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THOMSON REUTERS

[Sasikala, 5(5): May 2018] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1249390 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

AN EMPIRICAL STUDY OF SENTIMENT ANALYSIS TECHNIQUES FOR ONLINE REVIEWS

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ABSTRACT

The growth of web contributes a large amount of user developed content such as customer comments, opinions and reviews. Sentiment analysis in web embraces the problem of aggregating data in the web and extraction about opinions. Studying the opinions of customers helps to determine the people feeling about a product and how it is received in the market. Various commercial tools are available for sentiment analysis. In this paper, we are going to compare and analyze the techniques for sentiment analysis in natural language processing field.

Keywords: *Machine learning , Natural Language Processing Opinion mining, Sentiment analysis.*

I. INTRODUCTION

"What others think?" is always important information in a decision-making process. Every day people discuss various products in social media sites. Companies want a piece of that pie to determine how their audience communicates to find the important information that drives business. Sentiment analysis is the robotic mining of opinions and emotions from text through Natural Language Processing (NLP). Sentiment analysis involves categorizing opinions in text into categories like "positive" or "negative" or "neutral"[1].

Sentiment analysis can be processed in three levels: aspect-level, document-level, and sentence-level. Sentiment analysis in document level considers the entire document as a single topic and classifies positive or negative sentiment. The sentiment expressed in each and every sentence is classified in sentence level. Since sentences are part of the documents does not make much difference between sentence and document level. To get the detail opinion or sentiments have to process the document to aspect level. Aspect level sentiment analysis is to identify the aspects of the sentiment expressed towards each aspect and the given target entities.

The first step in Aspect level sentiment analysis is aspect term extraction identifies the terms in the sentence and list all the distinct aspect terms. For example, "I liked the *movie* but not the *music*", Multi-word aspect terms (e.g., "hard disk") should be treated as single terms (e.g., in "The *hard disk* is very heavy" the only aspect term is "hard disk"). The next step is aspect term polarity which classifies the term as positive, negative and conflict or neutral. The third step is aspect category detection and aspect category polarity [2]. For example, given the set of aspect categories {*food, service, price, ambiance, anecdotes /miscellaneous}*:"The restaurant was too expensive" → {*price}* "The restaurant was expensive, but the menu was great" → {*price, food*}

II. SENTIMENT CLASSIFICATION AND FEATURE SELECTION

Sentiment classification is to select and extract the text features. Feature selection in sentiment analysis is collecting the information from reviews in web and performing the following steps.

***Data Preparation*:** The data preparation step will pre-process the data and removes all the non-textual information and tags. Data pre-processing performs cleaning of data by removing the information like review date and name of the reviewer which is not required for sentiment analysis.

Review Analysis: finding parts of speech (POS) adjectives and counting the presence and frequency.

Sentiment Classification: Classifies the extracted words as positive or negative.

2.1. Feature selection methods

Feature selection method is divided into lexicon based and statistical methods. Statistical methods are fully automated where lexicon based starts with the small set of words. Three methods are included in this study are mutual information (MI), Chi-Square χ^2 and information gain (IG).

2.1.1. Mutual Information

The Mutual Information is the difference between expected and frequency of co-occurrence. In statistical terms, this is a measure of the strength of association between words s and t. In a given finite corpus where K is the number of times s and t co-occurs, D is the domain count, Y is the number of times t occurs without s and Z is the number of times s occurs without t. Then mutual information of s and t is calculated as

$$Mi(s,t) \approx log \frac{(K \times D)}{(K+Z) \times (K+Y)} \quad (1)$$

2.1.2. Chi-Square χ^2

Chi-square (χ^2) is the test of independence compares two categories s and t in a cross-tabulation fashion to determine the amount of association or difference. In a given finite corpus where K is the number of times s and t co-occurs, Y is the number of times t occurs without s, L is the number of times neither s nor t appears and Z is the number of times s occurs without t.

$$\chi^2(s,t) = \frac{D \times (KL - ZY)^2}{(K+Z) \times (Y+L) \times (K+Y) \times (Z+L)} \quad (2)$$

2.1.3. Information gain

Information gain measures the information in bits by predicting the presence and absence of the information. Given the training set, for each term information gain can be computed and removed from the feature selection whose gain value is less than the estimated threshold.

III. SENTIMENT ANALYSIS TECHNIQUES

Sentiment analysis techniques are machine learning, lexicon based and hybrid techniques. Machine learning techniques are implemented in supervised classification. Lexicon based approach relies on the collection of sentiment terms. A hybrid approach is the combination of both machine and lexicon based.

3.1. Machine learning technique

Machine learning approach is the design and development of algorithms which infers data from datasets or databases. Two types of datasets used are training and test set. Training set used by classifier categorizes documents based on characteristics and performance is validated by the test set. Supervised learning method finds the relationship between input and target attributes. Input attributes are nothing but independent variables and target attributes are dependent variables. A model is the structure of relationship which is used for predicting the relationship in attributes. The various classifiers in supervised learning methods are:

3.1.1. Naïve Bayes

The Bayesian Classification is a supervised statistical method for classification and contains practical learning algorithms. The posterior probability of a class can be computed using Naive Bayes model. This model works based on the distribution of the words in the document and suitable for a large data set. Bayes Theorem is used to predict the probability of the given feature set belongs to a particular label.

Bayes theorem provides a way of calculating the posterior probability, P(L|F), from P(L), P(F), and P(L|F). Naive Bayes classifier assumes that the effect of the value of a predictor (F) on a given class (L) is independent of the values of other predictors. The equation can be written as follows [18]:

$$P(L|F) = \frac{P(L|F)*P(L)}{P(F)} \quad (3)$$

3.1.2. Bayesian Network

A Bayesian network is part of probabilistic graphical models (GMs). An ambiguous domain can be represented using these structures. Each node in the graph points to a random variable and the edges between the nodes represents their probabilistic dependencies. These conditional dependencies in the graph are calculated by using known statistical and computational methods.

3.1.3. Maximum Entropy Classifier

Maximum entropy is a probabilistic approach used for natural language processing, segmentation, modeling and POS (part-of-speech) tagging. Maximum Entropy (MaxEnt) uses search based optimization to find the features. The general form of MaxEnt classifier uses word-level features can be described as: The probability of class c in document d and weight W is

$$p(c|d,W) = \frac{exp \sum_i f_{iW_{i(c,d)}}}{\sum_{c' \in C} exp \sum_i f_{iW_{i(c',d)}}} \quad (4)$$

For each word S and class c, features of (S, c) =T, where T is the total number of times S occurs in a document in class c.

3.1.4. Support Vector Machine Classifiers

Support vector machines (SVM) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis.

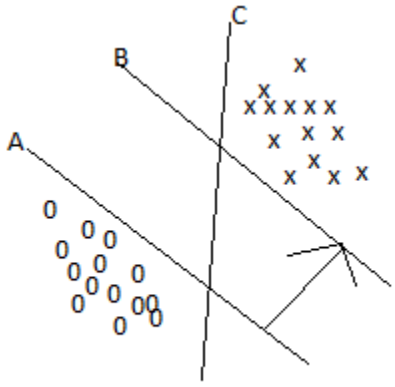

Fig 1. Using SVM for classification

In fig1: There are two classes 0 and x, there are three hyperplanes A, B and C. Maximum margin of separation is represented due to the normal distance of any of the data point is largest which leads to hyperplane A to provide the best separation between classes. Text data is suitable for SVM because of the sparse nature of the text. The features are irrelevant but they have a tendency to be correlated with each other and generally organized into linearly separable categories [3]. SVM is used for sentiment polarity classification.

3.1.4. Unsupervised Learning

Unsupervised machine learning is a machine learning function to depict unseen structure from unlabeled data. In supervised learning, a large number of training documents are provided which are used to train the machine and get the desired outputs. Sometimes it is difficult to generate a training set and it is easy to collect unlabeled documents. Unsupervised learning prevails over these complexities. Two classes of the method have been suggested for unsupervised learning are density estimation and feature extraction. Statistical models are built by density estimation technique. Feature extraction techniques try to dig out statistical regularities (or sometimes irregularities) straight from the inputs. The most widespread unsupervised learning method is cluster analysis, which is used to find hidden patterns or grouping in data.

3.1.5. Rule-based classifiers

The rule-based classifier is a machine learning methods that learn 'rules' to apply, knowledge and store. The characteristics of the rule-based model are identification set of rules that represents the knowledge. Association rule mining is part of the rule-based approach. The training phase generates the rule based on certain constraints. Support and confidence are the general constraints. Support indicates the frequency of item-set in the database and confidence refers success or truth of the rule.

3.1.6. Decision tree classifier

Decision tree classifier is a statistical model uses a decision tree which represents the class labels in the leaves and features of those labels in branches. Algorithm for decision tree works by picking the suitable attribute to split the data and expanding the leaf nodes of the tree until it satisfies the required condition.Decision tree classifier is all about finding attributes that return the highest information gain.

3.1.7. k-Nearest Neighbor

K-Nearest Neighbor is an Instance-based classifier works on unknown instances. It relates the known to unknown instances by distance or similarity. It does not involve prior assumptions about the distribution of data taken from the set of both positive and negative samples. A new sample is classified by computing the distance to the nearest training sample. Positive or negative sign of that point decides the classification of the sample. This approach of locating nearest neighbor and labelling the unknown instance with the same located class label as that of the known neighbor is referred as the nearest neighbor classifier.

3.2. Lexicon-based approach

A sentiment classification task uses opinion words. Positive and negative opinions are used to express the desired and undesired states. The collection of opinion idioms and phrases are called as opinion lexicons. There are three main approaches to collect the opinion word list. The first approach is manual and can be combined with the other two automated approaches to obtain the desired results without mistakes.

The automated approaches are Dictionary-based approach and Corpus-based approach. The basic steps of lexicon based techniques are [4]:

i. Pre-process the text (remove the noisy data)
ii. Initialize the sentiment score: sum ← 0
iii. Tokenize text: For each token, if it is present in the dictionary,
   a. If the token is positive then sum ← sum + N
   b. If the token is negative then sum ← sum - N
iv. If the score sum is
   a. sum > T (threshold), then the text is positive
   b. sum < T (threshold), then the text is negative

In dictionary-based approach, a small set of opinion words is collected manually with known orientations. This set is extended by searching thesaurus and WordNet corpora for synonyms and antonyms. In an iteration, the newly found words are added to the list. Iteration will proceed till no new words found. The corpus-based approach relies on context specific orientation opinion words.

ISSN 2348 – 8034
Impact Factor- 5.070

3.3. Hybrid Techniques

In hybrid techniques, both lexicon and machine learning approaches are used. The entropy weighted genetic algorithm (EWGA) which is the hybrid genetic algorithm that uses the information gain heuristic to improve feature selection. More than one technique should be combined in order to prevail over their individual drawbacks and gain each other's merits and enhance sentiment classification performance. Malandrakis et al. [21] combined a hierarchical model based on an affective lexicon and a language modeling approach, fused at the posterior level for Twitter sentiment analysis. The hierarchical lexicon-based model proved very successful in spite of using part-of-speech information and n-gram ratings. The language model was not as good independently but provided a visible improvement to the lexicon-based model. Overall these models achieved superior performance.

IV. SENTIMENT ANALYSIS TOOLS

There are many tools used for sentiment analysis for detecting the opinions of reviews, blogs or forums in the web which include text, star rating and emoticons. The popular lexicon-based tools available in the market are SentiWordNet, Panas-t, NRC and SentiStrength. A new sentiment analysis method that combines various approaches is SASA0.1.3(PYTHON package).The tool that explores Artificial Intelligence techniques is SenticNet. The tool which uses a wrapper model based entropy weighted generic algorithm is EWGA. The other java based tools are LingPipe, OpenNLP, MALLET and Weka. Opinion Observer is a sentiment analysis tool used to compare the reviews and presents the results in a graph [19].

V. DISCUSSION AND ANALYSIS

The trend of research shows a general cataloguing of sentiments relatively than building positive or negative classifications. The increase in a number of articles for general classification shows that sentiment analysis is growing. Many articles proved that using domain dependent data gives more accurate result than domain-independent data.[5,.6] Unsupervised methods are used because of the straightforward availability of unlabelled data.

Most of the research proved that Support Vector Machine (SVM) has high precision. The main constraint of the supervised learning is a creation of expert-annotated training set, and may not succeed when training data is inadequate. The following table shows the result of a comparative study of sentiment analysis techniques in web based on various techniques.

Paper	Dataset	Technique (Accuracy, %)
Nan Li [7]	Sino-Sports forum	SVM (80%) Decision Tree (58.2%)
K Nirmala Devi et al. [8]	Forums.digital.point.com	SVM (60%) Naïve Bayes (48.6%)
Evandro et al.[9]	Online blogs	Naïve Bayes (79.67%) SVM (85.50%)
A.Ortigosa et al.[10]	Facebook	SVM (83.27%)
Qiang Ye [11]	Yahoo.com(Tourism Review)	Naïve Bayes (80.71%) SVM(85.14%)
Turney [12]	Epinions	PMI (66%)
Ziqiong et al. [13]	Cantonese	Naïve Bayes (93%)

Paper	Dataset	Technique (Accuracy, %)
	Reviews	SVM (90%)
Zang et al.[14]	Twitter	Machine Learning and Lexicon based techniques (82.62%)
Kaiquan Xu et al. [15]	Amazon Reviews	SVM (61%)
Pang et al.[16]	IMDB	Naïve Bayes (81.5%) SVM (82.9%)
K Dashtipour et al. [17]	Blitzer (Books and DVD reviews)	Naïve Bayes and SVM (65%)
M.Govindarajan	Movie-Review Data	Naïve Bayes (NB) 91.15 % Genetic Algorithm (GA) 91.25 % Proposed Hybrid NB-GA Method (93.80%)

VI. CONCLUSION

This comparative study paper presented an outline on the recent updates in sentiment analysis and its techniques. After analyzing the articles, it is apparent that applying sentiment analysis to excavate the vast quantity of data has become a significant research problem. Most of the techniques used give good results, but no techniques resolve all the challenges. SVM and Naive Bayes have high precision than other algorithms. We can conclude that SVM has ascendancy with performance and accuracy, but still it is not suitable for imbalanced data sets.

Naïve Bayes is selected for less memory and pre-processing power requirements. More research on context-based sentiment is required. Using Natural Language processing tools in sentiment analysis has attracted researchers and still needs some enhancement. Hybrid techniques with improvement had shown good performance. The right selection of a classification model plays a vital role in sentiment analysis since the result influences the correctness of the system and the end product.

There is an immense need in the market for sentiment analysis tools and applications because every company wants the opinion of customers about their products and services for further enhancements and to compete with their opponents.

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