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| RESEARCH ARTICLE

Emotion Recognition-oriented Mobile Phone Users Purchase Evaluation Analysis

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| ABSTRACT
Sentiment analysis refers to analyzing people's emotional tendencies expressed in subjective texts. Emotional dictionary and machine learning-based analysis methods are the main research methods. Appraisal theory, developed by linguist J. R. Martin based on systematic linguistics, is mainly divided into three subsystems: engagement, attitude, and graduation. Based on the attitude system of appraisal theory, this paper analyzes 158 overseas purchase evaluations of the Xiaomi mobile phone using the emotion dictionary. 158 corpora were evaluated based on the selection of adjectives, adverbs, and negative words as categories of the Emotional Dictionary from 500 online shopping reviews and their ratings as criteria for emotional attitudes. The results prove that consumers generally have a positive attitude towards Xiaomi mobile phones, which are embodied in battery performance, mobile phone fluency, and camera, while the network compatibility and overall performance of mobile phones show a relatively negative emotional tendency. Therefore, this research can help consumers and businesses conduct sentiment analysis in a more comprehensive and efficient way, promote purchase decisions, and enhance product competitiveness. This study also provides enlightenment for the combination of appraisal theory and sentiment analysis.

| KEYWORDS

Emotional recognition; Purchase evaluation; Attitude system.

| ARTICLE INFORMATION

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1. Introduction

Sentiment analysis refers to the process of analyzing, processing, summarizing, and reasoning about subjective texts with emotional tones. It has become a research focus in fields such as computer science, computational linguistics, and natural language processing (Zhang, 2018). Sentiment analysis extracts people's opinions, emotions, evaluations, or attitudes from the text and analyzes how language is used to convey these opinions (Liu, 2020; Tripathy et al., 2015).

Appraisal theory, developed by linguists such as J. R. Martin on the basis of functional linguistics, aims to study how speakers attribute evaluations to language objects through language. It can be used to analyze the attitudes and stances of authors and speakers and to reveal how discourse activates various evaluative resources. The appraisal system provides a systematic emotional classification for sentiment analysis, enhancing the complexity and precision of emotional information. It also offers a new research direction that combines linguistics with natural language processing (Zhang, 2018).

With the development of the internet and cross-border e-commerce, sentiment analysis methods are increasingly applied to the analysis of purchase evaluations. Recently, Xiaomi smartphones have become one of the most popular Chinese products among overseas consumers in recent years.

Under such circumstances, as well as from an interdisciplinary perspective, this study combined appraisal theory with computational text sentiment analysis to analyze overseas users' purchasing evaluations of Xiaomi smartphones. First, we

integrated the attitude system with the sentiment analysis method to select, classify, and score emotional words in discourse text. Then, we built a domain-specific sentiment dictionary for smartphone purchase evaluations. Finally, we use Python regular expressions to match the dictionary with the corpus and calculate sentiment scores. By analyzing review texts based on attribute analysis, we aim to locate the aspects of strengths and weaknesses of products in a more effective and subtle manner. The combined contribution of both the adoption of sentiment analysis and appraisal theory provides insights into pedagogical implications for business English and business discourse analysis.

2. Literature Review

This study primarily analyzes the attitude system within the framework of the appraisal system. The Attitude System is further divided into three subsystems: affect, judgment, and appreciation. Affect refers to the positive or negative feelings of individuals; judgment evaluates the characteristics of a person, object, or behavior based on moral and ethical standards or social norms; and appreciation involves evaluating the value of objects according to specific criteria (Martin & Rose 2007). Therefore, affect encompasses more subjective attitudes, while judgment and appreciation take a more objective approach to evaluation. From a macro perspective, the Attitude System can be categorized into explicit and implicit attitudes, positive and negative attitudes, as well as distinctions in the source and intensity of the attitude (Shao & Wang, 2019). The integrated analysis approach employed in this study comprehensively incorporates most of these distinctions.

The primary research methods for sentiment analysis include approaches based on sentiment dictionaries and those based on machine learning. Depending on the granularity of the text, sentiment analysis can be divided into three levels: document-level, sentence-level, and aspect-level sentiment analysis. This means that sentiment analysis can be categorized into three tiers: discourse, sentence, and word (Wang & Bu, 2017). Unlike document-level and sentence-level analysis methods, aspect-level sentiment analysis focuses on analyzing different attributes of the target object, resulting in higher accuracy in sentiment analysis outcomes (Liu, 2020). This study applies the Attitude System and uses a sentiment dictionary-based method to conduct aspect-level sentiment analysis.

Sentiment analysis based on sentiment dictionaries involves extracting the sentiment values of words from a document by utilizing a sentiment dictionary. Prior to discourse analysis, it is necessary to construct a specific sentiment dictionary. Words from the evaluation discourse are then matched against the sentiment dictionary, and the overall sentiment orientation of the document is determined through weighted calculations. This method allows for the sentiment classification of words, making it easier for analysis and for readers to understand. The earliest English sentiment dictionary was SentiWordNet, and other commonly used resources include General Inquirer, Opinion Lexicon, and MPQA. In Chinese, widely applied sentiment dictionaries include the HowNet dictionary and the Chinese Sentiment Lexicon Ontology developed by the Dalian University of Technology (Che & Li, 2021; Wang et al., 2022). In this study, a sentiment dictionary for the mobile phone domain was constructed specifically by filtering adjectives, adverbs, and negation words from a larger review discourse of smartphones and assigning them varying degrees of sentiment scores and weights. Then the dictionary was extended by adding synonyms in further reference to SentiWordNet.

In sentiment analysis, linguistic research on discourse evaluation often adopts perspectives such as appraisal theory, metaphor, and pragmatics to study the evaluative features of discourse and the discourse strategies and functions they reflect. For example, Khoo et al. (2012) applied the appraisal system to political news reports on Iraq, analyzing the economic policies of Bush and Ahmadinejad. Computational linguistics approaches sentiment analysis using methods based on sentiment dictionaries or machine learning, primarily focusing on topic and opinion extraction, statement selection, evaluation word extraction, and sentiment recognition. This type of analysis often centers around mining opinions from product reviews, online news, microblogs, and movie reviews, as well as conducting online and media sentiment analysis, political news analysis, and more (Wang & Bu, 2017). For instance, Korenek & Šimko (2014) conducted sentiment analysis of microblog posts using a manually created sentiment dictionary and the appraisal system. Subsequently, scholars such as Taboada (2016) conducted more detailed research on the classification and evaluation of language in sentiment analysis, including assigning weights to sentiment intensifiers. Zhang (2019) analyzed overseas reviews of The Three-Body Problem using the sentiment analyzer in TextBlob. Similarly, Shao & Wang (2019) utilized Python and deep learning techniques to mine data, establish sentiment orientation models, and analyze sentiment in discourse related to reviews of well-known e-commerce platforms.

In sentiment analysis methods based on sentiment dictionaries, Zong et al. (2021) automatically constructed a sentiment dictionary for rural tourism by using the N-Gram language model and TF-IDF term frequency statistics to filter sentiment words from online reviews. Gao & Zhang (2021) conducted sentiment analysis of hotel reviews using a sentiment dictionary that incorporated professional dictionaries, including HowNet's sentiment dictionary, a phrase dictionary, a negation dictionary, and an adverb dictionary, as well as related domain-specific dictionaries, to classify sentiment.

However, in most studies, sentiment classification primarily focuses on two aspects: positive and negative, which cannot encompass all emotional information and lacks depth and systematization. Zhang (2018) argued that discourse analysis based on the Attitude System not only involves different categories and polarities of emotions but also allows for the extraction of elements such as sentiment orientation, sentiment holders, and evaluations, enabling deeper research at the semantic level. Zhang's study introduced the Attitude System as a framework for classifying sentiment orientation in texts, conducted a detailed analysis of training corpora, and achieved a high level of accuracy in machine learning based on sentiment lexicons. Che & Li (2021) also applied the appraisal system to analyze and compare the sentiment discourse in English-language letters to shareholders from Chinese and American companies. They built a specialized sentiment dictionary for this particular corpus and used this sentiment-laden portion of the text as a training set for machine learning to determine the sentiment polarity of the remaining text.

Therefore, it is evident that appraisal theory and sentiment analysis are often integrated through sentiment dictionary methods. Appraisal theory not only systematizes human emotions, including feelings and emotions but also involves the judgment of human behaviors and the appreciation of objects, encompassing the source and intensity of attitudes. Additionally, it can address various factors, such as the evaluator, the object of evaluation, the evaluative category, and the context. Thus, this paper posits that integrating the two approaches and conducting aspect-level analysis can yield more precise analytical results.

3. Methodology

Based on the theoretical framework, we provide a novel way of analyzing comments discourse, adopting appraisal theory and methods in sentiment analysis. Some methods have been adjusted to fit our study. The process of aspect-based analysis, emotional dictionary building and score computation will be illustrated respectively in this chapter.

3.1 Aspect-based Sentiment Analysis

In the previous section, we discussed our choice of aspect-level sentiment analysis based on text granularity. The sentiment analysis method selected was the sentiment dictionary-based approach. According to Liu (2010, 2020), aspect-level analysis is typically presented in the form of a quintuple (e, a, s, h, t), where e represents the entity (i.e., the object of analysis), a represents the attribute (i.e., the various attributes of the entity; if the evaluation is of the entity as a whole, this field is filled with "general"), s indicates the sentiment polarity (positive or negative), h refers to the source of the sentiment, and t represents the time the sentiment was expressed. This method of analysis is particularly efficient for products like mobile phones, which have distinctive attribute features, and it makes the analysis results more intuitive.

In this study, we adopted the concept of aspect-level analysis but modified the quintuple into a triplet (e, a, s) to suit our analysis goals. Here, e generally refers to the object of analysis, namely Xiaomi mobile phones. a represents different attributes such as battery performance, camera quality, and price. In this context, s not only reflects the sentiment polarity but can also indicate the underlying reasons for the sentiment through adjectives. Below is an example of an English review:

"I really love Xiaomi and Redmi phones. This is my third one, and I have usually had a good experience with them. This is also a great phone too, especially for the price of $148, which I paid, and the beautiful green color. I like everything about this Redmi 9 and all its features, except when I take pictures with it, they come out over-saturated in color."

Substantially, this study first selected 500 mobile phone user reviews from the Amazon platform, comprising approximately 28,000 words. Adjectives, adverbs, and negation words were extracted from these reviews to construct a sentiment dictionary specific to the mobile phone domain, which served as a standard for sentiment orientation judgment. Subsequently, we scraped all 158 purchase reviews written in English for the Redmi 9 International Edition, which was released by Xiaomi in 2020, for analysis. Based on this analysis, we obtained examples of aspect-level analysis, as shown in Table 1.

From this text, we extracted three attributes: price, features, and camera. Based on these attributes, we categorized the sentiment words accordingly. As a result, this review was summarized as an attitude classification centered around these three aspects, allowing us to more intuitively observe the performance features of the phone that consumers focus on, along with their corresponding evaluations and the underlying reasons for those sentiments.

Entity	Aspect	Sentiment (Reason)
Xiaomi	price	Positive (great)
Xiaomi	feature	Positive
Xiaomi	color	Positive (beautiful)
Xiaomi	camera	Negative (over-saturated)

Table 1 An example of aspect-based sentiment analysis

3.2 The Building of An Emotional Dictionary

The sentiment analysis method based on sentiment dictionaries first utilizes the dictionary to obtain sentiment values for sentiment words, followed by a weighted calculation to determine the overall sentiment orientation of the text. This method allows for the definition of the sentiment of words, making it easier for readers to analyze and understand. In this approach, we first used the nltk library in Python to assign part-of-speech tags to the raw text, then extracted adjectives, adverbs, and negation words. Following the scoring standards and methods provided by Taboada et al. (2011, 2016) and Liu (2010, 2015), we assigned sentiment scores ranging from -4 to -1 and 1 to 4 to adjectives according to the three subsystems of the Attitude System. Negation words were assigned a score of -3, and adverbs were weighted accordingly, resulting in a complete sentiment score. For example, the adverb "really" was given a weight of 15%, "very" a weight of 25%, and the adjective "good" a score of +2, so the sentiment score for "really very good" would be [2(100% + 25%)](100% + 15%) = 2.875.

We used Python's regular expressions to match our dictionary to the text for aspect-level analysis and sentiment scoring. Accordingly, our research primarily focuses on the following questions:

1. How can the Attitude System be integrated with sentiment analysis methods?
2. What are the characteristics and advantages of this combined analysis approach?
3. What contributions does the Attitude System make to sentiment analysis?

Thus, with the aid of the large model and further manual integration, our sentiment dictionary is overall as shown in Table 2.

Attitude system	Emotion words	Score	Sentiment
Affection	acceptable (3)	1	Positive
	willing happy (8)	2	
	impressed, surprised (7)	3	
	favorite satisfied (9)	4	
	Insufficient (5)	-1	Negative
	worried (7)	-2	
	disappointing cheated (8)	-3	
	distasteful repugnant (4)	-4	
judgment	entry-level ok (16)	1	Positive
	good nice (10)	2	
	great amazing (14)	3	
	excellent fantastic (19)	4	
	shaky (7)	-1	Negative
	hard complex (11)	-2	
	poor false defective (17)	-3	
	terrible appalling (11)	-4	
Appreciation	serviceable able (8)	1	Positive
	bright large (11)	2	
	useful better durable (16)	3	
	greatest biggest choicest (8)	4	
	insignificant trivial unimportant (5)	-1	Negative
	loose over-saturated (13)	-2	
	useless inconsiderable worthless (3)	-3	
	Ridiculous worst (5)	-4	
Negative words	not never nothing non- (4)	-3	
Adverb	really15 very25 definitely100 (15)	%	

Table 2 Emotional dictionary

3.3 Sentiment Score Computation

The final sentiment scoring is conducted based on the different attributes extracted from a piece of text and is scored using the sentiment dictionary built around the framework of the Attitude System. The following example illustrates the entire process with scoring examples listed in Table 3.

"*I really15% love Xiaomi and Redmi phones. This is my third one and I have usually had a good experience with them. This is also a great3 phone too, especially for the price of $148, which I paid, and the beautiful green color. I like everything about this Redmi 9 and all it is features, except when I take pictures with it, they come out over-saturated-2 in color. I have been trying to remedy it by trying different settings. I have even tried different phone camera apps, but they still turn out too15 bold-2 in color. Not sure exactly what is causing this unless it is an algorithm issue. Perhaps a Xiaomi camera app update will cure the problem. Otherwise, everything is great3 about this affordable1 smart phone. The screen is actually better3 looking than my more expensive AMOLED screen phones. It has a very25% natural1 color and quality. So as of right now, I do not use this phone often for photographs. sound quality is fantastic4 using earphones and headphones. So, it must have a quality DAC chip. Would give the phone 5 stars but because of the problems with the camera, it gets only 4.*"

Entity	Aspect	Reason	Adj	Adv	Neg	Score
Xiaomi	price	great	3		\	
Xiaomi	feature	good experience, beautiful color	2+3=5		\	
Xiaomi	camera	over-saturated, too bold	-4	15%	\	-2-2*(100%+15%) = -4.3
Xiaomi	general	great, affordable	3+1=4		\	
Xiaomi	screen	very natural color and quality	3+1=4	25%	\	3+1(100%+25%) = 4.25
Xiaomi	Sound quality	fantastic	4		\	

Table 3 Sentiment scoring example

4. Results and Discussion

Based on the scores, we further provide the results of customers' opinions in the general situation and in separate aspects. The advantages of our combination are discussed ultimately.

4.1 Attitude in General

According to the frequency of aspect, we got data in table 4 below.

Aspect	Frequency	Average score
General	86	4.82
Price	30	2.83
Battery	17	3.0
Screen	14	2.77
Speed	12	2.92
Camera	11	1.7
Quality	10	0.88
Fingerprint system	6	1.4
Shipping	6	2.6
Honesty	6	-0.3
Function	6	2
Wi-fi and network	6	-2.2

Table 4 Frequency of aspects

We can see that in addition to the general evaluation, consumers are more concerned about the price, battery, screen, speed, camera, and other aspects of Xiaomi mobile phones, or we can say that Xiaomi mobile phones have prominently positive or negative characteristics in these aspects. Thus, we have a preliminary understanding of its characteristics and the aspects that consumers care about.

Based on the sentiment scores associated with various attributes, it can be concluded that customers are generally satisfied with the overall performance of the smartphone. By utilizing our methodological framework, we can identify the specific reasons behind these sentiments by referencing the emotional words linked to the corresponding attributes in the indexed triplets and referring to the original text.

Firstly, the battery received a high score due to its durability, which is one of the key advantages of this smartphone. Customers expressed satisfaction with the price, screen quality, delivery speed, and packaging protection, all of which received relatively high average scores. This indicates a general approval of the phone's cost-effectiveness. In terms of the camera, while opinions varied, the overall sentiment was positive, suggesting significant potential for improvement in this area.

The only negative scores were related to network performance and integrity. The primary issue with the Wi-Fi and network was poor compatibility, which led to the most negative feedback. Regarding honesty, customer comments highlighted concerns about the alignment between advertising and actual performance, with some customers feeling that the marketing was exaggerated. This is an area that warrants improvement. Customers were generally satisfied with the stability of the fingerprint and facial recognition systems. However, according to the original comments, opinions on the speed of these recognition systems varied. Some customers viewed it positively, while others held the opposite view.

4.2 Attitude in Different Aspects

Aspects are usually presented in the form of nouns. Based on the aspects abstracted, we further summarize the collocation of emotion words to obtain the emotional tendency of consumers expressing these aspects; we present the results in word clouds as follows:

Figure 1 Modifiers for the aspect of price

In addition to the expression of "not worth," consumers mainly express their satisfaction with the price. Therefore, Xiaomi mobile phones are very cost-effective overall.

Figure 2 Modifiers for the aspect of battery

In addition to the general praise words, adjectives such as big and long can concretively show the advantages of its battery performance, mainly in terms of durability.

Figure 3 Modifiers for the aspect of screen

The screen seemed full of positive comments. However, comments about the screen are contradictory or neutral because the characteristics of its brightness and size will embody different feelings for different individuals.

For example, if the word "hard" refers to its ability to resist cracking, then it is probably a good characteristic. In the original comment text, it is "hard to see outdoors in the sun," which corresponds to the emotional word "bright." So, hard here refers to operability rather than crack resistance, while bright is more negative. Therefore, the context of the text is also a very important analysis factor.

Figure 4 Modifiers for the aspect of speed

The description of speed is mainly fast, so consumers are mainly positive about speed.

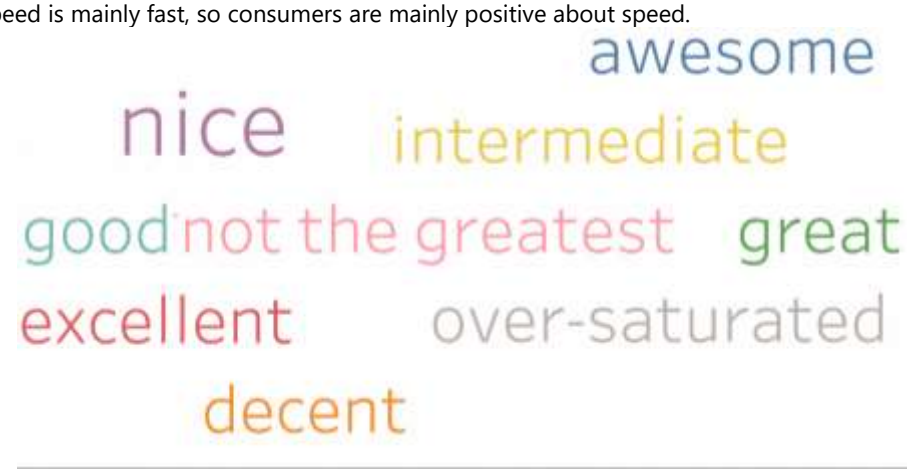

Figure 5 Modifiers for the aspect of camera

Judging from the modifiers, we can see that the camera performance is generally very good. Among them, the negative word "over-saturated" also directly reflects the need for improvement. This adjective reflects the reasons for consumers to have negative attitudes and can also help businesses find improvement points more directly and efficiently.

In the same way, we extract the frequency of emotion words to see which aspects are modified by different emotional tendencies. And summarized in Table 5 as follows:

Adjective	Frequency	Modified aspects	Frequency
good	56	general	22
		price	5
		battery	3
great	56	general	13
		price	6
		battery	2
excellent	15	general	10
		battery	2
fast	14	speed	7
		general	3
		charge	1
		Fingerprint scanner	1
		shipping	1
nice	13	general	5
		price	2
		camera	2
		screen	1
		display	1

Table 5 Frequency of modified aspects

All the high-frequency adjectives we have selected have positive meanings, so we can easily draw the competitive advantage of Xiaomi phones from the subjects they modify. Consumers have given a high evaluation of its overall performance, and the rest of the praise is mainly credit to its cost performance, battery, camera, and fingerprint scanner.

4.3 The Effects of Attitude System

After conducting sentiment analysis based on the Attitude System, we return to examine the role of the Attitude System itself in sentiment analysis; out of a total of 7,650 words, 721 words in our corpus of purchase reviews matched with the domain-specific dictionary. After removing duplicates, the following table presents the distribution of the remaining words.

Attitude system	Sentiment	Frequency
Affection	Positive	19
	Negative	9
Judgment	Positive	248
	Negative	30
Appreciation	Positive	148
	Negative	35

Table 6 The distribution of attitude system in sentiment analysis

Among the three subsystems, the comment discourse of Xiaomi mobile phones is mainly based on judgment, followed by appreciation and emotion. Representative words in the judgment are "good," "great," and "excellent." In the analysis of the previous chapter, these words mainly modify aspects like general, price, and battery. Judgment has a high tendency to express aspects' characteristics, which is mainly due to its own function of describing the characteristics of things. In addition, products like mobile phones are inherently made up of various aspects or functions, so the judgment system can largely help us distinguish consumer attitudes toward different aspects.

Appreciation is a manifestation of value, so it can be used as a reference standard for potential buyers. Words such as worth, cheap, and inexpensive can well reflect their value representation function. Specifically, words like able, capable, and compatible reveal the value of certain features on the phone, such as web and mobile compatibility. Bright, big, and huge are words that give us more insight into the state of the screen. Words such as fast, sluggish, and slow provide us with information about speed. Therefore, we can understand the value of each part through the appreciation system. A product like a mobile phone is more of a luxury than a necessity like rice, so consumers are initially highly focused on its material value. Therefore, appreciation has a very prominent

role in this aspect, and customers can refer to the appreciation system according to their own preferences and needs to make timely purchase decisions.

Finally, we can see that the affective system plays a relatively insignificant role in emotion analysis. The reason is most likely because consumers generally value the utility and material properties of electronic products like mobile phones, which are often reflected in judgment and appreciation systems.

To sum up, the application of the attitude system in sentiment analysis can well complete most of the analysis work and has significant advantages in quickly and accurately locating aspects and identifying related opinions.

5. Conclusion

Using the Attitude System in combination with a sentiment dictionary, we conducted an aspect-level sentiment analysis of Xiaomi smartphone user reviews. From the results, we can conclude that Xiaomi smartphones have significant advantages in battery life, price competitiveness, shipping, and camera performance. However, improvements are needed to support higher performance and enhance network connectivity across different regions. This interdisciplinary approach to analysis can enhance the efficiency and accuracy of sentiment analysis. Specifically, this type of review text can better assist merchants and consumers in identifying product strengths and weaknesses, positioning product advantages and disadvantages, and assessing product value.

There are still many areas in our analysis process that need optimization in the future. First, the construction of the sentiment dictionary could be further expanded. For instance, we could enrich the dictionary by searching for synonyms in existing sentiment dictionaries such as WordNet and HowNet. Second, the sentiment polarity of adjectives and adverbs is dynamic, influenced by their usage and different contexts, which affects their sentiment orientation. Similarly, the scoring method could also be optimized according to various contexts. To achieve more precise scoring, the influence of conjunctions and context should not be overlooked. Based on our current analysis, future research could adopt machine learning or deep learning methods for more accurate and large-scale analysis.

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