

## Retraction

# Retracted: Sentiment Analysis of International and Foreign Chinese-Language Texts with Multilevel Features

### Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### References

- [1] M. Zhu, "Sentiment Analysis of International and Foreign Chinese-Language Texts with Multilevel Features," *Discrete Dynamics in Nature and Society*, vol. 2022, Article ID 9879986, 12 pages, 2022.

## Research Article

# Sentiment Analysis of International and Foreign Chinese-Language Texts with Multilevel Features

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This paper takes the application of international Chinese to foreigners on the Internet as the research object. A variety of features are constructed according to the characteristics of international and foreign Chinese texts and networks. This paper selects three features: dictionary-based sentiment value feature, expression feature, and improved semantic feature. A text sentiment classification model is formed by fusing multiple features. Compared with the traditional model and other single-feature models on the self-built dataset, the experimental results show that its sentiment classification ability has been effectively improved. The results show that the accuracy, recall, and  $F_1$  value of the fused multilevel feature MFCNN model are much higher than the accuracy, recall, and  $F_1$  value of other models. This also shows that the improved model of this method has a better effect of improving the accuracy.

## 1. Introduction

With the vigorous development of China's Internet and other tertiary industries, as of March 2022, the number of netizens exceeded 1 billion. The Internet penetration rate is 59.6%. With the promotion of Chinese around the world and its widespread use in the Chinese community, the scale of Chinese-language netizens has exceeded 1.2 billion [1–3]. Therefore, effectively understanding the emotional tendencies of Chinese texts has become a research direction that has received much attention. Chinese text sentiment analysis has become one of the hottest problems in the field of natural language processing [4].

Sentiment analysis is of great significance to applications such as market research, potential user analysis, and online public opinion warning [5]. As an interdisciplinary problem, sentiment analysis research utilizes computer science to analyze textual subjective sentiment information. It has broad theoretical significance and application prospect. First of all, the difficulties faced by Chinese sentiment analysis include the common problems of any kind of natural language sentiment analysis, such as new word recognition and ambiguity resolution. There are also individualized

problems, such as Chinese word segmentation and part-of-speech definition specification. Secondly, due to the openness, freedom, and irregularity of online comment text, the semantic expression is more obscure [6]. Understanding emotional expressions requires more context. The network generates a large number of new words, and unregistered words interfere with the judgment of emotional polarity. How to effectively mine emotional information from massive and unstructured Chinese data is challenging [7].

More and more people use Chinese all over the world, and people can express their opinions on news on the Internet at any time. This enables Chinese texts to appear more on various Internet platforms and regions. In this way, the usage rate of Chinese in foreign countries has also been greatly improved. Due to this immediacy and interactivity, information such as attitudes and opinions of users in their daily life experiences in Chinese can map the user's emotional fluctuations into virtual cyberspace through text, video, and other different forms of expression. It is one of the most spoken languages in the world [8]. Chinese texts published on the Internet are the research objects for analyzing textual sentiment analysis. It is necessary to extract as much useful information as possible from the total Chinese

text data, and Chinese text sentiment analysis has also been a very popular research topic in recent years. In terms of public safety, certain trends can be predicted or early warnings can be made based on the public sentiment reflected in the text. In the commercial field, the emotional tendency information in user evaluation texts can help businesses understand the needs of different users. Text sentiment analysis is a method to extract subjective sentiment contained in text. Its main task is to extract users' emotional tendencies from the massive text data brought by the rapid development of the Internet. In this way, the hidden guiding value that can promote the development of all fields of society can be tapped [9, 10]. At present, it has greatly promoted the development of public opinion monitoring and user decision-making. Among the existing text sentiment analysis methods, those relying on sentiment dictionaries rely too much on the quality of the dictionaries, and the computational and maintenance costs are high. When using machine learning algorithms, constructing features is a huge effort and often ignores the semantic sequence associations of text. With the application of deep learning in the field of text sentiment analysis, automatic learning of sentiment features in text sequences is achieved. The generalized capture of the overall semantic information of the text overcomes the shortcomings of traditional sentiment analysis models to a certain extent. However, the current research on deep learning in sentiment analysis tasks is not perfect, and the improvement of sentiment analysis models still has high research value.

This paper mainly constructs multilevel features with emotion value features, expression features, and improved semantic features. The multilevel features include not only text features but also nontext features. On the basis of the above, a sentiment classification model is constructed by proposing a text sentiment analysis method that integrates multiple features. By learning more dimensions of sentiment information in the text, the sentiment classification accuracy is improved.

## 2. Relevant Theoretical Basis

**2.1. Text Mining.** As an extension of text data mining, text mining is mainly based on computational linguistics and mathematical statistics. Through the two previously mentioned techniques and theories, some useful information can be obtained from numerous text data, and its main purpose is to explore the relationship between characters, semantics, and syntax [11, 12]. The steps of text mining are shown in Figure 1 and they mainly include four parts: text analysis, feature extraction, core technology, and user interface. After obtaining the text source, the text is preprocessed, including word segmentation and text structure analysis. By calculating the weight of feature words, key summaries, specific information extraction, and text features are extracted [13]. The data is then analyzed and predicted by using five basic techniques such as classification and clustering. Finally, the results are obtained and displayed to the user in a visual interface.

Many core techniques in text mining are inseparable from mathematical statistics, natural language processing,

and machine learning. According to the different objects to be mined, the tasks of text mining can also be divided into tasks related to words and tasks related to documents. The task categories for text mining are categorized in Table 1.

**2.2. Emotional Mining.** Opinions exist in subjective texts. Subjective text is a form of natural language expression relative to objective text. It describes the thoughts or perceptions of an individual, group, or organization about things, people, and events. In addition to this, subjective texts also contain emotions and attitudes [14]. This document contains statements expressing opinions. Such texts are called opinion-based subjectivity texts. Opinion is a quadruple consisting of subject, holder, statement, and emotion. There is an inherent connection between these four elements. That is, the holder of an opinion makes an emotional statement of opinion on a topic. It should be noted that sometimes the subject is also referred to as the focus or object to distinguish possible ambiguities [15].

In general, the point of view in the text is given explicitly and sometimes indirectly, and emotional sentences can be identified using three lexical cues. Examples of declarative verbs that point out the event or thing to be commented on are say, point out, think, and so forth. Sentiment items contain words or phrases of polarity (positive, negative, or neutral), such as good, nice, wrong, and praise. Adverb prompting is the close association of adverbs with ideas, such as possibly, very, and extremely.

In addition to these three clues, there are two more clues that can be added to the analysis of ideas. Negative words reverse the polarity of words, such as no, would not, and never. A transition word reverses the polarity of the sentence preceding the transition word, such as although and but.

**2.3. Sentiment Mining and Sentiment Classification.** Sentiment mining is also known as opinion mining or sentiment orientation. Sentiment mining is defined as a collection of review texts that contain sentiments (or opinions) about an object. Sentiment mining aims to find the attributes and components of the commented object from each comment text and judge whether the comment is positive, negative, or neutral. Sentiment mining emerges on the basis of text mining to extract subjective expressions in textual information and an emerging discipline that analyzes the emotional tendencies and intensities contained in texts. It involves natural language processing, information retrieval, data mining, machine learning, artificial intelligence, corpus linguistics, and other research fields. Sense mining summarizes comments for users and mines useful patterns for them. According to the definition of opinion in China, the task of sentiment mining is to automatically find the elements and relationships in opinion from comments composed of natural language. It can be divided into four subtasks [16, 17]:

- (1) Topic extraction identifies feature words and topic terms in opinions

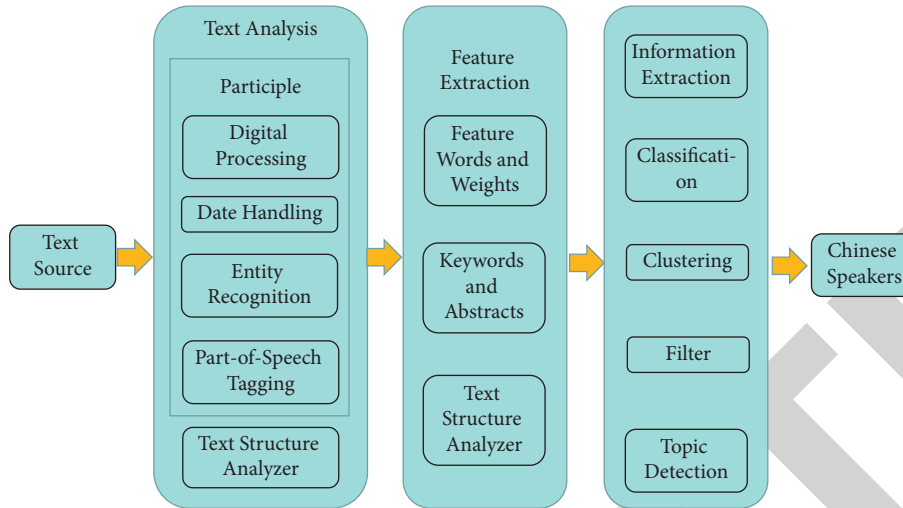


FIGURE 1: Main steps of text mining.

TABLE 1: Text mining classification.

	Words	Documentations
Guided learning	Part-of-speech tagging, disambiguation	Classification, information extraction, topic tracking, and detection
Unguided learning	Semantic analysis, keyword extraction, construction of sentiment dictionary	Book clustering, summarization, topic tracking detection

- (2) Opinion holders are the authors who identify the statement of the opinion or the publisher of the comment
- (3) The choice of statement is to distinguish between subjective and objective descriptions in the text and to extract the part of the statement of opinion
- (4) Sentiment analysis is the determination of the semantic tendencies and strengths of opinion statements

The formulation of the statement is the subjectivity classification problem of the text, and the sentiment analysis of the comments is the sentiment classification problem.

(1) Subjective classification

Let  $S = \{s_1, s_2, \dots, s_n\}$  be a set of sentences for the document. There are a total of  $n$  sentences. Subjectivity classification is a problem of distinguishing opinion-expressing sentences and other subjective sentences from objective sentences describing factual information.

(2) Sentiment classification

For sentiment classification, there are generally two classification methods: two-class sentiment classification and multiclass sentiment classification. Generally, it is necessary to establish a set  $D = \{d_1, d_2, \dots, d_n\}$  and a category  $C = \{\text{positive, negative}\}$ .

Sentiment classification is mainly to label elements  $d_i$  in set  $D$  as factors in category  $C$ .

**2.4. Text Preprocessing.** Before performing sentiment analysis on the text, it is necessary to preprocess the text first. If the text preprocessing cannot be done well in the initial stage, the computational cost of subsequent sentiment classification will increase exponentially. In addition, rough preprocessing will also damage the accuracy of the classification algorithm, so that the ideal classification results cannot be obtained [18]. There are four main ways to preprocess Chinese text: data cleaning, Chinese word segmentation, stop word removal, and simplified and traditional conversion [19].

(1) Data cleaning

In the data cleaning phase, the first thing to do is to unify coding. For the smooth development of subsequent experiments, standardized unified coding is required.

(2) Chinese word segmentation

This paper studies Chinese texts that differ from English texts. English writing uses a space as the separator between each word. In Chinese, there are no separators between words due to the inheritance of ancient traditional writing habits. In ancient Chinese, a single Chinese character often represented the meaning of a word, so people did not need word segmentation to write at that time. With the development of the times, there have been more and more two-character and multicharacter words in modern Chinese. The meaning of a word is no longer the same as a word. Therefore, it is very difficult to understand the meaning of a sentence without precise segmentation.

Different from the mechanical word segmentation method, the statistical word segmentation method focuses more on the adjacent cooccurrence

probability of two words in the string. The algorithm calculates the adjacent cooccurrence probability of each word in the string through point mutual information. When the cooccurrence probability of adjacent words reaches a certain threshold, the algorithm decides that they are likely to form a word. There are many mature Chinese word segmentation systems. There are mainly three popular Chinese word segmentation systems, namely, ICTCLAS word segmentation system, Jieba word segmentation toolkit, and Java word segmentation toolkit. These three systems are sufficient for Chinese text segmentation work.

### (3) Remove stop words

The categories of stop words in Chinese text mainly include words that are used too frequently and words that have no actual meaning.

### (4) Text structuring

Text structuring is an important step in dealing with text classification problems. The processed text is expressed in human language, and the algorithm cannot directly understand the meaning of the text. Therefore, it is necessary to structure the text first to facilitate the understanding of the algorithm. Methods of comparing mainstream text structuring are bag-of-words model and vector space model.

The BW model is a simplified sentiment analysis model, mainly based on natural language. It is mainly composed of words without order and without grammar. The most important thing in this model is the number of occurrences of the word and its weight among all factors. At the same time, it concatenates the bag-of-words models of all documents in the dataset to form a two-dimensional word-document matrix.

**2.5. Feature Selection.** Text data is high-dimensional in most cases. The words combined with Chinese characters and English are at least one million or even ten million. Under normal circumstances, after the text is divided into words, it is normal to leave hundreds of thousands of words after removing stop words. If all words are used as features at this time, the dimension of the feature space will be very high. Such high dimensionality is a disaster for most machine learning algorithms, so feature selection is performed on the data [20].

After feature selection, the operation speed of the algorithm can be accelerated. More informative features can be selected to enhance classification accuracy. The current mainstream feature selection methods mainly include mutual information, information gain, and chi-square test.

## 2.6. Text Vectorization

### (1) TF-IDF algorithm

In a piece of text, different words have different importance. The greater the weight of a word is, the better it can represent the theme of the text. TF-IDF (Term Frequency-Inverse Document Frequency) can be regarded as a statistical method to estimate the

importance of a word to a given text. It is widely used in text classification and information retrieval. Its main idea is as follows. If a word occurs frequently in certain texts but rarely in other texts, it can be considered that this word is very important for this type of text and can represent the text to a certain extent, so as to achieve a better classification effect. The TF-IDF algorithm is usually used to express the importance of words to different categories of text. Applying the TF-IDF algorithm to text feature representation is beneficial to improve the classification effect to a certain extent.

### (2) Word2vec model

Word2vec is a 3-layer shallow neural network model. Text can be converted into vectors after continuous training and optimization using a given corpus and model. The word vectors generated by the Word2vec model can be fed into other neural networks. Word2vec contains two important models. The CBOW model predicts the probability of the occurrence of the current word through the above information and the following information of a word. The Skip-Gram model is just the opposite. The probability of occurrence of the above word and the following word is predicted from the current word.

## 3. Overview of Text Sentiment Analysis Methods

**3.1. Overview of Text Sentiment Analysis.** At present, the research work of text sentiment analysis is mostly through some techniques and methods. It enables the computer to automatically analyze, identify, label, extract, and classify the emotional features contained in people's attitudes and evaluations about certain topics and events. The main research contents include four aspects. These four aspects are subjectivity and objectivity, extraction of emotional information, discrimination of emotional tendency, and calculation of emotional intensity [21, 22].

- (1) The research on identifying subjectivity and objectivity stems from the fact that objectivity texts have no emotional color but are only objective descriptions of things. Such texts have no value for understanding people's emotions. Sentiment analysis for subjective text will do more with less.
- (2) The object of extracting emotional information is mainly the subject, object, emotional vocabulary, and so on expressing opinions. By grasping this information, the collocation relationship between the subject and the object can be obtained. According to the emotional vocabulary, the discrimination accuracy of emotional tendencies can be greatly improved.
- (3) Discriminating emotional tendencies is the classification of emotional polarity. The earliest emotion polarity classification tasks are mostly two-dimensional emotion classification. However, with the continuous expansion and refinement of research,

multidimensional sentiment classification has gradually become a hot research topic.

- (4) Computing sentiment strength refers to using a real number representation for sentiment strength in the text. The polarity of the text can be judged from these values. Since texts often contain more than one affective disposition, most of the existing research on affective intensity calculation is at the sentence level.

The research method of text sentiment analysis mentioned above is shown in Figure 2.

*3.2. Analysis Method Based on Sentiment Dictionary.* The sentiment weight of each word is shown in Figure 3.

The weight of a sentiment word indicates the degree of the word on a certain sentiment tendency. Negative words can reverse emotional tendencies. The weights of degree adverbs indicate the degree of intensity, which can enhance or reduce the inclination of emotional words. According to the needs of specific fields and tasks, the vocabulary in the emotional dictionary can be continuously expanded [23].

After the sentiment dictionary is constructed, the words in the text data can be matched according to the rules. The weights of each word are synthesized to capture the sentiment polarity of the entire sentence. The emotional tendencies of paragraphs, chapters, and ultimately the entire document can be obtained step by step. Specific steps are as follows:

- (1) After text preprocessing, a sentiment dictionary can be constructed.
- (2) According to the given rules, the words need to be matched with the text data to be processed. Whether there is a negative word or an adverb of degree before and after the sentiment word is judged, these negatives and adverbs of degree can be grouped together.
- (3) If negative words or degree adverbs are used to modify the sentiment feature, the weight of the sentiment feature can be defined as the product of the number of negative words and the corresponding weight. Finally, the weight value needs to be multiplied by the degree value of the degree adverb.
- (4) Finally, the final scores for all groups can be summed as the final value. Anything less than 0 is negative. The magnitude of the score means the degree of positivity or negativity.

*3.3. Sentiment-Based Analysis Methods.* The sentiment analysis method established by the sentiment dictionary can also be called the sentiment analysis method based on machine learning. Based on the above methods, text sentiment analysis methods can be used as a learning classification problem. The core idea of the above method to deal with the problem is to complete the task through the algorithm. During the learning process, the performance of the built model will gradually improve. In the field of text sentiment analysis, the essence of this learning method is to structure Chinese text and regard it as two sets of training set and test set [24]. The previously mentioned training set and

test set are introduced into the classification algorithm and text features to establish a classification model. Finally, it is necessary to compare and analyze the results to verify the sentiment polarity of the text.

*3.4. Text Sentiment Analysis Method Based on Deep Learning.*

The most critical step in text sentiment analysis is to extract sentiment features in Chinese texts. At the same time, the extracted emotional features are also the key to ensure the accuracy of the subsequent model building. In general, algorithms and traditional models of text are ensured mainly through human experience. As for the research focus, the text sentiment analysis method based on deep learning and the text sentiment analysis method based on machine learning are consistent [25]. Only through continuous optimization and screening can the selected emotional features promote the analysis of text sentiment. The process of building a multilayer neural network model is shown in Figure 4. After processing the text data, it is necessary to continuously optimize the parameters and transform the features layer by layer during the training process. It can achieve the purpose of improving the quality of text representation and the final prediction accuracy.

Deep learning-based methods are also essentially based on emotional feature learning. However, in the process of text sentiment analysis and training, a large number of Chinese texts are needed as research objects. Only when the Chinese text cardinality goes far enough can the established model learn more emotional features, processing data at scale faster than machine learning methods [26].

## 4. Sentiment Analysis of International and Foreign Chinese Texts with Multifeature Fusion

Due to the rich content and various forms of Chinese texts, the semantic features only composed of text word vectors cannot fully express the emotional information of Chinese texts. Therefore, this paper proposes a text sentiment analysis method based on multifeature fusion. Fusion of multiple features forms a text sentiment classification model MFCNN. The model can learn more dimensional sentiment information of text from the multieigenvector matrix. Compared with the traditional CNN model and other single-feature models on the self-built dataset, the experimental results show that its sentiment classification ability has been effectively improved.

### 4.1. Dictionary-Based Sentiment Value Features

*4.1.1. Build a Dictionary.* The dictionary constructed in this paper includes basic sentiment dictionary, negative word dictionary, and degree adverb dictionary. The Boson NLP sentiment dictionary launched by Boson natural language processing company is used as the basic sentiment dictionary. The dictionary is constructed from text annotated by a large number of social networking sites. Compared with the traditional sentiment dictionary, the Boson NLP sentiment dictionary contains many popular Internet terms. It is more

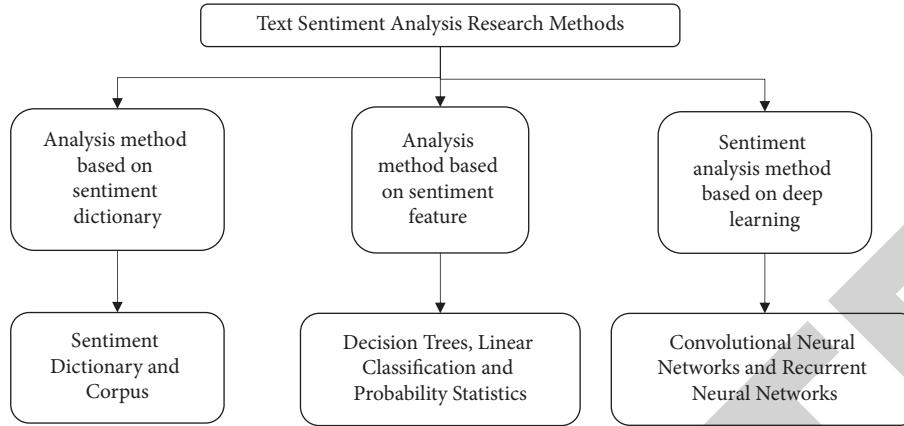


FIGURE 2: Research method of text sentiment analysis.

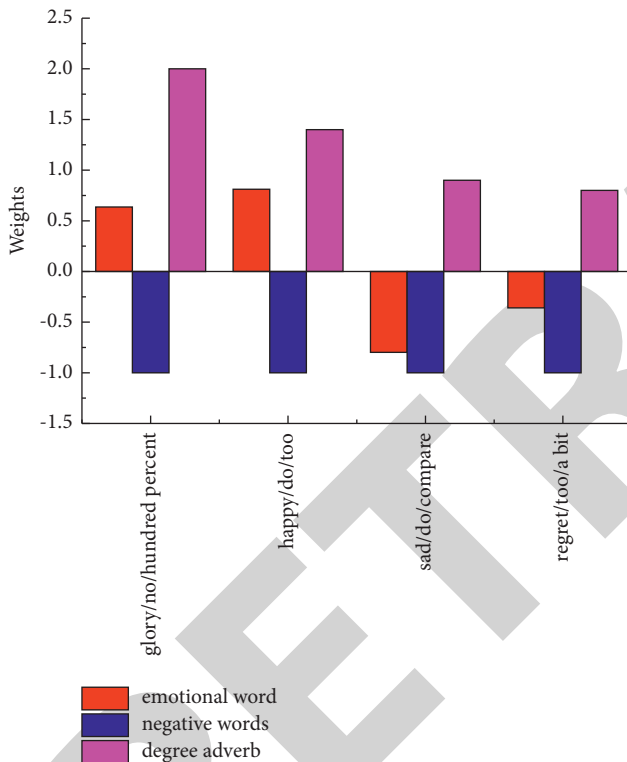


FIGURE 3: The sentiment weight of each word.

suitable for sentiment analysis of international and foreign Chinese texts under the conditions of the new era [27, 28].

There are two kinds of modifier dictionaries in this paper, namely, the dictionary of negative words and the dictionary of degree adverbs. If a negative word appears before the sentiment word, its sentiment tendency is likely to be opposite. This article is based on negative words in Chinese dictionaries. Combining with the common negative words in the text and further expansion, 71 negative words are sorted to form a negative word dictionary, and the weight of negative words is set to  $-1$ . The degree adverbs dictionary refers to the dictionary provided by HowNet and some degree adverbs in international Chinese texts are supplements. The adverbs of degree dictionary have a total of 219 words. A weight needs to be assigned to each degree adverb.

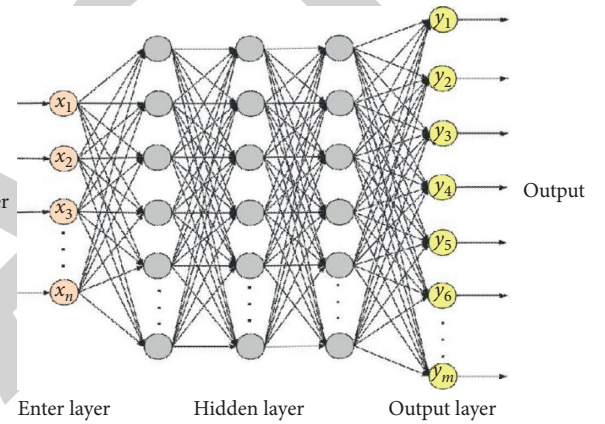


FIGURE 4: Multilayer neural network model.

**4.1.2. Sentiment Value Feature.** Based on the emotional words and modifiers contained in the matching text and the subsequent weighted calculation, the emotional value feature can be obtained as the representation of text emotion.

It needs to input international and foreign Chinese text and output text based on the sentiment value features of the dictionary. Text can be read and preprocessed. A sentiment dictionary is matched with words in the text. If the word is positive, the score is 1 point. If the word is negative, the score is  $-1$ . In neither case, the score is 0. If there is a modifier before the sentiment word, its quantity and weight need to be recorded. The sentiment value of the text can be calculated by

$$\text{score} = \sum_{j=1}^m \text{base} \times \prod_{i=1}^n \text{weight}_i, \quad (1)$$

where  $m$  is the number of bases,  $N$  is the number of weights, base is the base score, and weight is the degree adverb or negative weight.

**4.2. Facial Features.** Emotional words and emoticons are both common carriers of emotional cues. Although sentiment words also have sentiment information, it is not enough just to formulate rules to calculate sentiment scores

for a few words. In contrast to emotion words, emojis use graphical representations [29]. They have richer and more intuitive emotional information, and the emotions they express tend to be stronger. When emojis appear in text, they are more likely to dominate the sentiment of the text message. Statistical analysis of emojis is performed on the self-built dataset, and the results are shown in Figure 5.

As can be seen from Figure 5, 47% of the texts in the dataset contain emojis. It shows that nearly half of the microblogs in the dataset contain subjective emotional expressions displayed. 50% of the positive emotion text contained emojis. 42% of negative emotional text contains emojis. Expression features can be constructed based on the multidimensional information of emojis. This includes factors such as extreme emotions, occurrences, and semantic information of emojis. According to the emoticons in the self-built database, 85 emoticons need to be selected for the next step. Expressions can be divided into three different forms: positive, neutral, and negative. There are 37 positive emotion emojis and 43 negative emotion emojis. For emojis that are ambiguous or have no obvious emotional expression, they can be defined as neutral emotions. There are 5 of these emojis in total. Different emojis express different emotions. A score of  $-2$  to  $2$  is given according to the positive or negative emotion and the strength of the emotion expressed. Expressions expressing positive emotions range from  $0$  to  $2$  from weak to strong. Expressions expressing negative emotions range from  $0$  to  $-2$  from weak to strong. Emoticons that express neutral emotions are assigned a value of  $0$ .

The extreme value of text emotion is

$$\text{score} = \frac{\sum_{i=1}^M F(e_i, \text{pos})}{M} + \frac{\sum_{j=1}^N F(e_j, \text{neg})}{N}, \quad (2)$$

where  $M$  and  $N$  are the numbers of positive and negative emojis in the text, respectively.  $e$  is an emoji.  $\text{pos}$  and  $\text{neg}$  are the extreme value tables of positive and negative emoji, respectively. The function of function  $F$  is to take out the score of the corresponding emoticon in the extreme value table.

The cumulative distribution function (CDF) is

$$F_X(x) = P(X \leq x). \quad (3)$$

Figure 6 shows the relationship between the number of emojis and emotion polarity obtained from the statistical dataset.

It can be seen from Figure 6 that when there are three or more emojis in the text, the probabilities of expressing positive emotions and expressing negative emotions in this type of text are similar. When there are two or less emojis in the text, the tendency to express negative emotions is slightly higher.

When constructing the dataset, the expression words are vectorized through the Word2vec model. The word vector is used as the semantic information for the emoticon and is included in the expression feature.

**4.3. Improved Semantic Features.** In some cases, the semantic features of text can also be text word vectors. This is mainly due to the fact that word vectors themselves have

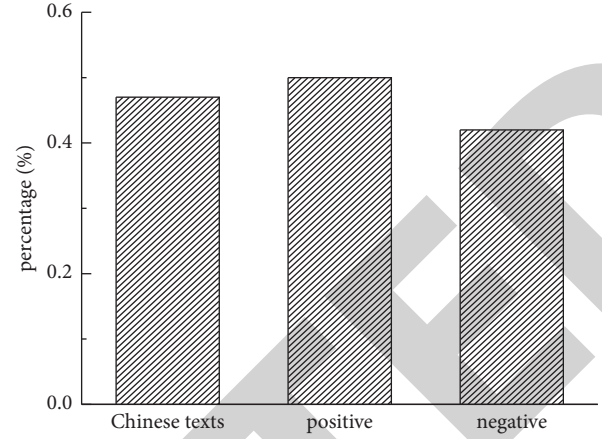


FIGURE 5: Statistical results of text with emojis.

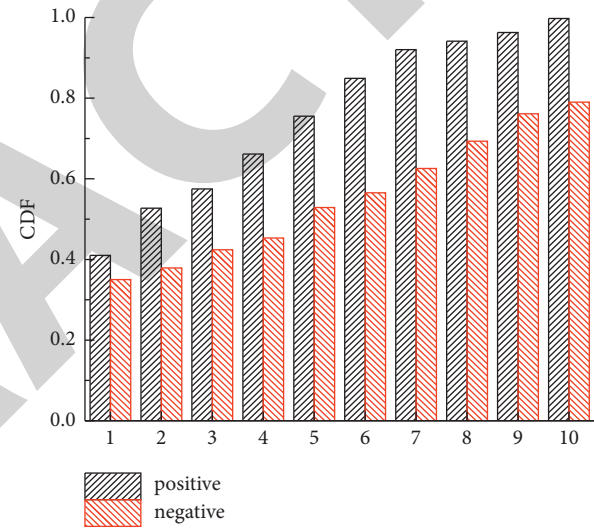


FIGURE 6: The relationship between the number of emojis and emotional polarity.

semantic information [30]. Therefore, this paper adopts the model Word2vec to convert all texts into text word vectors. In this way, there is no need to think too much about multidimensional issues, and the sequence information of words in the text is preserved as much as possible. In order to make the sequence information of the words in the text more perfect, the TF-IDF algorithm needs to be used to solve it. The text word vectors obtained based on the two above methods not only retain sequence information but also have corresponding weights. A text  $d_i$  can be assumed. The number of words after participle is  $Q$ . The word vector dimension is  $L$ . The text of the article is expressed as

$$d_i = \langle w_1, w_2, \dots, w_n \rangle. \quad (4)$$

The text contains multiple words, and each word has its corresponding word vector. By splicing them together, a vector matrix  $G(d_i)$  of  $Q \times L$  dimension of the text can be obtained. By multiplying with its weight matrix, the vector matrix  $W_G(d_i)$  can be obtained.



$$\begin{aligned} G(d_i) &= \{W(w_1), W(w_2), \dots, W(w_Q)\}, \\ W\_G(d_i) &= \{\text{weight}(w_1)W(w_1), \text{weight}(w_2)W(w_2), \dots, \text{weight}(w_Q)W(w_Q)\}, \end{aligned} \quad (5)$$

where  $W(w_i)$  is the word vector of word  $w_i$  in the text.  $\text{Weight}(w_i)$  is the weight value of word  $w_i$  calculated by the TF-TDF algorithm.

**4.4. Text Sentiment Analysis Method with Multifeature Fusion.** This paper takes the sentiment feature as one of the multilevel features. A text sentiment analysis method integrating multilevel features is established. The steps of establishing a text sentiment analysis method with fused multilevel features are obtained as shown in Figure 7.

The text part is stored in  $D_b$ , and the expression part is stored in  $D_e$ . The text preprocessing is performed on  $D_b$ , and the sentiment value feature of the text is calculated by combining the sentiment dictionary and the modifier dictionary.  $D_t$  is trained by the improved Word2vec model to obtain the text word vector, which constitutes an improved semantic feature. The emotion extrema of the expression are calculated by combining the emoji emotion extrema table. Together with the number of expressions and the semantic information, the expression features are formed together. The three features are fused to perform text sentiment analysis. As the most popular method for text sentiment analysis and building deep learning models, Text CNN is widely used in various sentiment analysis research works. Therefore, this paper takes it as the core of the research. Based on this method and theory, a novel sentiment analysis model (MFCNN) with multifeature fusion is established. The process of building a model is mainly to transform vectors through features and then construct a multifeature vector matrix through feature fusion. Finally, the model is obtained by inputting the textual convolutional neural network.

In summary, the fusion of multiple features is used to solve the problem of sentiment analysis of international and foreign Chinese texts. A new research scheme is provided for improving the performance of microblog text sentiment analysis.

## 5. Analysis of Results

**5.1. Text Vectorization.** Text vectorization is to convert the text that has been preprocessed into words and convert each word into a vector. Then, each word vector is formed into a vector matrix according to the order of the words in the text. This way the mapping of words to a vector space preserves their semantic information. Text vectorization is the cornerstone of text research. Whether the word vector can be correctly expressed will affect the judgment of text orientation. In this paper, the Word2vec model before and after the improvement is used to vectorize the text, and the final

sentiment classification results are compared. The specific parameters of the Word2vec model are shown in Table 2.

**5.2. Experimental Environment.** The experimental environment of this paper is shown in Table 3.

**5.3. Evaluation Standard.** The main evaluation indicators of text sentiment analysis are accuracy, precision, recall, and  $F_1$  value. The accuracy ( $Y_1$ ) is expressed as

$$Y_1 = \frac{A_1 + A_2}{A_1 + A_2 + A_3 + A_4}, \quad (6)$$

where  $A_1$  represents predicted positive affect and actual positive affect.  $A_4$  represents predicted positive affect and actual negative affect.  $A_3$  represents predicted negative affect and actual positive affect.  $A_2$  represents predicted negative affect and actual negative affect.  $Y_1$  is the accuracy rate.

The accuracy ( $Y_2$ ) is expressed as

$$Y_2 = \frac{A_1}{A_1 + A_4}. \quad (7)$$

The recall rate ( $Y_3$ ) is expressed as

$$Y_3 = \frac{A_1}{A_1 + A_2}. \quad (8)$$

The  $F_1$  value is a comprehensive consideration of precision and recall:

$$F_1 = \frac{2Y_2Y_3}{Y_2 + Y_3}. \quad (9)$$

The macro precision ( $P$ ), macro recall ( $R$ ), and macro  $F_1$  value ( $F_{11}$ ) can be

$$\begin{aligned} P &= \frac{1}{k} \sum_{i=1}^k Y_2(i), \\ R &= \frac{1}{k} \sum_{i=1}^k Y_3(i), \end{aligned} \quad (10)$$

$$F_{11} = \frac{1}{k} \sum_{i=1}^k F_1(i).$$

**5.4. Analysis of Results.** In order to make the fusion multifeature text sentiment analysis method better compare with the traditional high-level method, seven groups of fusion different multilevel feature analysis methods can be designed

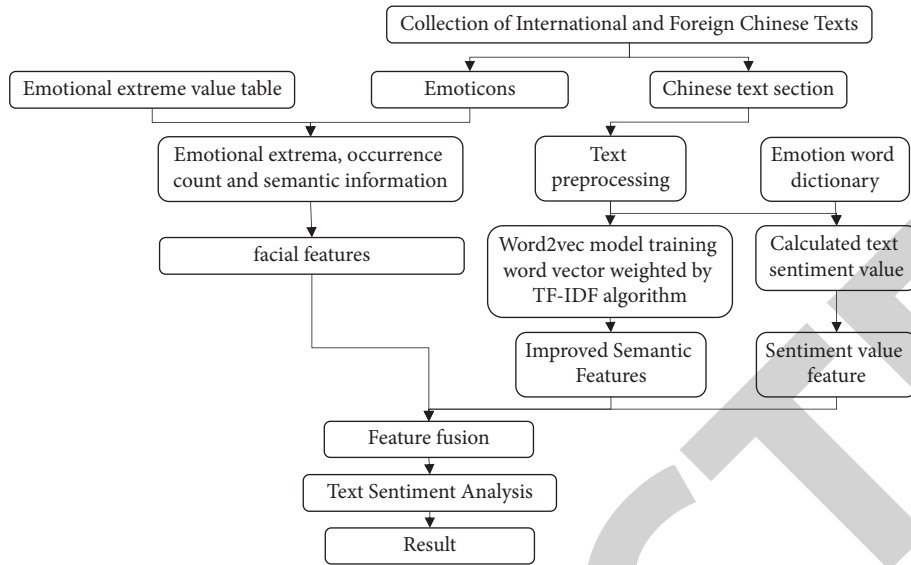


FIGURE 7: Flow chart of text sentiment analysis with multifeature fusion.

TABLE 2: Word2vec model parameter values.

Parameter	Values
Sentences	Data
Sg	0
Size	150
Window	5
min_count	5
hs	0
Iter	5

TABLE 3: Experimental environment.

Experimental environment	Specific configuration
Operating system	Windows 10
CPU	Intel (R) Core (TM) i7-10710U CPU
RAM	32 GB
Programming language	Python 3.6
Development tools	JetBrains PyCharm
Deep learning framework	Keras
Word vector training tool	Word2vec

as comparative experiments. These seven analysis methods must adopt the fusion method of different characteristics.

**CNN model:** The word vectors trained by the Word2vec model are input to Text CNN for text sentiment classification.

**TCNN model:** Word vectors are trained by Word2vec model weighted based on TF-IDF algorithm. Text sentiment classification is by input to Text CNN.

**SCNN model:** On the basis of the CNN model, the dictionary-based sentiment value features are fused.

**ECNN model:** On the basis of the CNN model, the expression features are fused.

**TSCNN model:** On the basis of the TCNN model, the dictionary-based sentiment value features are fused.

**TECNN model:** On the basis of the TCNN model, the expression features are fused.

**MFCNN model:** The dictionary-based sentiment value features, expression features, and improved semantic features are fused to form a multifeature vector matrix.

The text sentiment analysis method used in this paper is mainly based on the Text CNN model. The parameter values of this method are obtained as shown in Figure 8.

The maximum length of text reserved is 120. The part of the text whose length exceeds 120 will be discarded, and the

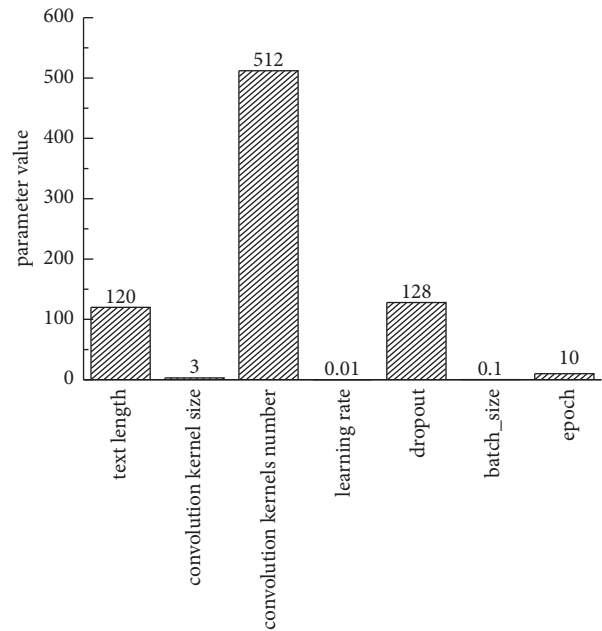


FIGURE 8: Model parameter values.

part whose length is less than 120 will be filled with 0. Other parameters not in the above table use default values.

The comparison results of the 7 groups of models on the binary dataset are shown in Figure 9.

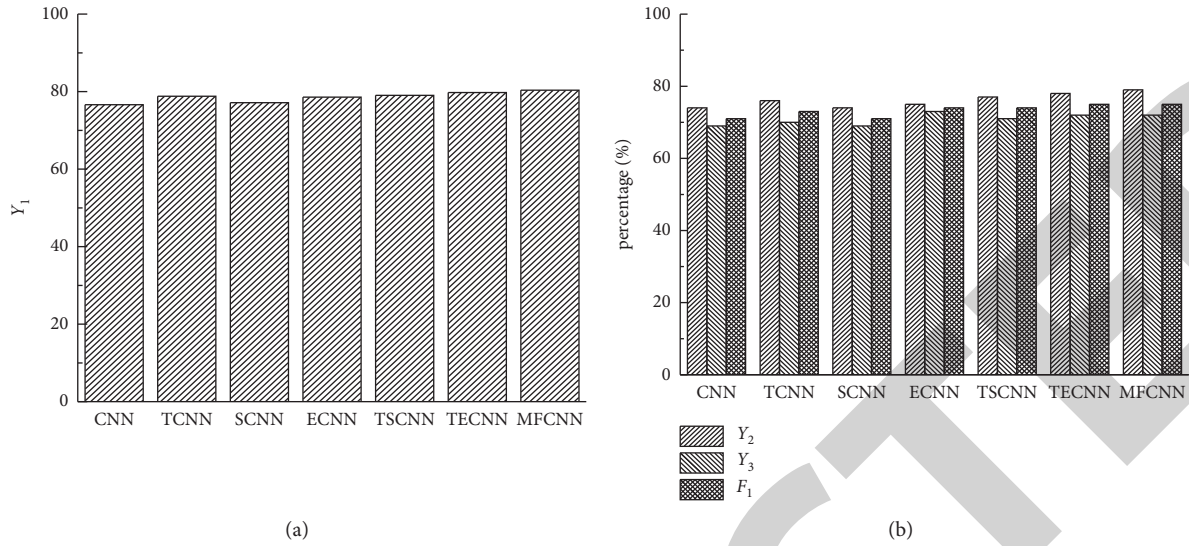


FIGURE 9: Comparison of experimental results. (a) Model accuracy. (b) The other three indicators.

It can be seen from the change rule of the histogram in Figure 9 that the accuracy of the improved model is much higher than that of the traditional model. This shows that the multilevel feature fusion model has greatly improved the effect of international and foreign Chinese text sentiment classification. This is mainly because the improved model can obtain more dimensional emotional information, which in turn improves the accuracy of the model.

Compared with the accuracy of the traditional model, the accuracy of the TCNN model fused with multilevel features can be greatly improved. This accuracy improves by about 22.1%. This shows that the model after the improvement of the TF-IDF algorithm has a positive effect on improving the weight of keywords in the text. The model incorporating multilevel features, after being improved by the TF-IDF algorithm, can help improve the performance of sentiment classification.

Compared with the CNN model, the accuracy of the TSCNN model, which combines the improved semantic features and sentiment value features, is improved by 24.2%. Compared with the CNN model, the accuracy of the TECNN model, which integrates the improved semantic features and expression features, is increased by 31.7%. The model accuracy improved by 31.7%. The MFCNN model that finally fuses the three features is 5.9% to 37.6% more accurate than other comparison models. It shows that the MFCNN model can learn more dimensional emotional information of text from the multifeatured vector matrix. The feasibility and effectiveness of the method are proved.

Compared with the accuracy of the traditional model, the improvement of the accuracy of the model after the model fusion of a single feature is not obvious. Therefore, when a single feature is fused to build a model, it does not help to improve the accuracy.

This paper proposes a weighted Word2vec model to train word vectors based on the TF-IDF algorithm. To demonstrate its effectiveness, it is compared with the traditional

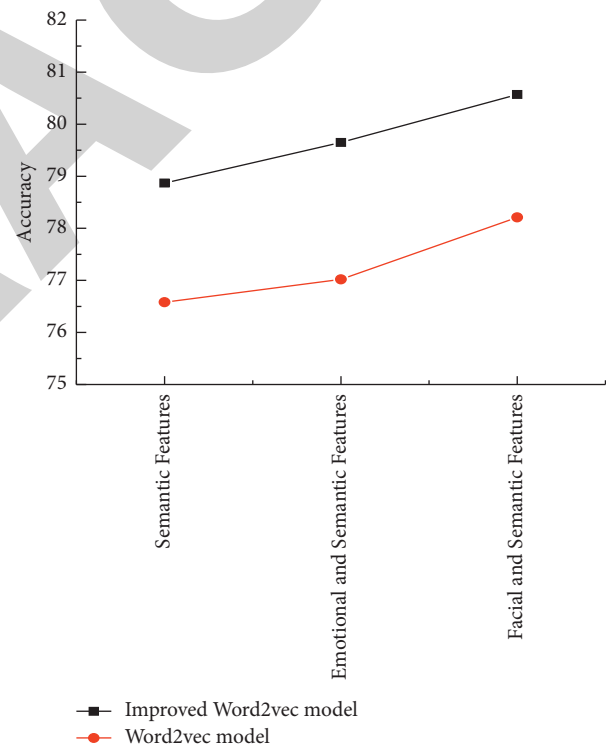


FIGURE 10: Comparison of the accuracies of the improved Word2vec model and the traditional model.

Word2vec model in three sets of experiments. The experimental results are shown in Figure 10.

It can be seen from Figure 10 that the improved Word2vec model achieves better results in sentiment analysis.

## 6. Conclusions

Based on the multilevel feature fusion theory, a novel text sentiment analysis method is proposed. By analyzing the

feature information related to sentiment polarity in microblog texts, dictionary-based sentiment value features, expression features, and improved semantic features are constructed, respectively. In the designed text sentiment classification model fused with multiple features, the features are combined in various ways through different feature construction methods, which can reflect the classification effect after fusing each feature. The experimental results show that the fusion of expression features or improved semantic features has a great improvement. The improvement effect of fusion emotional value features is small. The text sentiment classification model MFCNN that fuses multiple features achieves the best performance. It shows that the multifeature fusion gives full play to the complementary role of expression information, text information, and other information and further improves the sentiment classification effect of Weibo text.

A dictionary-based sentiment value feature, facial expression feature, and improved semantic feature are constructed. In the designed text sentiment classification model fused with multiple features, the features are combined in various ways through different feature construction methods. It can reflect the classification effect after fusing each feature. The experimental results show that the fusion facial features or the improved semantic features have a great improvement. The improvement effect of fusion emotional value features is small. The text sentiment classification model MFCNN that fuses multiple features achieves the best performance. It shows that the multifeature fusion gives full play to the complementary role of expression information, text information, and other information and further improves the effect of sentiment classification of international and foreign Chinese texts.

## Data Availability

The dataset can be accessed upon request.

## Conflicts of Interest

The author declares that there are no conflicts of interest.

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