# An Improved Sentiment Analysis Algorithm Based on Appraisal Theory and Fuzzy Logic

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**Abstract**

Millions of comments and opinions are posted daily on websites such as Twitter or Facebook. Users share their opinions on various topics. People need to know the opinions of other people in order to purchase consciously. Businesses also need customers' opinions and big data analysis to continue serving customer-friendly services, manage customer complaints and suggestions, increase financial benefits, evaluate products, as well as for marketing and business development. With the development of social media, the importance of sentiment analysis has increased, and sentiment analysis has become a very popular topic among computer scientists and researchers, because it has many usages in market and customer feedback analysis. Most sentiment analysis methods suffice to split comments into three negative, positive and neutral categories. But Appraisal Theory considers other characteristics of opinion such as attitude, graduation and orientation which results in more precise analysis. Therefore, this research has proposed an algorithm that increases the accuracy of the sentiment analysis algorithms by combining appraisal theory and fuzzy logic. This algorithm was tested on Stanford data (25,000 comments on the film) and compared with a reliable dictionary. Finally, the algorithm reached the accuracy of 95%. The results of this research can help to manage customer complaints and suggestions, marketing and business development, and product testing.

**Keywords:** Appraisal Theory; Fuzzy Logic; Sentiment Analysis; Opinion Mining.

## 1. Introduction

Recently, the sentiment analysis has become a very popular topic among computer scientists and researchers, because it has many usages in market and customer feedback analysis [1]. About 81% of Internet users search online at least once before purchasing a product, and 20% of them repeat it every day. Published reviews about products and services affect roughly 73% to 87% of buyers; hence, 20% to 99% of buyers prefer to choose the best services and products based on the existing opinions. These statistics indicate that customers now pay more attention to the views of other customers to receive more services and products. Customer opinions have always formed an important part of the information necessary for the decision-making. Before the advent of the World Wide Web (WWW), individuals asked the opinion of friends and experts to decide on purchasing products or services. However, the Internet and the Web have made it possible to understand the opinions and experiences of other people (regardless of the level of familiarity and expertise) [2]. With the advent of social networks, the possibility of interaction and communication between individuals has increased. This is because social networks have significantly tightened communication on the web and are being used by a wide range of people of different ages due to its' cheap, fast, and affordable access. The amount of data generated by web users during the exchange of information is also increasing. Individuals and companies that offer services or sell products have always been keen to see community feedback about their products and services [3].

Businesses need customer feedback to provide after-sales services, such as managing customer complaints, supporting and managing customer relationships, and predicting future sales. Therefore, sentiment analysis helps companies to know what customers think about their products so they can modify their products' features and introduce new products according to their customers' opinions [4]. People also need to know the opinions of other people in order to purchase consciously. Because, before buying, they will be aware of the experiences of other people and can decide which product is best. This requires the development of computational resources for the unlimited expansion of the expressing sentiment, as well as the increasing computing power to facilitate the processing of large amounts of data [5]. Extracting useful knowledge from this amount data is called sentiment

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analysis, which is widely used from business services to political campaigns [6]. With the development of social media, such as reviews, forum discussions, blogs, micro-blogs, Twitter, and social networks, the importance of sentiment analysis has increased [4].

Studies that examine the feasibility of doing this with greater precision and lower costs have largely relied on two main methods. The first method is the "Bag of Words," which recognizes negative and positive documents based on the frequency of the occurrence of different words in the document; in this way, different learning methods can be used to select or weigh different parts of the text [4][7-8]. However, the performance of Bag of Words is somewhat limited due to a few fundamental deficiencies in handling the polarity shift problem [4]. Another method is called "contextual polarity," which usually divides words into good and bad and then calculates the good and bad points for the entire document [9-10]. However, these methods have ignored the important aspects of sentiment analysis. Therefore, a more precise contextual analysis of attitudinal expressions is required. Moreover, "separate units" of such expressions are not words but rather evaluation groups, such as "very good" and "not so funny", which express a particular tendency [10]. To date, few studies have incorporated data mining components into the fuzzy logic. Moreover, few researchers have focused on the semantic differences of the sentiment classification characteristics, with most tending to categorize texts with positive and negative sentiments. The positive or negative sentiments of the comments reduce the accuracy of the sentiment analysis algorithm. In fact, sentiments have several aspects that are fully addressed in the appraisal theory [11]. This theory is based on terms such as "very good" and "not so funny," in which an appraisal group is a set of specified values that are placed in several independent contextual classes and read the speaker or author' opinion. In fact, sentiment analysis provides a grammatical system for evaluating the writer or speaker's opinions [12].

Because of these problems and defects, this study, by combining the appraisal theory and fuzzy logic provides the third group of sentiment analysis methods for sentiment analysis and classification in the attempt to cover all the features of commented words and opinions.

This study begins with a review of the literature, followed by a description of the research method used and proposed algorithm. Finally, the implications and conclusion of the study will be explained.

## 2. Literature Review

Sentiment analysis is a text classification task that seeks to classify documents in accordance with the view of individuals (polarity) on a particular subject [13]. Sentiment analysis uses automated tools to detect subjective information, such as opinions, attitudes, and feelings expressed in text [4]. It includes numerous tasks, such as sentiment extraction and classification, mentality detection, and opinions summary [14]. The most active research area of sentiment analysis is natural language processing, which is widely studied in data mining, web mining, and text mining [4]. Pang and Lee [2] studied a variety of techniques and approaches that are used directly in sentiment-based information search systems and are used to convey a sense of excitement to the reader about the intellectual richness and extent of the area. Different studies use different sentiment analysis tools and techniques to improve the accuracy and quality of meta-analysis algorithms, and to achieve the three main objectives of managing customers' complaints and suggestions, marketing and business development, and product evaluation.

- **Manage Customers' Complaints and Suggestions**

All businesses realize that products and services must be endorsed by customers in order to ensure their business continuity. Before the advent of the WWW, the reactions of people to products depended on the people around them. But today, with the advancement of technology, people's perceptions of products or services are very fast, which leads to the failure or success of those products or services. Businesses can follow these published comments to easily identify their weaknesses and strengths, so, they can modify their products features [4]. Therefore, different methods are used in research of sentiment analysis. For example, Whitelaw et al. [10] provided a method for classifying sentiments using appraisal groups, in which all the limited features of reviews combined together by using the Bag of Words model and trying to manage customer feedback. Kanade et al. [4] have also used the Bag of Words model along with dual sentiment analysis to classify the reviews. The proposed system uses a dictionary-based classification for accurately classifying the reviews as positive, negative and neutral. Both the product owner and the user can identify the quality of the product based on the sentiment graph that is generated based on the reviews for each product. Pak and Paroubek [7] used linguistic analysis for sentiment analysis. They indicated how to automatically use a collection of writings for sentiment analysis and opinion mining objectives. Their sentiment classifier can determine positive, negative and neutral sentiments for a document. Moghaddam [15] have also proposed a technique to automatically extract defects and improvements from customer feedback for summarizing them. The results of this study indicated that without any manual annotation cost, the proposed semi-supervised technique can achieve comparable accuracy to a fully supervised model in identifying defects and improvements.

- **Marketing and Business Development**

In the past, word-of-mouth advertising was used for marketing and business development. But today, with the development of social networks, it is done at a faster pace and with more quality and trust. Businesses use big data and sentiment analysis techniques to advertise and expand their markets. This has led to the emergence of products and services' platforms for customers. In this regard, Li et al. [16] have proposed a recommender system based on

opinion mining to extract opinion related information from the massive reviews. They analyzed the linguistic information and designed a two-layer selection algorithm to find the most suitable products for customers. Their method had great accuracy, feasibility, and reliability.

- **Product Evaluation**

Evaluating the reaction of customers to the beta version of some products or services can be costly or, in some cases, impossible for reasons such as speed of product delivery to the market or royalty, which would cost business owners. With the introduction of analytical techniques, it is possible to assure customer's feedback to the product before it is delivered to the market. For example, Denecke and Deng [17] used sentiment analysis techniques to test their medical products and patient feedback. They performed a quantitative assessment with respect to word usage and sentiment distribution of a dataset of clinical narratives and medical social media, characterized the facets of sentiment in the medical sphere and identified potential use cases. Andreevskaia and Bergler [18] also presented a method for extracting fuzzy sentiments from WordNet using the Sentiment Tag Extraction Program (STEP). They indicated that the Net Overlap Score can be used as a measure of the words' degree of membership in the fuzzy category of sentiment.

There are several methods of sentiment analysis, one of which is appraisal theory. This theory is based on terms such as "very good" and "not so funny". Khoo et al. [11] used appraisal theory to determine the positive, negative and neutral sentiments of manual and automatic text news. Korenek and Šimko [3] also improved the speed and accuracy of the sentiment analysis algorithm using appraisal theory.

The presentation of a new method for classifying sentiments using appraisal groups goes beyond the categories of "positive" and "negative" [10]. Sentiment analysis with fuzzy logic due to its reasoning (and a closer look at exact sentiments) helps producers or consumers, or any other interested person, to make an effective decision regarding their favorite product or service [19]. Yadav et al. [20] presented a refined method for classifying keywords based on their sense relative to other keywords in the text. Fuzzy logic is used to classify these words expressing sentiments according to their application in the sentence. Dragoni et al. [13] has also used fuzzy logic to create the relationships graph in order to represent the appropriateness between sentiment concepts and different domains. They developed a semantic resource based on the connection between an extended version of WordNet, SenticNet, and ConceptNet, that has been used both for extracting concepts and for classifying sentences within specific domains. Krishna, Pandty, and Kumar [21] developed a new model for opinion mining and sentiment analysis, which uses the machine learning and fuzzy approach to classify the sentiment on textual reviews, and to automate the process of mining attitudes, opinions and hidden emotions from text. Apple et al. [22] proposed a hybrid classification model based on fuzzy sets, a solid sentiment lexicon, traditional NLP techniques and aggregation methods to investigate and devise solutions to the Sentiment Analysis Problems. They indicated that their hybrid method is much better at the sentence level. Keith et al. [14] used a hybrid approach that combines an unsupervised machine learning algorithm along with a natural language processing technique to analyze the reviews and to tag part of a speech (POS) to obtain the syntactic structure of a sentence. The syntactic structure, along with the use of dictionaries, can determine the semantic orientation of the reviews through an algorithm. Haseena Rahmath [23] also proposed a multi-step opinion mining system that involves pre-processing to clean the document, a rule-based system to extract features and a scoring mechanism to tag their polarity. The proposed technique utilizes fuzzy functions to emulate the effect of various linguistic hedges such as dilators, concentrator and negation on opinionated phrases that make the system more accurate in sentiment classification and summarization of users' reviews.

The prior studies are categorized into the three categories to identify the various tools for sentiments analysis and their details. Figure 1 demonstrated how these categories are related to the main output of this research:

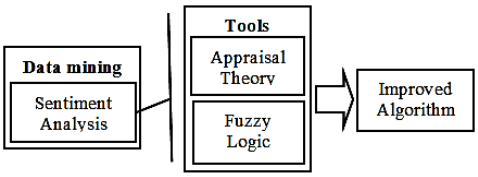


Fig. 1. Relationship between previous studies and present research

As can be seen from previous research, the studies have used two theories of appraisal theory and fuzzy logic separately to analyze the sentiments, but they have not studied the hybrid performance of these methods. Hence this study used a hybrid method of appraisal theory and fuzzy logic to improve the sentiment analysis algorithm. Many studies have been done in the field of sentiment analysis, therefore, a large number of data sets are the same data set that the proposed algorithm of this study is tested on. The importance of this is that we can compare the results of this research with the results of previous studies.

## 3. Conceptual Framework

This study is constructive and the CRISP-DM methodology, which is one of the greatest analytical methods for data mining projects, is used in this study. The general framework of the study is based on the research by Alamsyah et al. [24]. This framework analyses the sentiments using the appraisal theory. However, changes to the algorithm result in an unclear appraisal theory. In this framework, by applying the appraisal theory, the characteristics of comments are categorized and by using the techniques of text mining

and fuzzy logic, the orientation of the opinions from the positive and the negative is changed to the fuzzy range.

The algorithm has been implemented using the Python programming language. According to the CRISP-DM model, it is imperative to identify the business and data. All the opinions published on social networks and online shopping bases platforms pertain to the statistical population of this study. The proposed algorithm has been tested on Stanford University data. The data is divided into two groups: (i) positive and (ii) negative and needs no further preparation because the data type is textual and is ready to be processed in the programming environment.

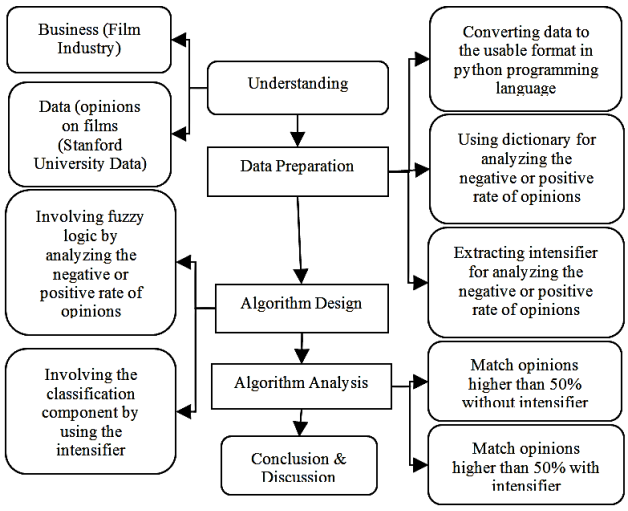


Fig. 2. Conceptual Framework

## 4. Algorithm Implementation

The Stanford University data used in this study comprise two sets of 12,500 negative and positive comments published about a movie [25]. These data are textual (txt) and their authors are anonymous. All the data are expressed in the author's own language and do not refer to anyone else. The importance of these comments can be examined in the following categories:

- Understanding customer's taste in the film
- Understanding the components of filmmaking for future releases

As all comments have been published in the author's own language, therefore, the discursive source constitutes the author's opinion. This dataset is divided into two groups: (i) Positive and (ii) negative. However, the degree of positive and negative is not known and thus would be determined through the proposed algorithm. Therefore, the fuzzy logic is used to determine the severity of the positive and negative aspects of the comments. To use fuzzy logic on data, it is necessary to have a dictionary that has positive and negative words, so that by comparing the dictionary and comments contained in the review of the movie, the degree of positive or negative comments will be determine. The majority of words in this dictionary have typos. In fact, these mistakes have been deliberately incorporated to include misleading words that are used extensively in social networks. In addition, a set of English adverbs has also been used to determine the classification and severity of the comment. For example, consider the following two sentences: the first sentence is positive at 87.5%. This figure is obtained comparing the positive sentence to the positive dictionary. As can be seen, there are seven positive words and a negative word, which results in a negative percentage of 12.5%. Each word that indicates the sentiment has a two-point score and each adverb has one point score thatits pseudocode is as below:

-------- file contents:

This show is awesome! I **love** all the actors! It has **great** story lines and characters. It is the **perfect** drama. James Caan and Josh Duhamel have **great** dialogue. They both can be really funny.I **miss** Vanessa Marcil on General Hospital, but she's **great** on here. James Lesure is **great**! He can be hilarious. Molly Sims plays a dimwit very well. The writing is awesome! They keep up an **excellent** pace. The show can really leave you hanging, which is one of my **favorite** elements of a show. I cannot wait until the new season starts. This show makes it to the **top** ten of all my shows. I hope this show stays on for a really long time. If people know what **good** is, it will. I never want the show to end. Ever.

-------- positive matches:

set(['perfect', 'great', 'good', 'love', 'top', 'favorite', 'excellent'])

-------- negative matches:

set(['miss'])

-------- results before matching the adverbs :

./data/positive/9201_10.txt - pos:14 - neg:2

./data/positive/9201_10.txt - pos:87.5 - neg:12.5

Subsequently, the classification and severity of the sentiments in the sentence is determined. This is done by assigning the coefficient to the sentence for each adverb. Because the adverbs represent the emphasis and strength of sentiments. Therefore, if one score is added to the total score of each positive clause, the effect of the adverb on the sentence will increase the positive percentage to 90%. Its peso code is as below:

-------- adverb matches :

set(['very', 'never', 'up', 'really'])

-------- results after matching the adverbs :

./data/positive/9201_10.txt - pos:18 - neg:2

./data/positive/9201_10.txt - pos:90.0 - neg:10.0

Table 1. Comparison of the Adverbs Effect in Sentiment Scoring

| Before the use of adverb | | After the use of adverb | |
|---|---|---|---|
| Positive | Negative | Positive | Negative |
| 14<br>87.5% | 2<br>12.5% | 18<br>90% | 2<br>10% |

The same trend is considered in negative statements that Its pseudocode is as below:

-------- file contents:

This movie is ridiculous. It's attempting to be a comedy but the screenplay is horrible. The whole movie is done in low light and you can't grasp the fact that it's a comedy. Truly is **bad** cinematography. You really have to sit there and watch it to realize there's a few jokes here and there going on but either way they're all inside jokes amongst themselves. This is more **like** a wannabe drama flick that went bad. It really is a very **pointless** movie. Their expressions reveal nothing but **dismay** and **disaster** which turns out that way anyway. Unless you want to be **bored** out of your ass, I suggest you stay away from this gag of a movie.

-------- positive matches:

set(['like'])
-------- negative matches:
set(['dismay', 'bad', 'bored', 'pointless', 'disaster'])
-------- results before matching the adverbs:
./data/negative/6533_1.txt - pos:2 - neg:10
./data/negative/6533_1.txt - pos:16.6666666667 - neg:83.3333333333

As it is clear, there are five negative words and a positive word that makes the sentence positive by 16.6%. Therefore, if one score added to the total score of each negative clause, the effect of the adverb on the sentence, will improve the negative percentage by about 5%. Its peso code is as below:

-------- adverb matches :
set(['very', 'away', 'there', 'really', 'more'])
-------- results after matching the adverbs :
./data/negative/6533_1.txt - pos:2 - neg:15
./data/negative/6533_1.txt - pos:11.7647058824 - neg:88.2352941176

Finally, the algorithm is run on all 25,000 comments on the movie browsing website. The results are shown in figure 3. As Figure 3 illustrates, the amount of negative words used in positive comments was greater than positive words, so that negative word strength overestimates the positivity of the opinion. By using the adverbs, the effect of the positive words in the positive comments increases and the accuracy of the algorithm in the calculation of the positive opinion increases. Figure 4 indicates the positive and negative outcomes of the comments after after including the adverbs in positive comments.

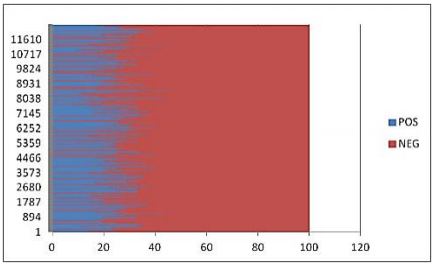


Fig. 3. The amount of positive and negative opinioon on positive comments

By using the adverbs, the effect of the positive words in the positive comments increases and the accuracy of the algorithm in the calculation of the positive opinion increases. Figure 4 indicates the positive and negative outcomes of the comments after after including the adverbs in positive comments.

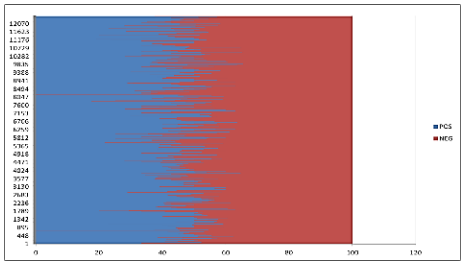

Fig. 4. The positive and negative outcomes of the comments after including the adverbs in positiv comments

The same is done for negative comments (Figure 5, 6). As shown in Figure 5, the negative words used in the negative comments were much higher than the positive ones.

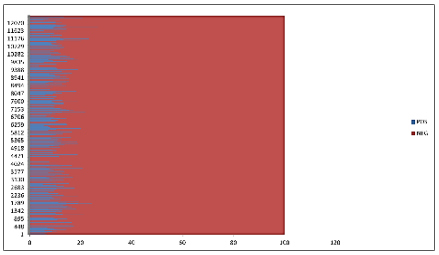

Fig. 5. The amount of positive and negative opinioon on negative comments

By using the adverbs, the effect of the negative words in the negative comments increases and the accuracy of the algorithm in the calculation of the positive opinion increases. Figure 6 indicates the positive and negative outcomes of the comments after including the adverbs in negative comments.

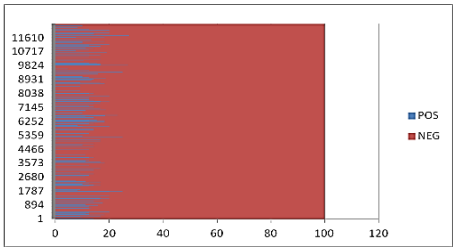


Fig. 6. The positive and negative outcomes of the comments after including the adverbs in negative comments

According to the results of the sentimen analysis, the movie, despite having positive comments, still has no general interest, and even positive comments contain a significant percentage of negative words. Moreover, the results indicate that before applying the appraisal theory, and only by using fuzzy logic, the positive feedback reached a precision of 79.632%, which improved after including the adverbs (the classification component of the appraisal theory) to 95.952%. Moreover, before applying the appraisal theory, and only by using fuzzy logic, the negative feedback reached a precision of 69.664%, which improved to 94.28% after including the adverbs (the classification component of the appraisal theory).

## 5. Comparison of the Proposed Algorithm with the Basic Algorithms

The accuracy of the proposed algorithm compare with the basic algorithms is indicated in table 2. According to the table 2, the study of Pang and Lee [8] divided comments into two positive and negative categories and achieved an accuracy of 86.4% in sentiment analysis. In addition, among the researches that have been analyzed the sentiments using the appraisal theory Whitewall et al. [10] earned the best score of 90% in the accuracy of sentiment analysis. The combination of fuzzy logic with appraisal theory has increased the accuracy of the sentiment analysis algorithm to 95%. In addition,

consideration of all the components of the appraisal theory as well as the fuzzy analysis of the opinions, and sentiment has improved the analysis algorithm. The results indicate a greater accuracy with the proposed algorithm compared to the previous algorithms (Ttable 2).

Table 2. The accuracy of the proposed algorithm compared with basic algorithms

| algorithm | Proposed algorithm | The algorithm of [8] | The algorithm of [10] |
|---|---|---|---|
| Accuracy | 95% | 86.4% | 90% |

## 6. Discussion and Conclusion

Internet and social media platforms resulted in changes not only to consumers' attitudes, perceptions and behaviours but also to the decision-making process itself. With the development of social media like as reviews, forum discussions, blogs, micro-blogs, Twitter, and social networks, the importance of sentiment analysis increased. Sentiment analysis is most active research areas in natural language processing which is widely studied in data mining, Web mining, and text mining. However, few studies have incorporated data mining components into the fuzzy logic. Moreover, few research have focused on the semantic differences of the sentiment classification characteristics. Therefore, this study, used a hybrid approach of the appraisal theory and fuzzy logic that has not been used in prior studies to cover all the features of commented words and opinions. Usually, the opinions about the film are divided into two categories of positive and negative. Therefore, the comments sentiment is quite clear. But the rate of positive or negative sentiments is not determined, that our proposed algorithm calculated the positive or negative percentage of words contained in the comment.

The adverbs used in the comment also determine the strength of the comment. In fact, the adverbs have been used to determine the classification of the appraisal theory. All the opinions expressed on the film are expressed in the author's own language. Therefore, the source of the commentary is the author. The study of Pang and Lee [8] has achieved an accuracy of 86.4% in sentiment analysis and divided comments into two positive and negative categories. In addition, among the researches that have been analyzed the sentiments using the appraisal theory Whitewall et al. [10] earned the best score of 90% in the accuracy of sentiment analysis. The combination of fuzzy logic with appraisal theory has increased the accuracy of the sentiment analysis algorithm. In addition, consideration of all the components of the appraisal theory as well as the fuzzy analysis of the opinions, and sentiment has improved the analysis algorithm. According to this study, before applying the appraisal theory, and only by using fuzzy logic, the positive feedback reached a precision of 79.632%, which improved after including the adverbs (the classification component of the appraisal theory) to 95.952%. Moreover, before applying the appraisal theory, and only by using fuzzy logic, the negative feedback reached a precision of 69.664%, which improved to 94.28% after including the adverbs (the classification component of the appraisal theory). The results indicate a greater accuracy with the proposed algorithm compared to the previous algorithms. The results of this study can be used for managing customer complaints and offers, sales forecasts, and the types of services and products available in the future, as well as for testing products and services in all customer-centric industries.

The use of the appraisal theory in sentiment analysis has increased in recent years. This method has three variables that should be identified and analyzed in the text. The study of these three variables is time-consuming and complex, requiring high computational power from the sentiment analysis machines. Therefore, the combination of this method with fuzzy logic was used only in the sentiment analysis, and the three other variables were not studied. Hence, it is suggested that future research develop an improved algorithm to analyze the users' sentiments in social networks based on the hybrid method of appraisal theory and fuzzy logic by considering all the variables of the appraisal theory.

In addition, the proposed algorithm involves fuzzy logic only in the trend orientation. However, fuzzy logic can be combined with all the appraisal theory variables to increase the accuracy of the model.

The algorithm used in this study can be used to measure the opinion and comments posted about various products. The output of this algorithm is usable for all products. The dictionary used in this research is a complete set of positive, negative and English constraints that cover a wide range of vocabulary. However, it is suggested to use this algorithm for comments posted in Persian by creating a Persian dictionary.

In addition, the proposed hybrid algorithm was validated on data from Stanford University, which was comments on a movie. These data were in English and had the language constraints. Therefore, it is suggested that future studies develop this algorithm in Persian-language social networks and evaluate its performance. Moreoer, In this research, we have been working with English, however, the proposed technique can be used with any other language.

The previous studies have used different data, which limits the possibility of comparing this method with previous methods. Morover, all the data of this research is quoted by the author him/herself, which practically influences the source of the discourse. Therefore, future research can, by using the classification variable in the appraisal theory examine the opinions expressed by others.

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