A Study of Sentiment Analysis Task and It's Challenges

Shubham V. Pandey
Dept. of Computer Science and Engineering
Government College of Engineering,
Amravati (Maharashtra), India
svpandey36@gmail.com

A. V. Deorankar
Dept. of Computer Science and Engineering
Government College of Engineering,
Amravati (Maharashtra), India
avdeorankar@gmail.com

***Abstract*— Reviews act as a valuable source of information for decision making. Online e-commerce sites has provided their users to make their opinion about products and services. Huge amount of such opinions are publicly available in the form of reviews. Manufacturers, retailer as well as customers have great interest in customer reviews. A customer has interest in such reviews to determine which product or a particular brand to buy. Manufacturers can analyze the improvement area in their product from such opinionated reviews. Due to large number of reviews available on internet for analysis, it is not cost worthy to read these manually. To optimize this time consuming task there is a need of an automated system which provides summarized result of user sentiments. Sentiment analysis (SA) is the field of study that analyzes people's sentiments or opinion from reviews or opinionated text. In sentiment analysis process machine learning is used to analyze sentiments, emotions and produce a summarized result for decision making. Sentiment analysis can be viewed as a natural language processing task, the task is to develop a system that understands the people's language. Sentiment analysis is a difficult task due to ambiguous nature of human languages(like English). In this paper we present a comprehensive study of sentiment analysis tasks and the challenges for sentiment analysis system. As the aspect based sentiment analysis is an active research area in SA, we will cover this level of sentiment analysis in detail.**

Keywords*— Sentiment analysis, feature extraction, opinion mining, text classification, Data mining.

I. 1 INTRODUCTION

Sentiment analysis involves developing a system that analyse and summarize the users' opinion from a unstructured review document. The objective of the opinion mining is to determine the reviewer's attitude about the product or services that he/she has reviewed. Sentiment analysis has its application in almost every business where the customer provide there feedback in the form of review comments. From business point of view, it is important to know that whether the customers are satisfied with their efforts or not. This type of information is available in critical comments of users. But it is not possible to analyze each comments manually to find strength and shortcomings of the organization or individual. Thus a sentiment analysis system is required that automatically classify users' opinion as positive or negative and provide a summary of the opinions.

Sentiment analysis is a Natural language processing (NLP) task which involves machine learning that is to train a system in such a way that it can understand human opinion extracted from different opinion sources. In this paper we present a descriptive study of sentiment analysis or opinion mining problems. Through this study we tried to cover : different types(levels) of sentiment analysis, Aspect-based sentiment analysis, and different challenges in sentiment analysis problem. The rest of the paper is organized in the following way. Section 2 discuss about levels in sentiment analysis problem, and then aspect-based sentiment analysis (which is one of the level of analysis) is described in section 3 in detail. Then we have mentioned some important challenges for sentiment analysis in section 4. Section 5 provides the details about how to measure the performance of a sentiment analysis(classification) system.

II. 2 . LEVELS OF SENTIMENT ANALYSIS

2.1 Sentiment analysis

Sentiment analysis, or also called opinion mining is the field of study which deals with people's opinions, emotions, sentiments, and attitude about various objects or entities, from written language.[1] Here the objects or entities may be a particular product or service offered to customers, attributes of the product, different events, topics or some organization itself. The main task in sentiment analysis is to identify whether a given opinion expressed by the opinion holder(e.g. customer) is positive or negative. Customers express their opinion in the form of reviews for various product and services. So for sentiment analysis task reviews is the input data and the summarized result of this reviews is output. Before we start with major challenges, issues and task of sentiment analysis, let's first consider the definition of opinion by[1] which is defined as quintuple.

Opinion = $<e_i, a_{ij}, s_{ijkl}, h_k, t_l>$

Where,

- e_i - represents the entity(i.e. product or service) for which opinion is given. Usually entity is explicitly stated by the reviewer, sometimes the review may contain multiple sentence, in that case entity name may appear(explicitly) in first sentence and rest of the sentence can

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refers(implicitly) to the entity mentioned in the first sentence.

- a_{ij} - represents the aspect of the entity e_i. Aspect means the feature, attributes or properties of the products(entity). In aspect based sentiment analysis, opinion target is collectively represented by entity e_i and its aspect a_{ij} .
- s_{ijkl} - Represents the sentiment for the target entity.
- h_k - Is the opinion holder that is it represent the author of review or feedback post.
- t_l - It denotes the time when review is posted by reviewer h_k .

2.2 Levels of sentiment analysis

Sentiment analysis is one of the active research field of text processing and data mining, in which the task is to extract the opinions from a set of opinionated documents. Sentiment analysis can be performed at three different levels.

Document level

Sentiment analysis at document level, deals with classification of entire opinion document as positive or negative. That is, the task is to identify whether a document D contains positive or negative sentiments. There is an assumption that document expresses opinion on a single product[5]. This assumption is not suitable for various applications where author is free to post his opinions on any products. User can express his opinion by comparing two or more product of same type.

Sentence level

A product review can contain multiple sentences, in which each sentence may or may not contain opinion and also polarity of opinion in each sentence may be different. Hence analysis of opinions at document level is not enough to extract user sentiment when each review in the document contains two or more opinionated sentences. Here the task of sentiment classification is performed at the sentence level and it determines whether the sentence express positive, negative sentiment or the sentence does not express any opinion(i.e. neutral sentence). Such neutral sentences are called objective sentences[1][5]. Task at this level is related to subjectivity classification which distinguishes objective and subjective sentences[1]. Objective sentences express factual information where as subjective sentences express author's views and opinions.

Feature-based or Aspect level

Feature based(or aspect based) sentiment analysis is concerned with analysis of the author's opinion for different issues which is discussed by author in his review[2]. This issues are nothing but the aspects or features of product or service which is reviewed by the author. To identify liking or disliking of a customer, which is a major concern of every business, a fine-grained analysis of customer reviews is required. Aspect level performs finer-grained analysis[1]. Unlike document-level and sentence-level analysis that operate at review sentence or paragraph, aspect level analysis looks at the sentiment word and its associated target entity. The main task at this level is to discover the author's opinion in review sentence and its opinion target. The target can be entity itself(i.e. product, service, or individuals) or their various aspect[1].

III. 3. ASPECT BASED SENTIMENT ANALYSIS

The current researches in sentiment analysis is going on at the aspect level because it precisely determines the users' opinion for various product at the feature level. Figure 1 shows the general sentiment analysis process. The aspect based sentiment analysis process can be divided into five subtasks.

1) Data extraction and preprocessing

2) Sentiment detection

3) Feature extraction and reduction

4) Sentiment classification

5) Sentiment summarization

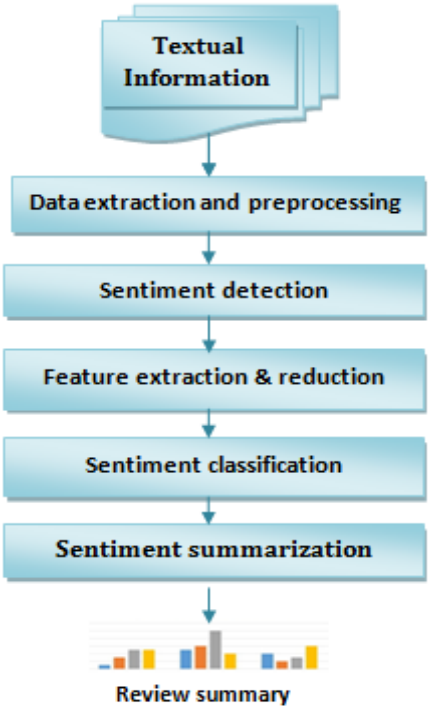

Figure 1: Sentiment analysis process

3.1 Data extraction and preprocessing

Sentiment analysis process begins with data collection task and then processing it for the further operations. Many datasets are available online for academic and research purpose. Sometimes the user reviews are available online in the form of blog, post etc. to work with such type of data, first we need to extract that data from online web page and store it in a local dataset. It is an important stage because the quality of data extracted can affect performance of sentiment analysis system[4].

Preprocessing

Data preprocessing is first step in any data mining method. For opinion mining, preprocessing means preparation of unstructured review document for sentiment classification and summarization. This involves tokenization, stop word removal, stemming etc.

- Tokenization : Tokenization is task of dividing large piece of data into small tokens. For feature level analysis, a review paragraph or multi-line review is divided into single sentences. The sentences is further tokenized to words, to extract the candidate feature set.
- Stopping : The process of removing stop words from a sentence is called stopping. Stop words are those words that occur very frequently in a document and this words are meaningless(or provide less meaning to the context of document) in information retrieval process [6]. The words like 'the', 'a', 'is', 'this' etc. are some common stop words. A list of stop words for a system can vary depending on the context. If we consider a sentence from restaurant domain "The food is good" then after stopping the output would be " food good".
- Stemming : Stemming or lemmatisation is a process to determine the root word from the derived words[7]. In information retrieval system stemming helps to identify and group morphological similar words. For example, the words 'connect', 'connection', 'connecting' and 'connected' can be reduced to the stem word 'connect'.

3.2 Sentiment detection

In sentiment detection phase each tokenized sentence of the review is analyzed for subjective information. That means Subjectivity classification is performed at this phase. The sentence that express any opinion is known as subjective sentence else it is called objective. For example

"(1)In India there are around 2226 wild tigers which is highest in the world.(2)Sundarban national park is a great place to see the royal bengal tigers."

The first sentence provide factual information and not an opinion. The second sentence is a subjective sentence that has an opinion. In this phase all subjective sentences are extracted from the dataset, that are only used for further operations.

3.3 Feature extraction and reduction

Feature extraction is an important task in aspect-based sentiment analysis. Selection of appropriate features is important because it affects the learning task[8] which results in poor accuracy of the system. A bag-of-word is a common method to extract the candidate features from the review sentences. The aspect(or feature) may be of single word or a multi-word aspect like "picture quality". The single word features are called unigrams, two word features are bigrams, like wise an N-word feature or aspect is called N-gram. The selected features also called candidate feature set contains large number of aspects and some of which are not useful. In feature reduction process, this unwanted features(also called noisy features) are identified and removed from the feature vector.

3.4 Sentiment classification

In this phase each opinionated sentence is classified as positive, negative or neutral category. In many sentiment analysis application this task is performed as a two-class classification, that is only positive and negative category is considered.

3.5 Sentiment summarization

Summarized result of large data makes the task of decision making easy. Generally decision makers make use of number of reviews, before to come across certain decision. Means opinion of a single person is not sufficient, a summary of large number of reviews is required. A widely used summary format proposed in [9] for aspect-based summary is described below.

<Product_name>:

Aspect 1: <Aspect_name>

Positive : <Number> <individual review sentences>

Negative : <Number> <individual review sentences>

Aspect 2: <Aspect_name>

Positive : <Number> <individual review sentences>

Negative : <Number> <individual review sentences>

...

Aspect N: <Aspect_name>

Positive : <Number> <individual review sentences>

Negative : <Number> <individual review sentences>

IV. 4 .CHALLENGES IN SENTIMENT ANALYSIS TASK

4.1 Named entity extraction

Named Entity extraction or named entity recognition(NER) is a subtask in text classification. It is a process that locates names of entities(people, place, object or organization etc) mentioned in an unstructured text(i.e. review sentences)[3]. In this task a sentence is passed as input to an algorithm, the sentence is processed to identify all nouns present in it. The names of individuals and entities are nouns in the sentences and thus the output of NER is set of all nouns that are names present in review sentence. Consider the following example in [3] of review.

"*(1) The Canon Power Shot is a great camera for beginners. (2) It is easy to use and it is very good quality. 3) The graphics are great and it takes the picture quickly. (4) It has a wonderful face identification feature which makes the picture even better than it was before. (5) After you take the picture you can also do a red eye correction! (6) Audio is pretty good but the HD quality is less than desirable"*

In the review the target entity is Cannon camera and the review mentioned the product name which is " *Canon Power Shot* " . It is a noun phrase and such mentioned names of the entities should be properly identify by the sentiment analysis system. An example of Standford CoreNLP NER tool for above review is shown in figure 2.

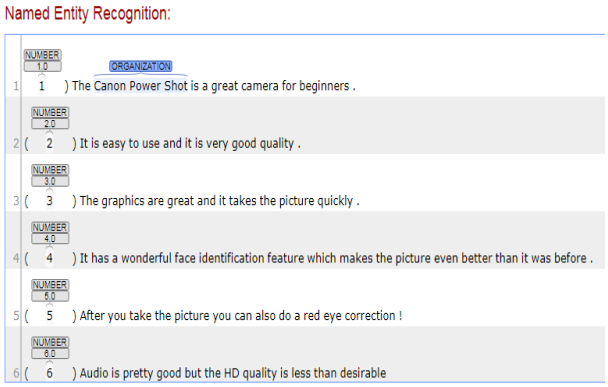

Figure 2 : Named entity recognition.

4.2 Co-reference Resolution

Co-reference resolution is a major challenge in aspect based sentiment analysis[3], because at this level of analysis we need to find the opinion target for each sentiment phrase expressed in sentences. In a multiline comment or review for a product, customer generally mentions the product name only in one of the sentence(i.e. usually in first few sentences). the customer then refers to that particular product by a pronoun in rest of the sentences. Resolving pronoun references to appropriate entity is a major task when the customer compares two or more product in a single review. In such reviews it is a difficult task to link pronouns to their target nouns(i.e. entities). For example, consider a sentence:

"The laptop was really good and it goes really fast."

In this sentence the pronoun 'it' refers to the noun entity 'laptop'. Figure 3 shows the co-reference resolution by the Stanford corenlp coreference tool for the given sentence.

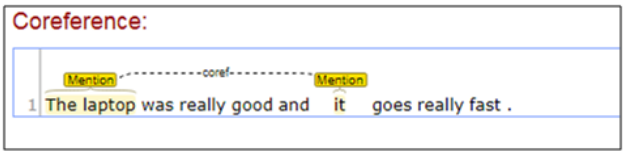

Figure 3: Co-reference Resolution

4.3 Domain Dependency

Sentiment analysis system can be developed for various application domain. A system designed for a particular domain may not produce the desired result for other domain. It requires some modification in the feature set and classification task because sentiment classification is a domain dependent process. For example if we consider the domains like movie review and car, then review expressed by user are totally different. And hence sentiment classifier needs to be train separately for each domain. Cross domain sentiment classifier is one of the major challenge in sentiment analysis.

4.4 Sentiment polarity determination

In sentiment classification, the main task is assign a category to the sentiment expressed(i.e. sentiment word). Generally adjectives provides the useful opinion words. A simple but not effective, approach to assign sentiment polarity is to use a sentiment lexicon. If an opinion word matches with the positive lexicon then its polarity is assigned as positive. Sentiment polarity detection is a difficult task because a word used to express positive opinion about one product, may be used to express negative sentiment about another product.

for example consider the following reviews:

(1) *"CPU size is small and it occupy less space"*

(2) *"The screen size of my laptop is small"*

In the first review opinion "small" for the aspect "size" represents positive opinion. On the other hand the same words used for aspect laptop screen express negative opinion.

4.5 Subjectivity classification

Subjectivity classification is a two class classification problem, where the task is to determine whether a sentence has subjective information or not. That is, it classifies sentences into subjective or objective category. Generally objective sentences represent factual information about the entities and object present in the world. On the other hand subjective sentences express personal emotions, beliefs or sentiment. For example consider the following review from mobile phone domain.

"(1)I brought Redmi Note5 mobile last week.(2) It has 5 mega pixel front camera.(3)Selfie captured by the phone was too good."

Here sentence (1) and (2) are objective sentence because it just provide information about the product i.e. its name, its brand and the configuration of one of the aspect that is front camera. Subjectivity classification task is performed before the task of sentiment classification. In sentiment classification our task is to identity polarity of the opinionated(subjective) sentences that is whether the opinion shows positive sentiment for the product (or service) or negative sentence. Thus subjectivity classification is performed first so that, we can have only opinionated sentences for sentiment analysis which can improve classification precision.

V. 5 EVALUATION MATRIX

Evaluation matrix is used to compare the performance characteristic of different sentiment classifier. The parameters on which the performance of sentiment classification system is evaluated are: accuracy, precision, recall and F-measure. Following terminologies are used in order to calculate this parameters.

- True Positive (TP): The number of positive opinions that are correctly classified as positive.
- True Negative (TN) : The number of negative opinions that are correctly classified as negative.
- False Positive (FP): The number of positive opinions that are incorrectly classified as positive.
- False Negative (FN): The number of negative opinions that are incorrectly classified as negative.

$$\text{Accuracy} = (TN + TP) / (TP + TN + FP + FN) \quad \text{(Eq.1)}$$

$$\text{Precision} = TP / (TP + FP) \quad \text{(Eq. 2)}$$

$$\text{Recall} = TP / (TP + FN) \quad \text{(Eq. 3)}$$

$$\text{F- measure} = (2*\text{Precision}*\text{Recall}) / (\text{Precision} + \text{Recall}) \quad \text{(Eq. 4)}$$

VI. 6 CONCLUSION

Sentiment analysis is currently an active research area in data mining field. This study helps to answer the queries like what is sentiment analysis, how to perform it, and what challenges one has to face while developing a sentiment analysis system. In this paper we have covered different levels of sentiment analysis and a detail discussion over aspect-based sentiment analysis is given. The important challenges to this research area like named entity recognition, sentiment polarity detection, subjectivity detection etc. have been described with suitable example. We have used Stanford CoreNPL tools to visualize the result of some basic operation of NLP which can be used for sentiment analysis. As sentiment analysis involves machine learning, we finally discussed the evaluation matrix, which is used to measure the performance of the system.

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