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A SURVEY OF MACHINE LEARNING TECHNIQUES FOR SENTIMENT CLASSIFICATION

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ABSTRACT

Opinion Mining also called as Sentiment Analysis is a process that provides with the subjective information for the text provided. In other words we can say that it analyzes person's opinion, evaluations, emotions, appraisals, etc. towards a particular product, event, issue, service, topic, etc. This paper focuses on the machine learning techniques used for sentiment analysis and opinion mining. These methods are further compared on the basis of their accuracy, advantages and limitations.

KEYWORDS

Sentiment Analysis, Natural Language Processing, Opinion Mining, Naïve Bayes, Support Vector Machine, Maximum Entropy, Multi Layer Perceptron.

1.INTRODUCTION

Language is one of the vital forms of communication. Communication is the process where exchange of thoughts takes place among group of people with the help of language (natural language). Here natural language could be English, Hindi, Marathi, German, French, and any other language. The message or the exchange of thoughts are done with the help of acoustics or gestures which are easy for human to understand. But, for a computer, same task is a bit difficult. This difficulty can be overcome by using Natural Language Processing (NLP). Natural Language Processing is a computerized approach used for analyzing naturally occurring data viz. text, speech, etc. Thus, we manage to say that the goal of NLP is to successfully perform human like language processing.

Now-a-days people rely on others opinions that are stated on the web in order to take any decision. Decision is a combination of reason and emotion which are complementary. Thus, Sentiment Analysis has gained a worldwide importance. It is a type of natural language processing that is used for keeping the track of mood of the public and assigning polarity to it. Lately, opinion mining and sentiment analysis has grab the attention of the researchers with the rapid increase of possible applications.

The paper presents a detail survey of various machine learning techniques and advantages and limitation of each technique. Related work done and past literature is discussed in section 2. Section 3 discusses about the data sources being used for sentiment analysis and opinion mining. A brief idea about opinion mining framework has been discussed in section 4. Section 5 discusses about the machine learning techniques in detail along with their comparison. Lastly, section 6 concludes the paper.

2.LITERATURE SURVEY

In this section we cite the relevant past literature that use the various sentiment analysis and opinion mining techniques. Most of the researchers concentrate on sentiment classification.

G. Vinodhini [1] has proposed the techniques used for sentiment classification which includes Naïve Bayes, the basic idea is to estimate the probability of categories given a test document by using the joint probability of words and categories, Statistical classification method based on the structural risk minimization principle from the computational learning theory (SVM), Centroid Classification, K-nearest neighbour Method, Winnow, well-known as online mistaken-driven method, and Ensemble technique, combines several base classification output to generate an integrated output.

Zhu Jian [1] proposed a model that uses artificial neural networks to divide the movie review corpus. This model classified the corpus into positive, negative and fuzzy tone. Whereas Long-Sheng Chen proposed an approach based on neural network. This approach combines the advantages of the machine learning techniques and the information retrieval techniques.

Blessy Selvam and S. Abiram [2] proposes that opinion mining can be useful in several ways. It helps to evaluate the achievements of a launch of new product in the field of marketing, determines which version of the product or service are popular and even identify which group of people like or dislike particular feature. They have focused on the framework of opinion mining and on the tasks which have been done in each phases.

Arti Buche, Dr. M. B. Chandak and Akshay Zadgaonkar [3] proposed the technique to detect and extract subjective information in text document that is opinion mining and sentiment analysis. Sentiment classification or Polarity classification is the binary classification task. It labels an opinionated document and expresses it as either an overall positive or an overall negative opinion. Sentiment analysis has been used in several applications including analysis of the consequences of events in social networks, and simply to better understand aspects of social communication in Online Social Networks (OSNs). The Authors [4] have discussed methods like Emoticons, LIWC, SentiStrength, SentiWordNet, SenticNet, SASA, Happiness Index, PANAS-t and lastly they have proposed a combined method and compared these methods based on the Coverage and Agreement.

V.S. Jagtap and Karishma Pawar [5] focuses on different approaches used in sentiment classification for sentence level sentiment classification. It focuses to analyze a solution for sentiment classification at a fine-grained level in which the polarity of the sentence can be assigned as positive, negative or neutral. According to them, Sentiment Analysis is the process of extracting knowledge from the peoples' opinions, appraisals and emotions towards the entities, events and their attributes.

Evolution of web technology has lead to the presence of large amount of data in web for the internet users. These users use the available resources in the web as well as directly or distinctly state their opinions or feedback, thus generating additional useful information. Jayashri Khairnar and Mayura Kinikar [8] gives various supervised or data driven techniques to sentiments analysis like NB, SVM, ME out of which SVM out performs the sentiment classification task also considering the sentiment classification accuracy.

Pravesh Kumar Singh and Mohd. Shahid Husain [9] concludes that although opinion mining is in a incipient stage of development but still there is a vision for dense growth for researchers. They attempted to appraise the various techniques of feature extraction. The important part to gather information always seems as what the people think. According to them, from a convergent point of view Naïve Bayes is best suitable for textual classification, aggregation for consumer services and SVM for biological reading and interpretation.

3.DATA SOURCES

This section discusses about the data sources used for opinion mining. The data here can be in the form of speech, text, gestures, etc.

- **Blogs :** Now-a-days people express their opinions or views about a particular product, service, event or issue on a particular place called blogs.
- **Review Sites :** Companies consider the reviews of customer in order to provide proper products and services. These reviews are stated on sites such as www.amazon.com, www.CNET.com, www.yelp.com, www.reviewcenter.com.
- **Data Sets :** Movie review data are most widely used datasets that contains four types of product reviews extracted from well known websites.
- **Microblogging :** The practice of creating and publishing small posts on a personal blog on a microblogging websites. For eg.: A “tweet” on twitter could be a microblog post.
- **News Articles :** Websites such as www.thesun.com, www.cnn.com, www.thehindu.com has news articles which allows the readers to comment on an ongoing event or issue.

4.SENTIMENT CLASSIFICATION FRAMEWORK

This section focuses on the meaning of the basic terminologies and a brief description of opinion mining framework which consist of preprocessing, feature extraction, sentiment analysis, and so on.

4.1.Basic Terminologies

- **Opinion :** It is a belief, judgement, or view about any object based on knowledge or experience.

Lui mathematically represents opinion as a quintuple (o, f, so, h, t) , where o is object, f is feature, so is the polarity of the opinion on a particular feature f , h is the opinion holder and t is the time when the opinion is expressed [10].

- **Opinion Holder :** The person who expresses their views about any object are called as opinion holder.
- **Object :** The object could be anything such as topic, product, services, events, etc. Therefore it can be defined as the entity about which the opinions are stated.
- **Feature :** The attribute of the object based on which assessments are made.
- **Opinion Polarity :** Whether the expressed opinion is positive, negative or neutral is indicated by Opinion Polarity.

4.2. Sentiment Classification Framework

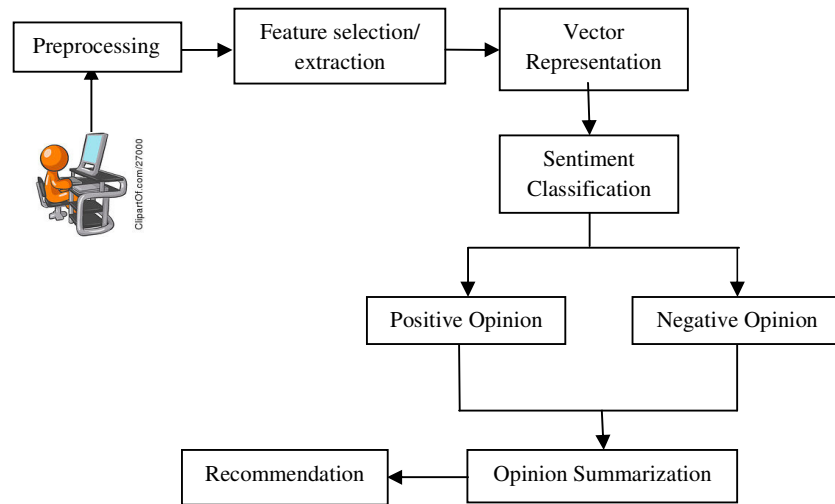


Figure 1. Sentiment Classification Framework [2]

4.2.1.Preprocessing

In this step of opinion mining, raw data is taken and processed for feature extraction [2]. It is further divided into following steps:

- **Tokenization** : Here the sentences are divided into words or tokens by removing white spaces and other symbols or special characters.
- **Stop Word Removal** : Removes articles like “a, an, the”.
- **Stemming** : Reduces the tokens or words to its root form.
- **Case Normalization** : Changes the whole document either in lower case letters or upper case letters.

4.2.2.Feature extraction

This step deals with

- **Feature Types** : It deals with identification of types of features used for opinion viz. term frequency, term co-occurrence, OS information, Opinion word, Negation, Syntactic Dependency).
- **Feature Selection** : It is used to select good features for opinion classification in following ways like Information gain, Odd ratio, Document frequency, and Mutual Information.
- **Feature Weighting Mechanism** : It computes weight for ranking the features using Term presence and term frequency and Term frequency and Inverse document frequency (TF-IDF)[2].
- **Feature Reduction** : It reduces the vector size to optimize the performance of a classifier.

4.2.3. Sentiment Analysis

Sentiment analysis mainly deals with classifying the polarity of a given text by expressing the opinion as positive, negative (objective). This process is carried out at three different levels.

- **Document Level :** At this level the document is taken as a whole and is labeled as positive or negative.
- **Sentence Level :** Here first the documents obtained are parsed into sentences and then the polarity of the sentences are classified as positive, negative or neutral.
- **Word or Phrase Level :** Analysis of product features (product attributes or components) for sentiment classification is called word or phrase or feature based sentiment analysis. It is fine grained analysis model among all other models.

5.SENTIMENT CLASSIFICATION TECHNIQUES

Sentiment classification uses two approaches to classify the nature of documents/sentence. Those are Machine Learning Approach and Lexicon Based Approach. Machine Learning belongs to supervised learning in general and text classification in particular. Thus it is also called as “Supervised Learning”. It comprises of many techniques like Naïve Bayes, Maximum Entropy, Support Vector Machine, K-Nearest Neighborhood, Centroid Classifier, Winnow Classifier, N-gram Model, ID3, C5, Neural Networks, etc[1].

5.1.Naïve Bayes Classifier

It is one of the simplest and widely used classifier which is based on the Bayes theorem. This classifier is generally used to classify documents and sentiments. The ground idea is to appraise the probability of test document belonging to each category and then selecting the most probable category. This can be mathematically stated as follows :

$$P(c_j | d) = \frac{P(d | c_j) P(c_j)}{P(d)}$$

Where, $P(c_j | d)$ = probability of instance of d being in class c_j

$P(d | c_j)$ = probability of generating instance of d in given class c_j

Naïve Bayes algorithm is implemented to estimate the probability of a data to be negative or positive. Thus, the probability (conditional) of a word with positive or negative meaning is calculated in view of a slew of positive and negative examples & calculating the frequency of each of class [8].

$$P(\text{Sentiment} | \text{Sentence}) = \frac{P(\text{Sentence} | \text{Sentiment}) P(\text{Sentiment})}{P(\text{Sentence})}$$

So,

$$P(\text{Word} | \text{Sentiment}) = \frac{\text{Number of words occurrence in class} + 1}{\text{No. of words belonging to a class} + \text{Total no of words}}$$

For example :

Two classes: “Pleasant”, “Unpleasant”

$P(c) = 3/5$ $P(\bar{c}) = 2/5$

Table 1. Example for Naive Bayes

Training set	Doc ID		c = Pleasant?
	1	ecstasy, love, joy, ecstasy	Yes
	2	happiness, relief, ecstasy	Yes
	3	compassion, ecstasy	Yes
	4	ecstasy, disgust, worry	No
	5	ecstasy, disgust, ecstasy	No
Test Set	6	ecstasy, disgust, ecstasy, worry, ecstasy, ecstasy	?

Estimation :

$$P(\text{ecstasy}|c) = (1+4) / (9+9) = 5/18$$

$$P(\text{disgust}|c) = P(\text{worry}|c) = P(\text{envy}|c) = (1+0) / (9+9) = 1/18$$

$$P(\text{ecstasy}|\bar{c}) = (1+2) / (7+9) = 3/16$$

$$P(\text{disgust}|\bar{c}) = P(\text{worry}|\bar{c}) = (1+2) / (7+9) = 3/16$$

$$P(\text{envy}|\bar{c}) = (1+1) / (7+9) = 2/16$$

Classification :

$$P(c|d) \propto P(c) \prod_{1 \leq k \leq n_d} P(t_k | c)$$

$$P(c|d_6) \propto 3/5 \cdot (5/18)^3 \cdot 1/18 \cdot 1/18 \approx 0.000002$$

$$P(\bar{c}|d_6) \propto 2/5 \cdot (3/16)^3 \cdot 3/16 \cdot 2/16 \approx 0.000007$$

5.2.Support Vector Machine (SVM)

Support Vector Machine is a new technique for non-linear binary classification task. It is used to find a maximum decision boundary between two document classes that will help to separate the document vectors. In other words, we can say it gives the best possible surface top separate the positive and negative samples in our case.

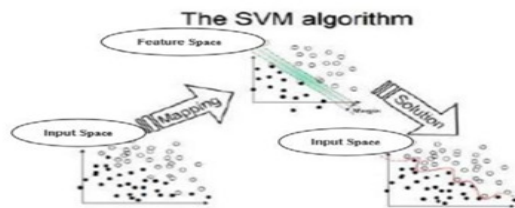


Figure 2. Flow of SVM Process [7]

SVM creates a hyper planes or a set of hyper planes in infinite dimension space. The SVM score z_j of a document is mathematically given as follows:

$$z_j = w_1x_{j1} + w_2x_{j2} + \dots + w_dx_{jd} + b$$

$$\text{i.e. } z_j = x_j^T w + b$$

where,

x_i is a p -dimensional real vector.

w is vector that contains the weights and is given as

$$\vec{w} = \sum_j \alpha_j c_j \vec{d}_j, \quad \alpha_j \geq 0, c_j = \{1, -1\}$$

b is a constant

5.3. Multi-Layer Perceptron (MLP)

Single Layer Perceptron is a classification technique that uses neural network in which data flows from input layer to output layer. The multi layer perceptron is similar to single layer perceptron with the difference that there exist one or more than one hidden layers between the input and the output. There exists a connection between input neurons and each hidden layers neuron. The neurons present in the hidden layer are then connected to neuron in other hidden layers. The number of neurons in the output layer depends on the binary prediction (one neuron) and non-binary prediction (more than one neurons). This arrangement makes a streamlined flow of information from input layer to output layer [7].

The popularity of MLP technique lies in its work as it can act as a universal function approximator. A “back propagation” network has at least one hidden layer with many non-linear units. These non-linear units can learn any function or relationship between group of input variable and output variable (discrete and continuous) which makes the technique of MLP quite general, flexible and non-linear tools [8].

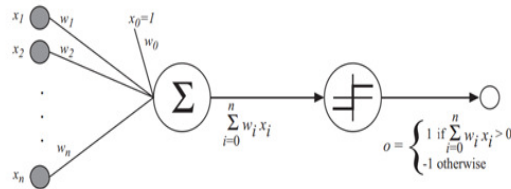


Figure 3. Single Layer Perceptron

It takes a vector of real-valued inputs (x_1, \dots, x_n) weighted with (w_1, \dots, w_n) calculates the linear combination of these inputs

$$\sum_{i=0}^n w_i x_i = w_0 x_0 + w_1 x_1 + \dots + w_n x_n$$

where,

w_0 is a threshold value

$x_0 = 1$

The output is 1 if the result is greater than 1, otherwise -1

5.4.Maximum Entropy

The principle behind Maximum Entropy as suggested by N. Anitha [9] is to find from the prior test data, the best probability distribution. No assumptions are made about the relationships among features. Maximum Entropy (ME) classification is a technique is used in a number of natural language processing applications and has also proven effective. Maximum Entropy sometimes outperforms Naive Bayes at standard text classification. Its estimate of $P(c | d)$ takes the exponential form as shown below [7].

$$P_{ME}(c | d) = \frac{1}{Z(d)} \exp \left(\sum_j \lambda_{i,c} F_{i,c}(d, c) \right)$$

Where, $Z(d)$ is a normalization function.

$F_{i,c}$ is a class function for feature f_i

$$F_{i,c}(d, c') = \begin{cases} 1, & \text{if } d_i > 0 \text{ and } c' = c \\ 0, & \text{otherwise} \end{cases}$$

Table 1 gives a clear picture about the recent works done in the field of sentiment mining using some of the above techniques [5].

Table 2. Summary of the Survey

Sr. No.	Technique	Remarks	Advantage	Disadvantage	Accuracy
1	Naïve Bayes	It is implemented to calculate the probability of a data to be negative or positive.	1. Model is easy to interpret. 2. Fast and efficient computation. 3. Not affected by irrelevant features	1. Assumes independent attributes	79%
2	Support Vector Machine (SVM)	It is implemented to develop a hyper plane in order to separate the data points of two classes from one another.	1. Very good performance 2. Data set dimensionality has low dependency. 3. Produces accurate and robust classifications	1. Lack of transparent of results. 2. Difficult interpretation of resulting model.	82%
3	Multi Layer Perceptron	MLP is a neural network in which data flows in one direction i.e., from input layer to output layer with one or more layers between input and output.	1. Most used type of neural network 2. Capable of learning almost any relationship between input and output variable.	1. Requires more time for execution. 2. Flexibility depends on enough training data need. 3. It is somewhat considered as complex 'black box'	84 - 89%
4	Maximum Entropy	The principle behind this algorithm is to find from the prior test data, the best probability distribution.	1. Provides proper distribution. 2. Do not assume statistical independence of random variables.	1. Requires more of the human efforts in the form of additional resource or annotations. 2. Cannot model the data that require $p(a b) = 1$ or 0	Depends on the no. Of features. Less the no. Of features less is the accuracy and vice-versa.

6.OPEN SOURCE TOOLS

A variety of open source text analysis tools used for NLP such as information extraction and classification can also be applied to for opinion mining as listed below :

- **Ling Pipe:** It is toolkit for processing text using computational linguistics [2].
- **Open NLP:** The Apache OpenNLP library is a toolkit used for processing natural language text. It is based on machine learning techniques. It includes the most common NLP tasks, such as tokenizer, part-of-speech tagger, named entity extractor, chunker, parser, and coreference resolution. In order to build more advanced text processing services these tasks are usually required. OpenNLP also comprises of maximum entropy and perceptron based machine learning [2].
- **Stanford Parser:** It is used as a POS tagger and sentence parsing from the NLP group [2].
- **NTLK:** Natural Language Tool Kit (NLTK) is a leading platform for building Python programs to work statistical and symbolic natural language data. The lexical resources such as WordNet, along with a group of text processing libraries is provided by NLTK along with easy-to-use interfaces to over 50 corpora [2].
- **Opinion Finder:** It is used to identify subjectivity of sentences and to mark various aspects of their subjectivity, including the source (holder) of the subjectivity [2].
- **Red Opal:** Online shoppers are highly task-driven keeping some goal in mind and they look for a product with features that are consistent with respect to their goal. Unfortunately, search functionality provided by existing websites are extremely time consuming for finding a product with specific features. The paper presents a new search system called Red Opal that enables users to locate products rapidly based on features [3].
- **Web Fountain:** Web Fountain is tool that fulfils the needs of analysis agents (miners) such as data gathering, storing, indexing, and querying. It is a high-performance, scalable tool which can be used at distributed platforms. A miner is a software component that extracts, analyzes, parses, and merges data from a Web Fountain data store.
- **Review Seer Tool:** In order to automate the work done by aggregation sites this tool is used. The Review Seer Tool uses NB Classifier to collect positive and negative opinions. Later these opinions are assigned a score to the extracted feature term [11].
- **Opinion Observer:** This tool is used for analyzing and comparing the opinions from the user generated contents on the Internet. As well as it shows the results in a graphical format with respect to the opinions generated for product (feature by feature) [11].

7.APPLICATIONS

Due to the large availability of opinionated data and the practical applications of sentiment analysis on various data sources, interest was generated in the field of sentiment analysis and opinion mining. Following are some of the applications of sentiment analysis [10]:

- **Business:** Adopted in many businesses where there is need of extracting the product reviews, brand tracking, modifying marketing strategies, etc.
- **Politics:** Enables tracking of opinion on issues and events which are of current importance and are related to political and social world. It helps the political organizations to determine which issues are close to the voter's heart.
- **Recommender System:** Sentiment analysis can be a sub-component of this system which can help not recommending those objects that receive negative opinions.
- **Expert Finding:** Sentiment analysis can be used in expert finding systems which can be used to track literary reputations.
- **Summarization:** When the number of online review of a product is large, summarization is used.
- **Government Intelligence:** It has proposed for monitoring the sources, the increase in antagonistic or hostile communication can tracked.

8.CONCLUSION

With the increased use of Internet, the necessity for sentiment analysis is also increasing. This is because people now-a-days depend on the reviews or attitudes expressed by other people on some kind of products, services, topic, issues etc. This reviews are readily available on internet and they could be expressed in any language. Thus the research in the area of NLP is of at most importance for commercial establishments and also for common man.

This paper presented the basic terminologies used in sentiment analysis viz., opinion, opinion holder, object, etc. Along with the basic terminologies the paper discussed the techniques used in sentiment analysis. There are several techniques used for sentiment analysis as foresaid. But the techniques considered here are the most popular techniques and they out performs as compared to other techniques. Also these techniques are compared on the basis of accuracy, their advantages and disadvantages. Thus, no classifier alone can give complete efficiency since the results depend on a number of factors.

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