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A Feature Based Opinion Mining for Product Reviews using Naive Bayes and K-Nearest Neighbor Classifiers

Minu P Abraham ,Udaya Kumar Reddy K R

Abstract—The explosive growth in the technology of web like social media, directs more number of people to express their sentiments, feedbacks or opinions towards the service, events, individuals, topics, products or social issues. Since the data get bigger extensively in everyday life, this makes so difficult for customers, manufactures as well as for end users of online websites to derive a conclusion on the accessibility of big data available as reviews. Opinion mining is referred to as a natural language processing technique that gives out the knowledge extraction of viewpoints or attitudes from the review texts. Feature-Based Opinion mining system aims to find the main aspects or features of a specified entity and the sentiment expressed on that entity by using natural language processing and AI techniques. Most of the studies have been conducted on aspect based opinion mining but not any of the particular works have justified to be adequate for assessing the critical or majorfactors. The major factors with respect to aspect based opinion mining are implicit or implied aspects, explicit or direct aspects and multiple aspect based. The Aspect based opinion mining by considering all these critical factors helps in analyzing the aspect of a particular entity and its sentiment more accurately. In this paper, an explicit aspect based opinion mining is carried out using naive bayes and K-nearest neighborclassifiers to generate more accurate opinions for product reviews. The end user can easily get opinions based on the particular aspect of the entity and the proposed work proves that the sentiment classification using naive bayes classifier provide with more accuracy than using K-nearest neighbor classifier.

Keywords—Aspect Extraction, Explicit Aspects, Online reviews, Sentiment Analysis, Text mining

I. Introduction

The privilege of freedom of speech has entrusted the common man to express their legitimate feelings ,attitudes and outlooks in newspapers, books, e-commerce, discussion forums, chatting, etc., The advancement in the web technology drives more people to participate in sharing their opinions about products, services, social issues and events[1]. Accordingly, everyday data is accumulating excessively which makes it more challenging or even impractical for manufacturers, consumers and other end users to compose a decision on the availability of these big data. Essentially, customers while buying a product are always interested in other customer's feedback.

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***** Correspondence Author (s)
Minu P Abraham, Assistant Professor, Department of CSE, NMAM Institute of Technology, Nitte.
Dr. Udaya Kumar Reddy K.R, Diploma in Computer Science and Engineering from Siddaganga Polytechnic, Tumkur, Bangalore University.

These activities provide positive impact on many research activities [2]. Therefore, there is a requisite of adequate mining technique that will screen noisy data and brings about general and important sentiments about a product, service or social issues. This necessity leads to opinion mining. Opinion mining is another curious and challenging sub-fields in data mining. What people think or their comments about aparticular entity has outstanding influence on the decision making process of end users. The sentiment is a view, feeling, opinion, attitude or feedback by a person about a particular entity, product, event, or a service [2]. The users who buy products on-line put forth their opinion or sentiment helps other users to know about the features or feedback of the product. These on-line reviews help the customers and the manufactures to know what exactly the users like or dislike about the product. In modern times, there is a huge rise in the number of reviews which contributes the size of the reviews to cross terabytes [3]. By reading a few number of reviews, the user will not get a clear idea about the product. But the huge size of the reviews not only makes the users to feel difficult in analysing the product but also the vendors of the products find it difficult what exactly the requirements of customers on that product. If the product reviews are mined or the sentiment expressed by the users can be extracted and presented in a summarized form, then it will be helpful for both consumers as well as the vendors to take quality decisions on the product.

1.1. Opinion mining taxonomy

Opinion mining(OM) is regarded as a classification problem and it can be defined as the task of identifying the user's views, opinions, attitudes or emotions towards entities expressed in the form of *positive*, *negative or neutral* comments by applying Natural language processing, Information extraction and Machine learning techniques [1][2][3]. Based on the previous study in [4], different classification levels in OM are briefly explained below:

1.1.1. Document level: It considers the whole document or paragraph as a one complete data unit and the entire document or paragraph is categorized into positive, negative or neutral. Here the result is the overall opinion of the document. This OM method is commonly known as document level sentiment classification.

1.1.2. Sentence level: The inputto be processed is a sentence here and the sentence is categorized as negative ,positive, or neutral, which is commonly referred as sentence level sentiment classification. It has to find out whether the review sentence is subjective or objective. Objective sentences are facts about something and subjective sentences describe people's sentiments. If the identified sentence is a subjective sentence,thensentence level SA classifies that into positive, negative or neutral category.

1.1.3. Aspect-level: Document/sentence is grouped as positive, negative or neutral depends on the aspect or feature of the document/sentence is commonly referred as aspect level sentiment classification. It is also known as Phrase level opinion mining. Goal in this level is to discover aspects or features of the particular entity, product or service. Aspect extraction is an ongoing research in aspect level Sentiment Analysis[4,5]. Features in the sentences can be explicit, implicit or multi-aspects. Some features are not explicitly mentioned in the reviews. The different classification levels of Sentiment Analysis with example is listed in Table 1[4].

Table 1: Different Classification levels in SA with example.

Levels in SA	*Example*	*Opinion*
Document level	*"An awesome phone seriously and it is a beautiful thing. I have had this beauty for nearly 2 months now and I truely love it"*	*Positive*
Sentence Level	*"It is really an awesome phone"*	*Positive*
Aspect level	*1)"The mobile phone's voice quality is really good". Explicit Aspect (Voice quality)*	*Positive*
	2)"The phone is very sleek and affordable". Implicit Aspects (appearance and price)	*Positive*

II. RELATED WORK

Many researchers have used various techniques in opinion mining and some are briefly explained. As in [2], the various sentiment classification techniques are shown in Figure 1. There are mainly two techniques: Lexicon based approach and Machine learning based approach. In the literature below authors have used different techniques for aspect extraction and its polarity identification.

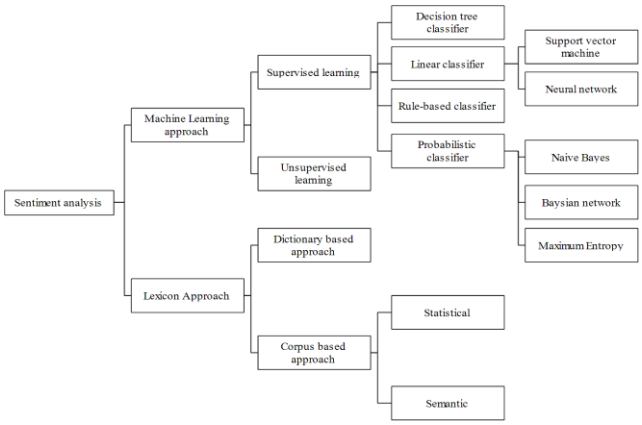

Figure1: Various Sentiment Classification Approaches

Pang et al.[6] is used the technique of Supervised machine learningto perform the classification of sentiments present. The explicit aspects are extracted using unsupervised approach. Some of the Machine learning methodsNaïve Bayes, Support Vector Machine and Maximum Entropy classifications are used[2]. These methods are commonly used for topic classification. P.Kalaivani et al. [7] used three supervised machine learning algorithms such as Support Vector Machine, Naive Bayes, as well as K-Nearest Neighbor. These three algorithms are performed on movie reviews for sentiment classification which includes 1000 positive and in addition 1000 negative reviews and the performance of each method used is compared. SVM approach performed well when compared to k-NN and Naive Bayes. The accuracy obtained by the SVM approach is 80%.

Anurag et al. [8] introduced a modern approach called combined approach to categorize the review text based on the sentiment presented in reviews. They were able to improve the anticipated classification results with the support of two classifier combination rules. They also explained and proposed a way for handling the smiley as well as slag words, which overall generate a good sentiment classification with higher accuracy.Jayashri Khairnar et al. [9] focused mainly on the Support Vector Machine which performs the task of sentiment classification and also calculates the accuracy of sentiment classification. With the help of the small datasets in a two dimensional feature space the concept of SVM is explained. It classifies the data in high dimensional space with the use of kernel methods. L.Hemalath et al. [10] proposed a method to perform different supervised learning where they used emotions for training data and which is treated as noisy labels and showed that is a powerful way to carry out various supervised learning techniques. By using the proposed method machine learning algorithms could achieve higher accuracy for classifying sentiments. They used the twitter data set, though the twitter reviews have a unique property when compared to other. It classifies tweet sentiment with the same performance. Wei Yen Chong et al.[11] exhibited the underlying review on assumption examination by utilizing the tweeter informational collections. Their review was to outline a model which removes feelings situated in the subjects of the tweeter informational collections. Assumptions are identified in view of particular subject utilizing Natural Language Processing systems. To depict the semantic association over feeling vocabulary and subjects the examinations requires the dictionary. By assessing feelings in the vocabulary which are related to the subjects, the extremity of tweets are ordered. One of the confinements in the pre-processing is, the muddled tweets must be changed over into legitimate sentences, which is very troublesome and furthermore not viable.

Chetan Kaushik et al. [12] proposed a procedure which can easily accomplish the opinion mining on huge informational collections. The positivity, negativity as well as the neutrality of a document is classified by utilizing a method which can perform in a quick and legitimate way. This approach accomplished great speed and effectiveness, yet it can't scale the enormous informational collections for better execution. The objective of their work is to perform conclusion mining quickly so the enormous informational collections can be dealt effectively. The work is clarified by introducing a strategy which expands the productivity at managing the issues like bypass expressions and understood assessments which still should be settled.

Alessia D'Andrea et al. [13] exhibited a different methodology utilized as a part of the assumption arrangement and in addition the different instruments utilized for the examination of the opinions. The strategies are arranged 1.As for elements and furthermore on the advantages\limitations 2. Devices are characterized on the premise of different methods utilized for investigation of the assumptions. The means utilized as a part of the characterization of slants are additionally introduced in the work suggested. By utilizing machine learning instrument, the slant extremity is anticipated. The generally used device for perceiving the extremity of the emotions is pondered in their work. Sharma et al. [5] has introduced a dictionary based approach to determine the sentence orientation of the reviews. Polarity is measured by considering majority of the opinion words present in the seed list. Schouten et al. [14] has introduced a simple aspect detection algorithm by using a co-occurrence based method for category detection and a dictionary based sentiment classification algorithm. For sentiment classification method, a technique is used which creates a sentiment lexicon based on the aspect sentiment annotation. Xueke et al. [15] introduced a new approach known as JAS(Joint/Aspect Sentiment) model which is used to jointly extract features and feature dependent sentiment lexicons from online consumer reviews. This method focuses on the opinion words which is specific for the aspects along with their aspect aware sentiment polarities with regard to a specific feature or aspect. Schouten et al. [16] explained and experimented about the co-occurrence between the implicit word and the notional word to extract the implicit aspect from the reviews than co-occurrence between explicit word and notional word [14], which gained the maximum efficiency. Walaa Medhat et al.,[4] has given broad investigation of the most recent information in the estimation examination area. The fields identifying with the SA strategies are clarified, for example, exchange learning, feeling recognition, and building assets which are drawing the consideration of the scientists in the present time. The target of this work is to give picture of SA procedures and the fields identified with the SA system. It additionally intends to give the advanced order of an immense number of flow articles and the clarifications and flow patterns of the examination in the notion investigation.

III. PROPOSED METHOD

The proposedmethod for feature based opinion mining for product reviews has several steps. This method is applied on product reviews. The various steps involved in opinion mining are input review collection, input data pre-processing, Feature extraction along with the opinion word extraction, sentiment polarity identification and result summarization. The proposed model for the effective feature based opinion mining is depicted in the figure 2. The input data contains reviews about the product i.e., cell phone and accessories which contains lot of explicit aspects. It has mainly four phases. Each phase depends on the output of other phase and it proceeds as a series as shown in the Figure.2.

3.1. Phase I

Pre-processing refers to the removal of unwanted data from the input data sets. The first step in pre-processing is to split the extracted reviews into sentences and then to a list of words. This process is called tokenization. Further, stop words like "a", "an", "the" which are not required for the sentiment classification are removed from the tokenized data. Finally tokenized data are tagged using Parts Of Speech tagger. POS tagger is a software tool which is used for mapping the word in a given sentence with its corresponding part of speech based on its context.ie., it scans text in a document. In this phase, for tokenizing and for POS tagging,NLTK tool is used. The dataset contains reviews about product i.e., cell phone and accessories which includes plenty of explicit aspect based reviews.

3.2. Phase II

Phase II consists of the main component of this model to identify the explicit features in a review. The key task in this Phase is that a review sentence is analysed for identifying the explicit aspects along with the corresponding opinion word. Generally, Adjectives or Verbs present in a review sentence are considered as opinion of a product; Moreover, it has the sentiment strengths and negative words. *For example: As compared to Nikon canon camera is low in price*. Therefore, the opinion word is low and price is a feature of the product.

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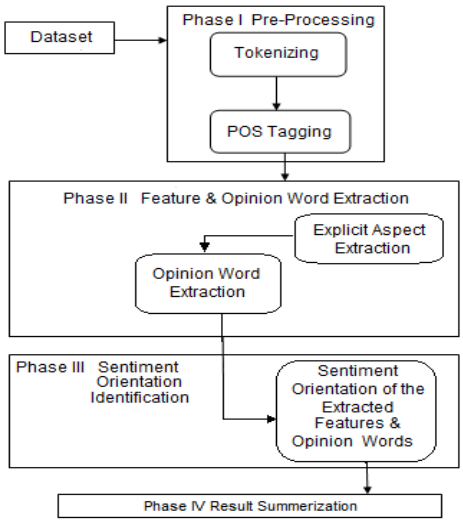

Figure 2: The Model for Feature Based Opinion Mining

3.3. Phase III

Phase III finds the sentiment orientation of the every review sentence. It consists of two steps. In the first step, according to their opinion words expressed by customers ,each feature of the product will be given a weight. Accordingly, in the second step sentiment orientation will be calculated according to their weights, moreover, it will be classified as positive, negative and neutral.

3.4. Phase IV

Finally summarization will be calculated by the customer's opinion about features of the product in Phase IV.

3.5. Review Extraction.

First step is to collect reviews from e-commerce sites of mobile products. Here, the reviews are extracted from the kaggle websites.Kaggle is a website which consist of Scripts, assortment of public datasets, as well as a dedicated forum for conversation and collaboration between data scientists working on a given dataset, which is extensively used for research purpose. The data set will be in the form of CSV file format which contains the various mobile product reviews along with their brand names and rating.

3.6. Pre-processing

Data pre-processing is an information analysing strategy that includes changing raw information into a justifiable format. Real-world information is frequently deficient, conflicting, as well as lacking in specific practices or trends, and is possibly going to contain numerous mistakes. Data pre-processing is a demonstrated technique for settling such issues. Some of the data pre-processing steps are tokenizing, removal of punctuation marks, removal of stop words and POS Tagging.

3.6.1. Tokenizing:

Tokenization is the method of separating a stream of content into words, expressions, images or other important components called tokens in lexical analysis. The list of tokens are used for further pre-processing, For example, parsing or text mining. The reviews stored in CSV files are given as input to stop word removal process.

3.6.2. POS Tagging:

Output of Stop word removal process of the reviews from the previous step are then considered as input to Parts of Speech Tagger. To tag the words to their respective parts of speech, Stanford POS Tagger is used. As a result, input reviews are POS tagged to their corresponding parts of speech.Examples of POS tagging is shown in Table 2.

Table 2.Examples of POS Tagging

Review sentence (Before POS tagging)	***Review sentence (After POS tagging)***
"Great phone Samsung"	*great_NNP_phone_NN _samsung_NNP*
"Very Pleased"	*very_RB pleased_JJ*

3.7 Extraction of Features

In the proposed work Noun and noun phrases are regarded as explicit features. Usually the noun phrases are considered as explicit features, and those features are extracted. Noun words in every sentence are taken as item sets for single transactions. Feature Extraction is implemented by using the algorithm as given below.

Algorithm : *Feature and opinion word Extraction*

for each *review sentence*

for each *product reviews which is POS tagged*

If *the review sentence contains nouns and adjective words then*

extract the noun and noun phrases store in separate text file as feature words

extract adjective as opinion words and its nearby adjective as its effective opinion words

end if

end for

end for

The above algorithm will first extract the noun and noun phrases from POS tagged output. These features will be stored in separate file.

3.8Classification of Extracted Features and Opinion Word.

The review sentences containing only the explicit aspects and the opinion words are considered for classification. The Naive Bayes and KNN classification algorithm is applied for classifying the opinion on extracted features as positive, negative and natural. The input for this stage is the POS tagged output.

3.8.1. Naive Bayes Classifier:

Naive Bayes classification algorithm is established on Bayes' theorem by the concept of class conditional independence. ie., the outcomeof an attribute value on a specified class is independent of the values of the other attributes.

The Naïve Bayes classification algorithm is used to categorize the input reviews based on the features extracted. These reviews are categorized as either positive or negative with respect to the extracted aspect based on the opinion words present. Naive Bayes classifiers are one among the most popular algorithms for learning to classify text documents, which is especially suitable when the dimensionality of the inputs is very high. The method of maximum likelihood is used for the Parameter estimation for Naive Bayes models.[18].

Given an input problem to be classified, depicted by a vector, $X=(x_1, x_2, x_3 .... x_n)$ representing *n* measurements or features, it assigns to this instance probabilities $P(C_k| x_1, x_2, x_3 .... x_n)$.The conditional probability can be decomposed as (1) by using Bayes' theorem,

$$P(Ck/x) = \frac{P(Ck).P(x/ck)}{P(x)} \quad (1)$$

Where $P(Ck|x)$ represents the probability of given text, $P(x)$ which belong to class x. It also gives a useful framework for evaluating and understanding many learning algorithm.

3.8.2. K-Nearest Neighbour Classifier:

The K-nearest neighbor algorithm (k-NN) in pattern recognition is considered as a non-parametric techniquewhich is used for classification and regression. It consistsof k-nearest training samples in the feature space. It is considered as one of the most straightforward and powerful classes of classification algorithm. It depends on the theory that, for a given arrangement of tests in a preparation set, the class of another yet inconspicuous event is probably going to be that of the greater part of its nearest "neighbor" instance from the training set. It works by examining the k nearest instances in the informational index to another event that should be classified, and making an expectation of what classes most of the k-neighbors have a place with. The thought of closeness is formally given by a separation work between two focuses in the attribute space, determined from the prior as a parameter to the algorithm. A case of separation capacity normally utilized is the standard Euclidean separation between two focuses in a n-dimensional space, where n is the quantity of traits in the informational collection.

IV. RESULTS AND DISCUSSIONS.

The experimental evaluation was performed on product reviews which contains the reviews of mobile phone and its accessories. The reviews are obtained from kaggle site. After pre-processing step, POS tagging is performed using Stanford POS tagger.The snapshot of the output obtained after POS Tagging is shown in Figure 3.

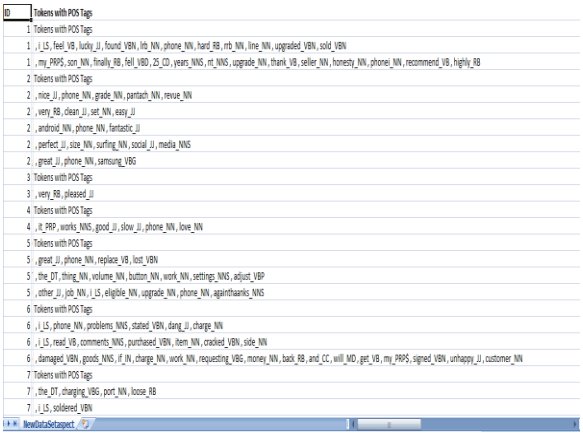

Figure 3: Snapshot of the POS tagged reviews

The example of the extracted aspect and the corresponding opinion words and the sentiments are shown in Table 3.

Table 3:Extracted explicit aspect and the corresponding opinion words and the sentiments

Sl No:	Explicit Aspect	Opinion word	Sentiment
1	*Price*	*good*	*Positive*
2	*Battery life*	*fantastic*	*Positive*
3	*Appearance*	*bad*	*Negative*
4	*Camera*	*fair*	*Positive*
5	*Size*	*Unhappy*	*Negative*

V. PERFORMANCE ANALYSIS

The Figure 4 shows the comparative analysis that is obtained after classifying the reviews using proposed algorithm. Here the X-axis depicts the amountof reviews of the products and Y-axis shows the accuracy in percentage obtained after applying Naive Bayes and KNN algorithm. The Figure 5 and figure 6 explains the parameters used for evaluating the precision and recall for extracted explicit aspect and opinion words.

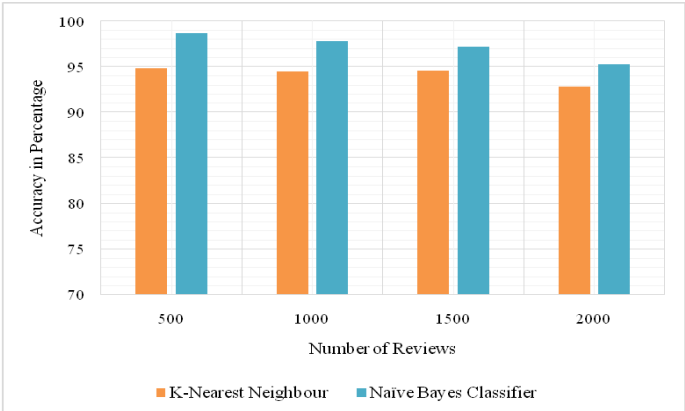

Figure 4: Comparative Analysis of the Naïve Bayes and KNN algorithm for the extracted explicit aspect.

Table 4 shows the accuracy calculated for Naïve Bayes and K-Nearest Neighbors classification algorithm for different number of reviews.

Table 4: Accuracy calculated for Naive Bayes and K-NearestNeighbor

No of Reviews	K-Nearest Neighbour	Naive Bayes Classifier
500	94.8%	98.7%
1000	94.5%	97.8%
1500	94.6%	97.2%
2000	92.8%	95.3%

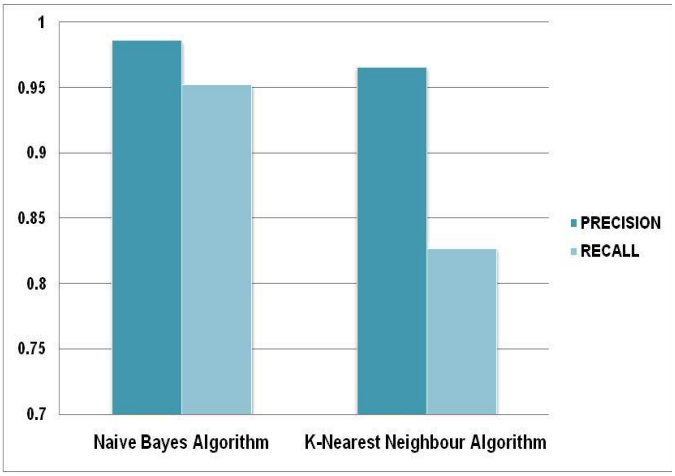

Figure 5: Parameters of evaluation for extracted explicit aspect

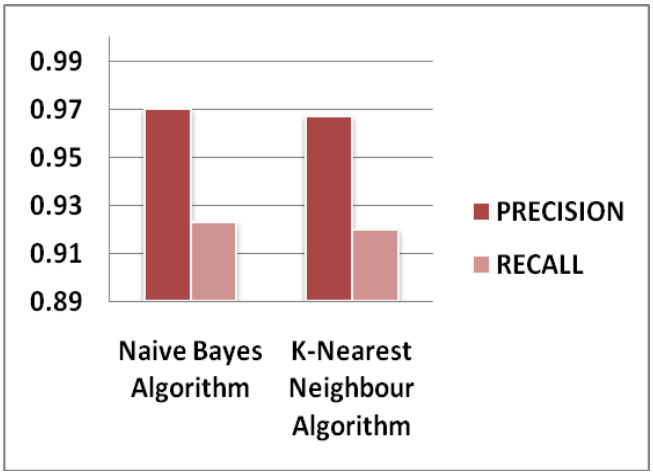

Figure 6: Parameters of evaluation for extracted opinion words

5.1 Precision, Recall and Accuracy

The performance of the proposed model is tested by using the standard parameters precision and recall. Precision is used to measure how much extracted values are correct. Recall is how much fraction of relevant values is extracted. Precision, Recall and Accuracy is calculated by using the following equations (2),(3) and (4)

$$\text{Accuracy} = \frac{TP + TN}{(TP + TN + FP + FN)} \quad (2)$$

$$\text{Precision} = \frac{TP}{TP + FN} \quad (3)$$

$$Recall = \frac{TP}{TP + FP} \quad (4)$$

Where TP represents the number of input reviews correctly categorized as positive, TN represents the number of input reviews categorized correctly as negative, FP represents the number of input reviews grouped wrongly as positive, and FN represents the number of input reviews grouped wrongly as negative.

Table 5 shows the performance evaluation parameters such as precision, recall calculated for extracted opinion words.

Table 5: Precision and recall calculated for extracted opinion words

	Naïve Bayes Algorithm	K-nearest Neighbour
Precision	0.97	0.923
Recall	0.967	0.92

The performance analysis of the proposed system concludes that naïve Bayes Classifier is more accurate than K-Nearest Neighbor classifier for the product dataset which is used.

5.1. Various Challenges in aspect level opinion mining

A good aspect-based opinion mining algorithm should consider some important factors in order to mine the right information which are: *implicit aspect, multi-aspect in a sentence, question based sentences, domain and language adaptability*, which affect the accuracy and effectiveness of an aspect based opinion mining algorithm. But these are very challenging in Aspect Based Opinion mining. Firstly, implicit aspects are those features which are implied in a sentence. For instance: *"The restaurant was expensive"* here implicit aspect is price [17]. Secondly, multi-aspects are those features which are mentioned in a single sentence, however, where one aspect is positive and other aspect is negative.For instance: "*The food is very good, but the atmosphere is not good"*[11]. Thirdly, question based sentences are self explanatory instance: *"Is the voice quality of this X camera is good?"*[10]. Hence, the customer is interested in knowing the "voice quality" aspect. Explicit features are directly mentioned in a sentence for instance: *"their services are excellent"*, here 'service' is explicit feature [11]. Lastly; domain and language adaptation means that aspect-based Opinion mining algorithm should be adaptable to multiple domains and languages.The process of mining opinions would ease this task by providing a summary of customer reviews in terms of aspects of a product or service indicating whether it is positive or negative.

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VI. CONCLUSION AND FUTURE WORK

With the advancement in web and internet technology, large amounts of data is produced every day, which made it difficult for the customers, manufacturers or even for social network users to get accurate and correct information. Which led to the concept of aspect based opinion mining. For purchasing the product online, people often see reviews about the products in the various websites and then come to a conclusion whether to buy the product or not. But it is highly impossible to read all hundreds or thousands of reviews.This decision making process is very important before purchasing any product.

The work presented in this paper is able to extract the explicit features and the corresponding opinion from the given product reviews. For the extracted explicit aspect and corresponding opinion words sentiment orientation is calculated. Classification method is applied on the extracted features. Both the Naive bayes and KNN is applied to classify the sentiments and the accuracy is calculated.Naive Bayes Classifier gives more accuracy,precision and recall than K-nearest neighbor classifier. Customers can decide whether to buy the product by seeing the features and its opinion.Only the mobile products are considered for analysis here. It can be done for many other products reviews. Here only the explicit aspect is extracted along with the corresponding opinion words. In future we can extract the critical factors like implicit aspect, multi based aspects along with the opinion words to improve the accuracy.

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AUTHORS PROFILE

Minu P Abraham, working as Assistant Professor in the Department of CSE, NMAM Institute of Technology, Nitte. She has completed her B.Tech in Computer Science and Engineering from Kerala University and M.Tech in Computer Science and Engineering from Visvesvaraya Technological University. She has 9 years of teaching experience and 2 years of research experience. She has published 4 research papers in reputed journals. She has also presented 4 conference papers in national and international conferences. She is a lifetime member of Indian Society for Technical Education.Her fields of interests are Datamining, Text mining, Natural language processing and Artificial Intelligence.

Dr. Udaya Kumar Reddy K.R, In 1993 he completed his Diploma in Computer Science and Engineering from Siddaganga Polytechnic, Tumkur, Bangalore University. In 1998, he completed his Bachelor of Engineering in Computer Science and Engineering from Golden Valley Institute of Technology, K.G.F, Bangalore University, India. In 2002, he completed his Master of Engineering in Computer Science and Engineering from University Visvesvaraya College of Engineering, Bangalore, India. In 2011, he completed his Ph.D. in Computer Science and Engineering from National Institute of Technology, Trichy. He has over 20 years of teaching and research experience and currently he is Professor and Head of Computer Science and Engineering department at NMAMIT, Nitte. He has published many research papers in reputed journals.His fields of interests are Algorithmic graph theory, Design of Compilers, Theory of computation, and Data Mining

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