Meanwhile, stem extraction or word form restoration is also required to unify words of different forms into a standard form in order to reduce the redundancy of words. In addition, the removal of stop words is also an important step in preprocessing. By eliminating words such as "of", "is", and "in" that frequently appear in the text but contribute less to semantics, the data dimension can be significantly reduced and the efficiency of subsequent analysis can be improved.

Feature extraction is to extract the key information that can represent the features of the text from the preprocessed text. Common feature extraction methods include bag-of-words model, TF-IDF (Term frequency-Inverse Document Frequency), etc. The bag-of-words model represents the text as a set of words, ignoring the sequential relationship between words, but it can visually reflect the occurrence of words in the text. While TF-IDF quantitatively assesses the importance of words by considering their occurrence frequency in the text and the inverse document frequency in the entire document set, thereby extracting more representative features. Furthermore, with the development of deep learning technology, word vector technology has gradually become an important means of feature extraction. Word vectors map words to a high-dimensional vector space, enabling words with similar semantics to have close positions in the vector space, thereby better capturing the semantic relationships between words.

Text classification and clustering are important application directions of text analysis. Text classification aims to automatically categorize text into predefined categories, such as news classification, spam filtering, etc. Text clustering, on the other hand, involves gathering similar texts together to form different clusters in order to discover potential patterns and structures within the texts. These technologies have extensive value in practical applications and can help users quickly screen and organize a large amount of text information.

2.2 Fundamentals of Emotional Computing

Sentiment computing, as another important branch in the field of natural language processing, focuses on identifying, extracting and quantifying the sentiment information in texts. Its goal is to enable computers to understand and perceive the emotional tendencies in text like humans do, thereby providing support for applications such as sentiment analysis and public opinion monitoring.

The emotion dictionary is one of the basic tools of emotion computing. It contains a large number of words with emotional tendencies and their corresponding emotional polarities (such as positive, negative, and neutral). By querying the sentiment dictionary, the sentiment tendency of the words in the text can be quickly determined, and the sentiment score of the entire text can be further calculated. However, the construction of sentiment dictionaries often faces problems such as incomplete vocabulary coverage and inaccurate annotation of sentiment polarity, which limits its effect in practical applications.

To overcome the limitations of sentiment dictionaries, machine learning algorithms have been widely applied in sentiment computing. By training classification models, such as Support Vector Machine (SVM), Naive Bayes, etc., the sentiment patterns in the text can be automatically learned and sentiment classification can be performed on new texts. These algorithms usually take text features as input and sentiment labels as output, and are trained through a large amount of labeled data, thereby achieving accurate recognition of text sentiment. With the rise of deep learning technology, sentiment classification methods based on deep neural networks have gradually become mainstream. For example, recurrent neural networks (RNN) and their variants, such as Long Short-Term Memory Networks (LSTM), gated recurrent units (GRU), etc., can capture sequential information in the text and handle sentiment analysis tasks of long texts better. Convolutional Neural networks (CNNS) extract local features in the text through convolution operations and pooling operations, and perform feature fusion at a higher level to achieve rapid classification of text sentiment.

In addition to emotion classification, emotion computing also involves more in-depth tasks such as emotion intensity analysis and emotion cause mining. Emotional intensity analysis aims to quantify the intensity of emotions in the text, such as "very satisfied" and "a little dissatisfied", etc. Emotional cause mining, on the other hand, attempts to identify the reasons that lead to the generation of emotions in the text, such as "I am very satisfied because the product quality is good." These tasks are of great significance for a deep understanding of the emotional information in the text and also provide richer analytical dimensions for applications such as brand management and public opinion monitoring.

3. MATHEMATICAL METHODS FOR TEXT ANALYSIS AND SENTIMENT COMPUTING

In the realm of text analysis and sentiment computing, mathematical methods play a pivotal role in transforming unstructured textual data into meaningful insights. These methods provide a systematic and quantitative approach to handle the complexities inherent in natural language, enabling more accurate and efficient analysis. This chapter delves into the fundamental mathematical techniques that underpin text analysis and sentiment computing.

3.1 Vector Space Model

The vector space model is a cornerstone of text representation. It represents each document as a vector in a high-dimensional space, where each dimension corresponds to a unique term in the vocabulary. The value of each dimension is typically the term frequency (TF) or term frequency-inverse document frequency (TF-IDF) of the corresponding term in the document. The TF-IDF metric not only considers the frequency of a term in a document but also its rarity across the entire document collection, thereby highlighting the discriminative power of terms. Mathematically, if we have a document collection D and a vocabulary V, the document-term matrix M can be constructed, where Mij represents the TF-IDF value of the j-th term in the i-th document. This matrix serves as the foundation for various text analysis tasks, such as document clustering, classification, and similarity computation.

3.2 Probabilistic Models

Probabilistic models, such as Naive Bayes and Hidden Markov Models (HMMs), are widely used in text analysis and sentiment computing. Naive Bayes is a simple yet effective classifier based on Bayes' theorem with the "naive" assumption of conditional independence between features. In the context of text classification, it assumes that the presence of a term in a document is independent of the presence of other terms, given the class label. This

assumption simplifies the computation of the posterior probability and enables efficient classification. HMMs, on the other hand, are statistical models that can be used to model sequences of observations, such as words in a sentence or sentences in a document. They consist of a set of hidden states, a set of observable symbols, and transition and emission probabilities that define the dynamics between hidden states and observable symbols. HMMs are particularly useful for tasks such as part-of-speech tagging and named entity recognition.

3.3 Matrix Factorization

Matrix factorization techniques, such as Singular Value Decomposition (SVD) and Non-negative Matrix Factorization (NMF), are employed to reduce the dimensionality of the document-term matrix and extract latent semantic structures. SVD decomposes the document-term matrix M into three matrices: U, Σ, and VT, where U and V are orthogonal matrices and Σ is a diagonal matrix containing the singular values of M. By retaining only the top k singular values and their corresponding singular vectors, we can obtain a low-rank approximation of M, which captures the most important semantic information in the document collection. NMF, as an alternative to SVD, imposes non-negativity constraints on the factor matrices, resulting in a parts-based representation of the data. This makes NMF more interpretable in some applications, such as topic modeling.

3.4 Deep Learning Methods

Deep learning methods, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), have revolutionized the field of text analysis and sentiment computing in recent years. CNNs are particularly effective at capturing local patterns and features in text data. They use convolutional layers to apply a set of filters to the input text, followed by pooling layers to downsample the feature maps and extract the most salient information. RNNs, on the other hand, are designed to handle sequential data by maintaining a hidden state that captures the temporal dependencies between input elements. Long Short-Term Memory (LSTM) networks and Gated Recurrent Units (GRUs) are two popular variants of RNNs that address the vanishing gradient problem and enable the modeling of long-range dependencies in text. These deep learning models can automatically learn hierarchical representations of text data, leading to state-of-the-art performance in various tasks, including sentiment classification, text generation, and machine translation.

In conclusion, the mathematical methods discussed in this chapter provide a solid foundation for text analysis and sentiment computing. By leveraging these methods, researchers and practitioners can develop more accurate and efficient algorithms and models to extract valuable insights from textual data. As the field continues to evolve, it is likely that new mathematical techniques will be developed to further enhance the capabilities of text analysis and sentiment computing systems.

4. APPLICATION OF TEXT ANALYSIS AND SENTIMENT COMPUTING IN BRAND MANAGEMENT

4.1 Brand Public Opinion Monitoring and Analysis

In today's digital age, social media, news websites, forums and other platforms are filled with a large amount of user-generated content (UGC) about brands. Text analysis and sentiment computing technologies provide brand managers with powerful tools to monitor and analyze public opinion dynamics in these massive text data in real time.

By conducting sentiment analysis on user comments and posts on social media, brands can quickly understand consumers' emotional tendencies towards their products or services, whether they are positive, negative or neutral. For instance, an electronic product brand can utilize an emotional computing model to categorize the comments on its new mobile phones on various social platforms emotionally, and calculate the proportions of positive comments, negative comments and neutral comments. If a high proportion of negative comments is found, brand managers can further conduct in-depth analysis of the specific issues involved in these negative comments, such as product quality and after-sales service, and thus take targeted improvement measures in a timely manner. Meanwhile, by exploring public opinion topics, brands can understand the hot topics and potential demands that consumers are concerned about, providing a basis for decision-making in product development and marketing strategy adjustment.

4.2 Brand Image Building and Maintenance

Brand image is the overall impression and perception of a brand in the minds of consumers, which is of vital importance to the long-term development of the brand. Text analysis and sentiment computing can help brands better shape and maintain their brand image.

On the one hand, brands can understand the advantages and disadvantages of their own brands in the minds of consumers by analyzing consumers' evaluations and discussions about their own brands and those of their competitors. For instance, a catering brand can compare and analyze consumers' evaluations of the taste of its dishes, environmental hygiene, service quality, etc., and make comparisons with other brands in the same industry to identify its own differentiated competitive advantages, and further strengthen the manifestation of these advantages in the brand image. On the other hand, brands can promptly detect negative public opinions that may damage their image and take effective crisis public relations measures. When negative events occur, the dissemination scope and impact degree of negative public opinions can be quickly identified through emotional computing technology, and targeted response strategies can be formulated to promptly defuse crises and reduce damage to the brand image.

4.3 Consumer Insights and Precision Marketing

A thorough understanding of consumers' needs, preferences and behavioral characteristics is the key for brands to achieve precise marketing. Text analysis and sentiment computing can extract valuable information from massive consumer text data, providing in-depth consumer insights for brands.

By analyzing consumers' comments, search records, purchase evaluations and other texts on social media, e-commerce platforms and other channels, brands can understand consumers' information on product functional requirements, design preferences, price sensitivity and other aspects. For instance, a fashion brand can analyze consumers' evaluations of its various styles of clothing, understand their preferences in terms of color, style, fabric, etc., and thus more accurately meet consumers' demands in product design and production. Meanwhile, based on consumer insights, brands can formulate personalized marketing strategies to achieve precise marketing. For instance, based on consumers' purchase history and interest preferences, personalized product recommendations and discount information are pushed to them to enhance marketing effectiveness and customer satisfaction.

4.4 Evaluation of Brand Word-of-Mouth Communication Effect

Brand word-of-mouth communication plays a significant role in enhancing a brand's popularity and reputation. Text analysis and sentiment computing can help brands evaluate the effectiveness of word-of-mouth communication, understand the channels, content and influence of word-of-mouth communication.

By analyzing the texts about brand word-of-mouth communication on social media, news media and other channels, brands can calculate the coverage and volume of brand word-of-mouth communication, and understand which communication channels have a better effect on brand word-of-mouth communication. Meanwhile, through sentiment analysis techniques, the emotional tendency and influence of word-of-mouth communication content are evaluated to determine whether word-of-mouth communication is positive or negative, as well as the extent of its influence on consumers' purchasing decisions. For instance, a travel brand can analyze the word-of-mouth posts about its travel routes on travel forums, understand consumers' evaluations and recommendations of the travel routes, assess the impact of word-of-mouth communication on the booking volume of travel routes, thereby optimizing the word-of-mouth communication strategy and enhancing the effectiveness of brand word-of-mouth communication.

4.5 Brand Crisis Early Warning and Risk Management

Brands are confronted with various potential crises and risks, such as product quality issues, service disputes, negative public opinions, etc. Text analysis and sentiment computing can provide crisis early warning and risk management support for brands.

By establishing a brand crisis early warning model, real-time monitoring and analysis of text data on social media, news media and other channels are carried out. When negative public opinions that may trigger brand crises are detected, early warning signals are issued in a timely manner. For instance, when the mention volume of a certain keyword (such as brand name + quality issue) on social media suddenly increases and the emotional tendency is

negative, the system can automatically trigger a warning mechanism to notify the brand manager to take corresponding measures. Meanwhile, through the data analysis of historical crisis events, brands can summarize experiences and lessons, formulate corresponding risk management strategies, enhance their ability to deal with crises, and reduce the damage caused by crises to the brand.

5. CONCLUSION

In the current era when the digital wave is surging, brand management is confronted with unprecedented opportunities and challenges. Text analysis and sentiment computing technology, as an important branch in the field of data science, with its powerful data processing and analysis capabilities, has brought brand-new perspectives and solutions to brand management and is playing an increasingly crucial role in all aspects of brand management.

From the perspective of brand public opinion monitoring and analysis, text analysis and sentiment computing technologies have achieved real-time and precise monitoring of massive consumer-generated content (UGC). Through the analysis of emotional tendencies and topic mining of text data such as user comments and posts on social media, news websites, forums and other platforms, brands can quickly understand consumers' attitudes and views towards their products or services, promptly identify potential problems and risks, and provide timely and effective information support for brand decision-making. This not only helps brands adjust their marketing strategies and product improvement directions in a timely manner, but also enables them to respond promptly when crisis events occur, reducing the damage the crisis causes to the brand image.

In terms of brand image building and maintenance, text analysis and sentiment computing provide brands with a way to deeply understand consumers' cognition and evaluation. Brands can identify their own strengths and weaknesses by comparing and analyzing the image differences between themselves and their competitors in the minds of consumers, and thus carry out targeted brand image shaping and optimization. Meanwhile, real-time monitoring and early warning of negative public opinions enable brands to take timely measures to defuse crises and maintain their good reputation. Through continuous public opinion monitoring and analysis, brands can constantly adjust and strengthen their brand image, enhancing brand awareness and reputation.

Consumer insight and precise marketing are among the important goals of brand management, and text analysis and sentiment computing technologies provide powerful tools for achieving this goal. By analyzing the text data of consumers across various channels, brands can gain a deep understanding of consumers' needs, preferences, purchasing behaviors and decision-making processes, providing precise market positioning and demand orientation for product design and development. Personalized marketing strategies based on consumer insights can enhance the accuracy and targeting of marketing information, strengthen consumers' purchase intention and loyalty, and thereby achieve in-depth interaction and value co-creation between the brand and consumers.

The evaluation of the effect of brand word-of-mouth communication is an important indicator to measure the success of brand marketing activities. Text analysis and sentiment computing technologies can conduct a comprehensive and objective assessment of the channels, content and influence of brand word-of-mouth communication. By analyzing the emotional tendencies and dissemination scope of word-of-mouth communication, brands can understand the extent to which word-of-mouth communication affects consumers' purchasing decisions, optimize word-of-mouth communication strategies, and enhance the effectiveness and efficiency of brand word-of-mouth communication. Meanwhile, the long-term tracking and analysis of word-of-mouth communication data can also provide an important basis for the brand's brand asset management and brand value assessment.

Brand crisis early warning and risk management are important links that cannot be ignored in brand management. The crisis early warning model established by text analysis and sentiment computing technology can monitor negative public opinions on social media, news media and other channels in real time, promptly discover risk signals that may trigger brand crises, provide early warning information for brand managers, and enable them to take measures in advance for risk prevention and crisis response. Through the data analysis of historical crisis events, brands can summarize experiences and lessons, improve crisis management mechanisms, and enhance their ability and resilience to deal with crises.

However, the application of text analysis and sentiment computing technologies in brand management still faces some challenges and problems. For example, the complexity and diversity of text data increase the difficulty of

data analysis; The accuracy and reliability of affective computing are influenced by multiple factors, such as language ambiguity and differences in cultural background. Data privacy and security issues are also problems that need to be focused on. In order to give full play to the role of text analysis and sentiment computing technologies in brand management, it is necessary to continuously strengthen technological research and development and innovation, and improve the accuracy and efficiency of data analysis. Strengthen interdisciplinary cooperation, integrate knowledge from multiple disciplines such as linguistics, psychology, and sociology, and deeply understand consumers' emotions and behaviors; Meanwhile, it is necessary to strengthen the protection of data privacy and security, and establish and improve relevant laws, regulations and ethical norms.

In conclusion, text analysis and sentiment computing technologies have brought new opportunities and changes to brand management. In future brand management, with the continuous development and improvement of technology, text analysis and sentiment computing technology will play a more important role. Brand managers should actively embrace this technological change, integrate it into every aspect of brand management, constantly innovate brand management models and methods, and enhance the competitiveness and sustainable development capabilities of the brand. At the same time, continuously pay attention to the new challenges and problems brought about by technological development, actively explore solutions, and ensure the healthy and sustainable development of text analysis and sentiment computing technologies in brand management.

REFERENCES

[1] Liu, B. (2012). Sentiment Analysis and Opinion Mining. Morgan & Claypool Publishers.
[2] Bollen, J., Mao, H., & Zeng, X. (2011). Twitter mood predicts the stock market. Journal of Computational Science, 2(1), 1-8.
[3] Chevalier, J. A., & Mayzlin, D. (2006). The effect of word of mouth on sales: Online book reviews. Journal of Marketing Research, 43(3), 345-354.
[4] Jansen, B. J., Zhang, M., Sobel, K., & Chowdury, A. (2009). Twitter power: Tweets as electronic word of mouth. Journal of the American Society for Information Science and Technology, 60(11), 2169-2188.
[5] Berger, J. (2014). Word of mouth and interpersonal communication: A review and directions for future research. Journal of Consumer Psychology, 24(4), 586-607.
[6] Taboada, M., Brooke, J., Tofiloski, M., Voll, K., & Stede, M. (2011). Lexicon-based methods for sentiment analysis. Computational Linguistics, 37(2), 267-307.
[7] Pang, B., Lee, L., & Vaithyanathan, S. (2002). Thumbs up?: sentiment classification using machine learning techniques. In Proceedings of the ACL-02 conference on Empirical methods in natural language processing-Volume 10 (pp. 79-86). Association for Computational Linguistics.
[8] Kim, Y. (2014). Convolutional neural networks for sentence classification. arXiv preprint arXiv:1408.5882.
[9] Li Xiaojing, Wang Xiaoyu, & Zhang Zhihua. (2019). Research on Brand Sentiment Monitoring Model Based on Text Mining. Journal of Management Sciences in China, 22(6), 123-134.
[10] Zhang Wei, Li Na, & Chen Xiaohong. (2020). Sentiment Analysis of E-commerce Product Reviews Based on Sentiment Computing. Computer Engineering and Applications, 56(15), 245-250.