

Comparative Study of Various Sentiment Classification Techniques in Twitter

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Abstract—Due to increasingly use of various social-sites the Sentiment Analysis become a popular area for research. Various companies are using these social sites to check whether their customers are satisfied with the services provided by them or not. In this paper, different techniques for Sentiment Classification are described in detail. Also the various existing Hybrid techniques are studied. This paper also represents the research gaps of these techniques which are useful for the future work.

Keywords—Sentiment Analysis , Sentiment Classification Levels , Twitter , Hybrid , Machine Learning Techniques.

I. INTRODUCTION

Sentiment is a view, feeling or opinion of a person for some product, event or service [1, 2, 3]. Sentiment Analysis or Opinion Prediction is a challenging problem for classification and prediction, extraction and summarization of sentiments and emotions expressed by various peoples in online text [1,2]. Opinion Mining is replacing web based survey and traditional technologies conducted by companies for finding public opinion about services and product provided by them[1]. It is a multidisciplinary problem, which uses techniques from computational linguistics, machine learning, and natural language processing, to perform various detection tasks at different text-granularity levels. This field aims at solving the problems related to sentiments and opinions provided by the users about products, services and politics in newsgroup posts, review sites, etc [13]. There are different techniques for classifying, extracting customer reviews like Data Mining, Text Classification, Text Mining and Text Summarization, Opinion Mining [13]. Opinion Mining or Sentiment Analysis is the field to extract the sentiments or opinionated text and summarize or classify in understandable form for user [15]. Opinion Prediction is to extract the negative, positive or neutral opinion summary from unstructured textual data.

II. SENTIMENT ANALYSIS WITH SOCIAL WEBSITES

Microblogging today has become a very popular communication tool among Internet users[15]. Millions of messages are using popular web-sites that provide services for

micro blogging such as Twitter, Tumblr, Facebook. In the past few years, there has been a large growth in the use of social sites platforms such as Twitter. Companies and media organizations are finding various ways to mine Twitter for information about what user think about their services and products. Twitter contains a very large number of short messages. Each tweet done by user is 140 characters in length .Tweets are mostly used to express a tweeter's emotion or sentiments on a particular subject. There are companies which poll twitter for analysing or mining the sentiments or emotions on a particular topic. The challenge for these firms is to gather all such relevant data, detect and classify the overall sentiment on a topic. Twitter has been selected with the following purposes in mind.

- Twitter is an Open access social network.
- Twitter is an Ocean of sentiments.
- Twitter provides user friendly API making it easier to mine sentiments in real time.

III. SENTIMENT CLASSIFICATION

Sentiment Classification is used to classifying the according to the sentimental polarities of opinions it contains. Classification Classify the polarity of a given text in the document, sentence, feature or aspect level [8].

A. Various steps in Sentiment Classification are

The various steps in Sentiment Classification are [8]

a). Pre-processing

Pre-processing the data is the process of cleaning and preparing the text for classification. The whole process involves several steps: online text cleaning, white space removal, expanding abbreviation, stemming, stop words removal, negation handling and finally feature selection.

b). Feature Selection

Features in the context of opinion mining are the words, terms or phrases that strongly express the opinion as positive or negative. This means that they have a higher impact on the orientation of the text than other words in the same text.

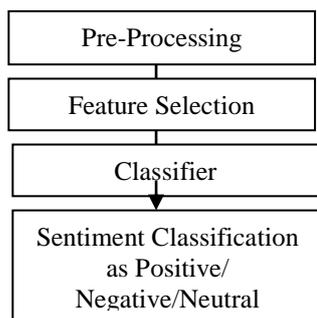


Fig. 2: Steps in Sentiment Classification

c). *Classifier*

In this step, the input to the classifier is the labelled data called training data which pre-processed in above steps. The classifier is trained on this data and finally run on the test data to measure the performance of the classifier. Various algorithms used are SVM(Support Vector Machine), NB (Naive Bayes), ME (Maximum Entropy) etc and lexicon based and also hybrid approach (combination of both machine learning and lexicon based).

d). *Sentiments Classification as Positive/ Negative/Neutral*

In these steps the sentiments are classified as negative, positive and neutral sentiments.

B. *Levels of Sentiment Classification*

The various levels of sentiment Classification are

Sentiment Analysis is performed at four different text granularity levels[8]. Each one of these levels differs from the others in the level of granularity of the analysed text, as follows:

a). *Document Level Sentiment Analysis: [8]*

The basic information unit is a single document of opinionated text. In document level classification, a single review about a single topic is considered. The task at this level is to classify whether a whole opinion document expresses a positive or negative sentiment. The challenge in the document level classification is that the entire sentence in a document may not be relevant in expressing opinion about an entity. Therefore subjectivity/objectivity classification is very important in this type of classification. The irrelevant sentences must be eliminated from the processing works

b). *Sentence Level Sentiment Analysis: [8]*

In the sentence level sentiment analysis, the polarity of each sentence is calculated. Objective and subjective sentences must be found out. The subjective sentences contain opinion words which help in determining the sentiment about the entity. After which the polarity classification is done into positive and

negative classes. The advantage of sentence level analysis lies in the subjectivity/objectivity classification. The traditional algorithms can be used for the training processes.

c). *Phrase Level Sentiment Analysis: [8]*

Both the document level and the sentence level analyses do not discover what exactly people liked and did not like. The phrases that contain opinion words are found out and a phrase level classification is done. This can be advantageous or disadvantageous. In some cases, the exact opinion about an entity can be correctly extracted. But in some other cases, where contextual polarity also matters, the result may not be fully accurate. Negation of words can occur locally. In such cases, this level of sentiment analysis suffices.

C. *Approaches Used in Sentiment Analysis*

There are three major approaches for twitter specific sentiment analysis.

a). *Lexical Based Approach: [8]*

A lexical approach typically utilizes a dictionary or lexicon of pre-tagged words. Each word that is present in a text is compared against the dictionary. If a word is present in the dictionary, then its polarity value is added to the “total polarity score” of the text. For example, if a match has been found with the word “excellent”, which is annotated in the dictionary as positive, and then the total polarity score of the blog is increased. If the total polarity score of a text is positive, then that text is classified as positive, otherwise it is classified as negative.

b). *Machine Learning Approach: [8]*

The other main avenue of research within this area has utilized supervised machine learning techniques. Within the machine learning approach, a series of feature vectors are chosen and a collection of tagged corpora are provided for training a classifier, which can then be applied to an untagged corpus of text. In a machine learning approach, the selection of features is crucial to the success rate of the classification. Most commonly, a variety of unigrams (single words from a document) or n-grams (two or more words from a document in sequential order) are chosen as feature vectors. Machine learning approach is further classified as supervised machine learning and unsupervised learning classification Algorithm.

- *Supervised Machine Learning Classification: [8]* This is most popular data mining technique. Classification used to predict the possible outcome from given data set on the basis of defined set of attributes and a given predictive attributes. The given dataset is called training dataset consist on independent variables (dataset related properties) and a dependent attribute (predicted attribute). A training dataset created model test on test corpora contains the same attributes but no predicted attribute. Accuracy of model checked that how accurate

it is to make prediction. Classification is a supervised learning used to find the relationship among attributes.

- Unsupervised Machine Learning Classification:** [22] In contrast of supervised learning, unsupervised learning has no explicit targeted output associated with input.[22] Class label for any instance is unknown so unsupervised learning is about to learn by observation instead of learn by example. [22]Clustering is a technique used in unsupervised learning. The process of gathering objects which have similar properties into a group is called clustering. Objects in one cluster are not similar to the objects in other clusters.

c). *Hybrid Approach:*

In this, both the machine learning and lexicon based approaches are combined. It gives the better performance than both. The main advantage of their hybrid approach using a lexicon and machine learning techniques is to obtain the best of both worlds-the high accuracy, readability and stability from a supervised learning algorithm.

D. *Existing Techniques Used In Sentiment Analysis*

Large growth in databases has increased the need to develop technologies to mine the knowledge and information. Data mining techniques are useful for this purpose, these techniques are neural networks, fuzzy logic, Bayesian networks, genetic algorithm, classification, clustering, Association, decision tree, multi agent systems, churn prediction and many more

a). *Naive- Bayes (NB)*

The Naïve Bayes algorithm assumes that all the features are independent of each other[23]. We represent a document as a *bag of words*. With the bag-of-words model we check which word of the text-document appears in a positive-words-list or a negative-words-list[23]. If the word appears in a negative-words-list the total score of the text is updated with -1 and vice versa. If at the end the total score is negative, the text is classified as negative and if it is positive, the text is classified as positive.

Steps of the Technique	
1.	Generate two database, first one is of words with their labels and the second one is of opinions or sentences
2.	Split sentence into single words
3.	Now, compare these individual words find in sentence with words in database.
4.	Compare the probability of negative and positive labels
5.	Find the probability of labels.

Table 1: Steps in the Naive Bayes

$$P(c|t) = P(c) P(t|c)/P(t)$$

Above,

c represents a specific class and t represents the text user want to classify.

P(t) and P(c) is the prior probabilities of class and text.

P(t | c) is the probability the text

In our case, the value of class c might be Negative or Positive, and t is sentence.

The goal is maximizing P(c | t) by choosing the value of c.

	Advantages	Disadvantages
1.	It is easy and fast to predict class of test data set. It also perform well in multi class prediction	If categorical variable has a category (in test data set), which was not observed in training data set, then model will assign a 0 (zero) probability and will be unable to make a prediction. This is often known as “Zero Frequency”.
2.	When assumption of independence holds, a Naive Bayes classifier performs better compare to other models like logistic regression and you need less training data	On the other side naive Bayes is also known as a bad estimator.

Table 2: Advantages and Disadvantages of Naive Bayes

b). *SVM (Support Vector Machine)*

SVM is generally used for text categorization [24]. It can achieve good performance in high-dimensional feature space. An SVM algorithm points represents the examples in space, and are mapped to separate the examples of different categories by a clear margin. It gives best results as compare to Naive Byes and Various Sentiment Tools. The basic idea is to find the hyper plane represented by vector w which separates document vector of one class from the vectors of other class.

Steps in SVM	
1.	It starts learning from data that has been already classified.
2.	Groups the data with the same label in each convex hull
3.	Determines where the hyperplane is by calculating closest points between the convex hull.
4.	Then it calculates the hyperplane, which is the plane that separates the labels.

Table 3: Steps in SVM

In SVM, it is easy to have a linear hyper-plane between two classes. [24]But, should we need to add this feature manually to have a hyper-plane. No, SVM uses a technique called the kernel trick. These functions simply do the transform of low dimensional input space to high dimension. It does extremely complex data transformations, then find out the process to separate these data transformations based on the outputs or labels defined by user.

	Disadvantages	Advantages
1.	It doesn't perform well, when we have large data set because the required training time is higher	It works really well with clear margin of separation
2.	It also doesn't perform very well, when the data set has more noise i.e. target classes are overlapping	It is effective in high dimensional spaces.
3.	SVM doesn't directly provide probability estimates, these are calculated using an expensive five-fold cross-validation.	It is effective in cases where number of dimensions is greater than the number of samples

Table 4: Advantages and Disadvantages of SVM

c). CBR

[22]Case Based Reasoning Case based reasoning is an emerging Artificial Intelligence supervised technique used to find the solution of a new problem on the basis of past similar problems. [22]CBR is a powerful tool of computer reasoning and solve the problems (cases) in such a way which is closest to real time scenario. [22]It is a recent problem solving technique in which knowledge is represented as past cases in library and it does not depend on classical rules. The previous problem's solution is stored in Case base or Knowledge Base which is CBR repository. CBR uses this knowledge base to solve the new problem similar to past problem if needed to . In Knowledge Base new instance solution consists of four R's in CBR cycle. Nowadays this is emerging technique used in

opinion prediction systems. Knowledge extracting techniques are combined with Statistical methods to enhance searching of cases, browsing and Reusing for solving new problems and for semantic analysis of a sentence in natural language that can be easily manipulated and used in a text data mining process. This sentence analysis depends and uses various types of knowledge that are: a case base , a lexicon and hierarchy of index. [22]Case based reasoning model is based on the classification rules and course of similarity for the assurance of the compliance.

	Advantages	Disadvantages
1.	It is intuitive , no knowledge elicitation is required to create rules or methods.	Adaptation may be difficult. Cases may be needed to prepare by hand.
2.	It makes the development easy.	Needs case base , case-selecton , may be case – adaptation algorithm.
3.	In this system learn by acquiring new cases through use. This makes maintenance easy.	Can take large time and large memory .

Table 5: Advantages and Disadvantages of CBR

d). Random Forest

Random Forests was the first technique which brought the concept of ensemble of decision trees which is known Random Forest, which is composed by combining multiple decision trees[26]. While dealing with the single tree classifier there may be the problem of noise or outliers which may possibly affect the result of the overall classification method, whereas Random Forest is a type of classifier which is very much robust to noise and outliers because of randomness it provides. Random Forest classifier provides two types of randomness, first is with respect to data and second is with respect to features. Random Forest classifier uses the concept of Bagging and Bootstrapping.

Steps in Random Forest	
1.	Input : B = Number of Trees, N = Training Data, F = Total- Features, f = Subset of Features
2.	For each tree in Forest B: a) Select a bootstrap sample S of size N from training
3.	. b) Create the tree Tb by recursively repeating the following steps for each internal node of the tree. i. Choose f at random from the F. ii. Select the best among f. iii. Split the node.data.
4.	Once B Trees are created, Test instance will be passed to each tree and class label will be assigned based on majority of votes.
5.	Output : Bagged class label for the input data

Table 6: Steps in Random Forest

Sr. No.	Advantages	Disadvantages
1.	Almost always have lower classification error and better f-scores than decision trees.	Random forests have been observed to overfit for some noisy datasets classification/regression tasks.
2.	Deal really well with uneven data sets that have missing variables.	If the data contain groups of correlated features of similar relevance for the output, then smaller groups are favoured over larger groups

Table 7: Advantages and Disadvantages of Random Forest

e). *Maximum Entropy*

Maximum Entropy is a technique that helps us to estimate probability distribution from data[26]. The principle of MaxEnt is that the distribution should be as uniform as it can be, when nothing is known. We use labelled data to train the MaxEnt classifier and create a model, with a set of constrains that will characterize the class expectations for the distribution.

Sr. No.	Advantages	Disadvantages
1.	Performs well with depended features	Low Performance with independent features.
2.	Uses algorithms like GIS and IIS to apply features	The feature selection could become a complex

Table 8: Advantages and Disadvantages of Maximum Entropy.

The Maximum entropy distribution in the usual exponential form: Maximum Entropy Distribution:

$$c(d)= 1(d)\exp(\sum\lambda i f i(d;c)) \dots\dots (1.1)$$

Normalizing Factor:

$$(d)= \sum\exp(\sum\lambda i (:)) \dots\dots(1.2)$$

In (1.1) every (:) is a feature for the classifier, the parameter λi is to be estimated

Z(d) (1.2) is a factor that will normalise the result to an appropriate probability .

The maximum entropy classifier in order to learn the features can use the Generalized Iterative Scaling (GIS) and Improved Iterative Scaling (IIS) algorithms

f). *Decision Tree*

Decision trees are popular methods for inductive inference[21]. They learn disjunctive expressions and are also robust to noisy data .[21] A decision tree is a k-array tree in which each internal node specifies a test on some attributes from input feature set representing data. Each branch from a node corresponds to possible feature values specified at that node. Every test branch represents the test outcomes. Decision Tree induction is a greedy algorithm which follows top down , divide and conquer approach.

Steps in Decision Tree	
1.	It begins with tuples in the training set then selecting best attribute yielding maximum information for classification.
2.	Next step is the generation of test node and after this a top down Decision tree Induction divides tuple set according current test attribute values.
3.	Classifier generation stops when all subset tuples belong to the same class or if it is not worthy to proceed with additional separation to further subsets, i.e. if more attribute tests yield information for classification alone below a pre-specified threshold.

Table 9: Steps in Decision Tree

Sr. No.	Advantages	Disadvantages
1.	Decision trees are relatively easy to understand when there are few decisions and outcomes included in the tree.	Decision Trees do not work well if you have smooth boundaries. i.e they work best when you have discontinuous piece wise constant model.
2.	Nonlinear relationships between parameters do not affect tree performance	Each split in a tree leads to a reduced dataset under consideration. And, hence the model created at the split will potentially introduce bias.

Table 10: Advantages and Disadvantages of Decision Tree

g). *Neural Networks*

Artificial neural networks are constructed from a large number of elements with an input fan order of magnitudes larger than in computational elements of traditional architectures [25]. This artificial neuron is interconnected into group for processing information. Neurons of neural networks are sensitive to store item. This neuron can be used for storing of large number of cases, distortion tolerant represent by high dimensional vectors Recurrent neural networks refer to a type neural networks whose connections form a directed cycle. This allows neurons to store an internal state or memory in a

previous time step that influences the network’s output at timestep t.

CNN is one of most commonly used connectionism model for classification. The focus of Connectionism models are to learn from environment stimuli and to store this information in neurons in form of neurons. The weights in a neural network are adjusted according to the training data by some learning algorithm.

Sr. No.	Advantages	Disadvantages
1.	Neural networks are very flexible with respect to incomplete, missing and noisy data.	There are no general methods to determine the optimal number of neurones necessary for solving any problem.
2.	Neural networks do not make a priori assumptions about the distribution of the data, or the form of interactions between factors	It is difficult to select a training data set which fully describes the problem to be solved.
3.	Neural networks are able to approximate complex non-linear mappings	Don't perform as well on small data sets.

Table 11: Advantages and Disadvantages of Neural Network

E. Research Gaps

A research Gap is the missing element in the existing research literature, and you have to fill with your research approach.

The various research gaps in Sentiment Analysis are as follows:

a). Identification of subjective part:

Sometime, in some cases the same word can be treated as objective or as subjective in other. Which makes it difficult to identify the subjective part?

For example: The language used by Mr. William was very crude. *Crude oil* is naturally occurring, unrefined petroleum product composed of hydrocarbon deposits and other organic materials.

b). Domain Dependent:

Same Phrase and sentences can have different meanings in different languages

For Example,[27] the word “unpredictable“ is positive in the domain of movies, dramas ,etc, but if the same word is used in the context of a vehicle’s steering, then it has a negative

c). Detection of Sarcasm:

It means expressing negative opinion in a positive way about target.

Example: [27]“Nice perfume. You must shower in it.”The sentence contains only positive words but actually it expresses a negative sentiment.

d). Comparisons Handling:

The Comparisons are not handled by Bag of Words. Example:[27]“IIT’s are better than most of the private colleges”, the tweet would be considered positive for both IIT’s and private colleges using bag of words model because it doesn’t take into account the relation towards “better”.

e). Entity Recognition:

Text that gives information about any entity needs to be separated

Example: “[27]I hate Nokia, but I like One Plus”. According to simple bag-of-words this will label as neutral.

f). Order Dependence:

[27] Discourse Structure analysis is essential for Sentiment Analysis/Opinion Mining.

Example: X is way better than Z, conveys opposite opinion from, Z is way better than X.

g). Explicit Negation of sentiment:

Various negative words can be used as sentiment words like no, never etc.

h). Building a classifier for objective sentences:

Most of the researches mostly focus on classifying the tweets as positive or negative. But there is need to classify the tweets which show sentiment vs. no sentiment at all.

i). The warded expressions:

In some sentences the overall polarity of the document is determined by some part of the sentence.

Example: [27]“This Movie should be Awesome. It sounds like whole supporting cast has done good work.”

IV. COMPARATIVE ANALYSIS

In this section the comparison between existing hybrids sentiment analysis techniques are describes in the form of table.

Paper	Technique Used	Results
[28]	SVM , Word based Technique	Accuracy increases due to selection of positive and negative word list for comparing with features as per the review type and another reason is combining the more than one approach i.e. hybrid approach for sentiment analysis.
[29]	Dictionary based Approach , Fuzzy Logic	Negation is handled in this approach results in increased accuracy.
[30]	Enhanced Emotion Classifier , Improved Polarity Classifier , SentiWordNet Classifier	Experimental results show that the proposed technique overcomes the previous limitations and achieves higher accuracy when compared to similar techniques.
[31]	Machine Learning Approach(SVM , NB , ME)	This paper presents the best machine learning approach to sentiment analysis on tweets results in increased accuracy.
[32]	Rule based Classifier , Lexicon based Approach , Machine Learning (SVM)	Fscore of 56.31%
[33]	Naive Bayes , Genetic Algorithm	Increased accuracy.
[34]	BiLSTM-CRF and CNN	sentence type classification can improve the performance of sentence-level sentiment analysis; the proposed approach achieves state-of-the-art results on several benchmarking datasets
[35]	Lexicon Based , SVM , Context Valence Shifter	The tweets are classified more accurately and produces better results
[36]	Naive Bayes ,Lexicon Based Approach	The proposed approach has the ability to increase the accuracy of the classifier and provide flexibility to the user in giving a tweet with variety of sentiment words.
[37]	Naive Bayes , Two Laye CRF	Increased accuracy
[38]	Two SVM with different feature selection	80% accuracy

Table 4.1 Comparison between Existing Sentiment Analysis Based User Recommendation Techniques

V. CONCLUSION

Sentiments can be more accurately classified by working on the limitations of various discussed techniques. It also found that different types of features and classification algorithms

can be combined in an efficient way in order to overcome their individual drawbacks and benefit from each other's and to increase the performance.. This paper discussed different sentiment machine learning classification approaches: NB,

SVM, DT, RF, NN, etc. And their advantages and disadvantages along with semantic analysis and also the various research gaps in sentiment Analysis.

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