Polarity Shift Detection Approaches in Sentiment Analysis: A survey

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Abstract— **Sentiment analysis is a process of identifying and categorizing opinions expressed in a piece of text. It classifies the text into positive, negative or neutral. Lexicon-based and Supervised Machine Learning-based are the two main approaches in sentiment analysis. Bag-of-words model is used to represent the text as a vector of independent words and machine learning algorithms are used for classification. Polarity shift is the major problem in the Bag-of-words model. Polarity shift is a sentiment classification problem. It can reverse the sentiment polarity of the text. Classification performance of machine learning based systems can get affected by polarity shift. Negation is the type of polarity shift. Negative words can change the polarity of the sentimental words. Polarity shift detection methods are used to detect the polarity shift in the sentences. It helps to improve the performance of machine learning classification algorithms. Natural Language Processing can be used for feature extraction and classification. Sentiment analysis uses Natural Language Processing for extraction of opinion words from the text. Sentiment analysis plays an important role in identifying the opinion of the people about a specific topic or entity. This survey paper reviews the sentiment analysis approaches and highlight the need to address polarity shift problem in sentiment analysis. The different polarity shift detection techniques are discussed in this paper.**

Keywords—*Sentiment Analysis, Supervised Machine Learning, Polarity Shift*

I. INTRODUCTION

Sentiment analysis is the study of people's sentiments, views, opinions, or emotions towards certain entities. Sentiment analysis is also known as opinion mining. Sentiment analysis deals with the automatic detection and classification of opinions expressed in text written in natural language [1]. Subjectivity is the linguistic expression of somebody's opinions, sentiments and emotions. Objectivity is

the expression of facts [1]. Lexicon based and machine learning based are the two approaches of the sentiment analysis [2]. Sentiment lexicon is used in the lexicon based approach. Sentiment lexicon is a collection of known and defined words. A specific sentiment is assigned to each word in the collection. The lexicon based approach is divided into dictionary based approach and corpus based approach [2]. Semantic and statistics methods are used by both dictionary based and corpus based approach. Supervised machine learning methods are based on training classifiers. It contains two sets of documents i.e. Training and a Test set. The labelled training document is required in supervised learning approach. Training set is used by classifier to learn about the document. The test set is used for validation. Naive Bayes, Support Vector Machine, and Maximum Entropy are the examples of classifiers. Sentiment analysis task is divided into three categories; Aspect level, Sentence level, Document level [3]. It is shown in Fig. 1. Aspect level analysis deal with the aspects of items. It can also be considered as phrase level analysis. In Sentence level, each sentence is considered as an entity. Summation method is used to provide overall result of the document. In document level, the whole document is considered as a single entity.
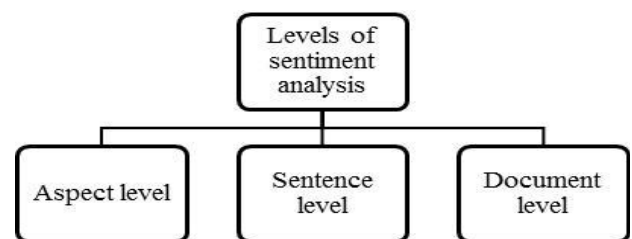

Fig. 1. Levels of sentiment analysis

II. POLARITY SHIFTING

Polarity shifting occurs when the polarity of the sentence is different from the polarity expressed by the sum of the content words in the sentence. Polarity shifters are responsible for polarity shifting. Polarity of the sentiment can be reversed by polarity shifters, e.g., Negation, contrast and sentiment inconsistencies. Polarity shifters, also known as "Valence Shifter" and "Sentiment Shifter" [4]. The sentiment orientation of the word can be changed from positive to negative or vice-versa. For example, I do not like this book [5]. In this sentence, the polarity of the like word is positive, but the polarity of the whole statement is reversed due to polarity shifting caused by 'not' word. Negation is a very common linguistic construction that affects polarity [1]. The Negation scope detection method considers static delimiters, dynamic delimiters and heuristic rules focused on polar expressions. Negation is conveyed by common negation words and other lexical units, such as diminishers [1].Bag-of-words model is used to represent the text as a vector of independent words and machine learning algorithms are used for classification. Polarity shift is the major problem in the Bag-of-words model. In a bag-of-words representation, the supervised classifier has to figure out by itself which words in the dataset, or feature set, are polar and which are not [1].

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III. RELATED WORK

A lot of research has been done by researchers to detect a polarity shift in the aspect, sentence and document level sentiment analysis. Term-counting and machine learning are the two main methods in the literature for document and sentence level analysis [3]. In term-counting method, the orientation scores of content words in a text are added to calculate the overall orientation of the text. In Machine learning method, text is represented as bag-of-words model. Sentiment classification is considered as a statistical classification problem. Classification can be done using any supervised machine learning algorithm.

Polarity Shift Detection Approaches:
- Dual sentiment analysis model
- Polarity shift detection, elimination and ensemble approach
- Term counting with polarity shifting approach
- Sentence polarity shift algorithm
- Sentiment classification with polarity shifting detection approach

A. Dual Sentiment Analysis Model

Dual sentiment analysis (DSA) is the data expansion technique to deal with the polarity shift problem in sentiment classification [3]. The data expansion technique is used to create sentiment reversed review from the original review. Both original and reversed reviews are used in pairs to train a sentiment classifier and make predictions. It is done using a dual training algorithm and dual prediction algorithm [3]. DSA algorithm is extended to DSA3 which deals with positive-negative-neutral class. A corpus based dictionary is created to remove DSA's dependency on an external antonym dictionary.

B. Polarity Shift Detection, Elimination and Ensemble Approach

Polarity shift problem in document level sentiment analysis is handled by Polarity Shift Detection, Elimination and Ensemble (PSDEE) approach [4]. It consists of three stages. First stage detects the polarity shift. A hybrid model is used to detect different types of polarity shifts. It is a combination of rule-based and statistic-based methods. Second stage eliminates the polarity shift problem in negations. The corpus based method is used to create corpus-sense antonym dictionary. Negated words are replaced by the antonym words. Each document gets divided into four parts, namely polarity unshifted text, eliminated negations, explicit contrasts and sentiment inconsistency. A weighted ensemble of base classifiers is used in the third stage. It gives an integrated output by combining the output of several base classification models. Stacking algorithm is used to learn the ensemble weights of three classifiers [4].

C. Term Counting with Polarity Shifting Approach

Corpus is a collection of texts. It is constructed for polarity shift detection. It is a collection of trigger words, such as never, not and however. Detection rules are extracted from a corpus for polarity shifting of sentimental words. Total number of positive and negative words are calculated and it is used to derive the sentiment measure [5]. The rule based system is used during the calculation to detect polarity shifted words. It considers the positive word (negative) as negative (positive) one if it is detected as polarity shifted word. Term counting with polarity shifting classifier is combined with machine learning-based classifier to improve the performance of the classification. Negation, contrastive transition, modality, implication, irrelevance are the five structures which causes the polarity shift [5].Polarity shift structure is shown in Table I.

- Negation: Function-word negators and content-word negators are the two main types of negation structure. Content-word negators contain sentimental words and content meaning.
- Contrastive Transition: It is used to express contradiction. Contrast words can be used to connect one word, sentence, or paragraph to another. Intra-sentence, extra-sentence, and extra-paragraph are subcategories of contrastive transition.
- Modality: It deals with the attitude of the person. Time, Hypothesis, Uncertainty are the subcategories of modality.
- Implication: It is the opinion expressed by a holder on specific targets. Holder, Target and Opinion are the subcategories of implication.
- Irrelevance: It deals with the irrelevant sentences. Sentences are not related to the topic concerned.

TABLE I: Polarity shift structures

Structure	Trigger words
Negation	Not, never
Contrastive Transition	However, nevertheless, though
Modality	Possibly, probably, perhaps, may be
Implication	Others, instead, something
Irrelevance	No explicit trigger words

Heuristic rules are designed to detect polarity shift [5]. Trigger words are used to design heuristic rules. They are categorized into four types [5].

- Intra-clause Rule: If a trigger word is from negation, modality, and implication category, the sentimental words in the clause is considered as polarity-shifted.

- Intra-sentence Rule: If a trigger word is from intra-Sentence Contrastive Transition category, the sentimental words in the clause before the trigger word is considered as polarity-shifted.

- Extra-sentence Rule: If a trigger word is from extra-Sentence Contrastive Transition category, the sentimental words in the sentence before the trigger word is considered as polarity-shifted.

- Extra-paragraph Rule: If a trigger word is from extra Paragraph Contrastive Transition category, the sentimental words in the sentence before the trigger word is considered as polarity-shifted.

Study of different polarity detection techniques is shown in Table II.

TABLE II: Study of polarity detection techniques

Name of reference paper	Techniques	Classifiers	Datasets
Dual sentiment analysis: Considering two sides of one review [3]	Dual training algorithm, Dual prediction algorithm, Corpus based method	Linear Support Vector Machine, Naive Bayes, Logistic Regression	Product reviews
Polarity shift detection, elimination and ensemble: A three-stage model for document-level sentiment analysis [4]	Hybrid model (Rule and statistic based), Corpus based method, Ensemble model	Linear Support Vector Machine, Naive Bayes, Logistic Regression	Product reviews
Sentiment classification with polarity shifting detection [5]	Term counting and Rule based method	Term counting with polarity shifting	Product and movie reviews

D. Sentence Polarity Shift Algorithm

Document-level sentiment classification of reviews gives low accuracies [6]. Contextual information may not be directly identified by bag-of-words model. Sentence-level information may provide better summary of the overall sentiment expressed in each review. Sentence Polarity Shift (SPS) algorithm improves sentiment classification by removing inconsistent sentiment polarities [6]. It uses some default sentiment classification techniques. For example, subjectivity detector, which discards the objective sentences and gives the subjective sentences only. Sentence polarity shift identifies and extracts consistent sentiment polarity patterns from the default subjective sentences. Thus, subjective sentences with inconsistent sentiment polarities are discarded. It is assumed that sentences with consistent polarity patterns represents the absolute sentiment of a review. A hierarchical clustering technique is used to cluster review dataset according to the polarity shift patterns contained in each review. Nearest neighbor selection technique is used to extract consistent sentiment polarities from a review [6].

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E. Sentiment Classification with Polarity Shifting Detection Approach

Sentiment classification with polarity shifting detection approach improves the performance of sentiment classification [7]. Binary classifier is used to divide sentences in a document into two parts: sentences with polarity shifting structures and sentences without any polarity shifting structure. A machine-learning-based classifier is proposed to detect polarity shifting and then two classifier combination method is applied to perform polarity classification. The polarity shifting training data is automatically generated through a feature selection method. Frequency measurement and ratio measurement are the two basic measurements [7]. Frequency measurement measures the document frequency of a term in one category. Ratio measurement measures the ratio between the document frequency in one category and other categories. Weighed Frequency and Odds (WFO) method is proposed to incorporate both basic measurements [7].

IV. SENTIMENT ANALYSIS SYSTEM

Sentiment analysis system is considered as the process of text mining. Sentiment polarity is the output of the system. Sentiment analysis system consists of following steps:
- Preprocessing
- Feature Selection[8]
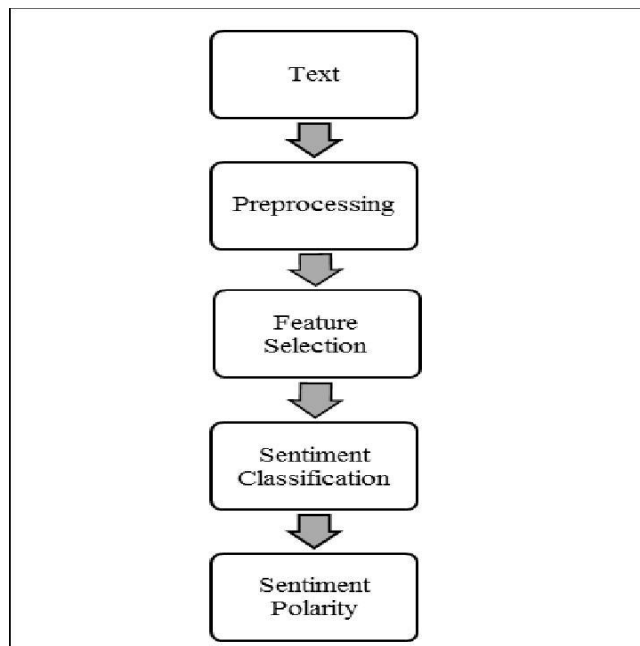- Sentiment Classification[9]
- Sentiment Polarity

Fig. 2. Sentiment Analysis System

A. Preprocessing

Preprocessing is carried out to remove stop words, non-textual contents, markup tags from the text. It consists of following steps:
- Tokenization
  A word is considered as a token. The string is divided into a list of tokens and a bag-of-words is constructed. Text with white spaces is divided to form a list of individual words and it can be used as a feature to train a sentiment classifier [10].
- Stop Words Removal
  Articles, prepositions can be used frequently in the text. They are removed because they do not affect the sentiment of the sentence. A dictionary can be used to remove stop words [10].
- Stemming
  A word can have different forms such as nouns, verbs, etc. The affixes are removed from a word and they are replaced by a base form of that word [10].

B. Feature Selection

A word is selected as the feature of a text.
- Unigram: One word is considered at a time in the text.
- Bigram: A pair of sequential words is selected at a time in the text.
- N-gram: A set of sequential words is taken depending on the value of N. If bigram feature is selected, the value of N is two [9] [10].

C. Sentiment Classification:

Classification methods are used to classify the text into polarity (positive/negative). Training dataset is used to learn the model and trained model is applied to the test dataset. Any supervised classification method can be used for sentiment classification.

- Naïve Bayes:
  Naïve Bayes is a probabilistic classifier [10]. It is based on Bayes theorem. The posterior probability of a class is computed based on the distribution of the word. Bag-of-words model is used for feature extraction. Bayes theorem is used to predict the probability that the given feature set belongs to a particular label [10].

- Support Vector Machine:
  Support Vector Machine is used to classify both linear and non-linear data [11] [12]. In case of linearly separable data, the SVM finds the linear optimal separating hyper plane i.e. the linear kernel. It is considered as a decision boundary which separates data of one class from

another. The SVM uses nonlinear mapping to deal with linearly inseparable data. Nonlinear mapping is used to transform the data into a higher dimension. A linear hyperplane is constructed to solve the problem. Kernel functions are used for transformations [11].

D. Sentiment Polarity

It gives the overall sentiment of the text. This is the final step in sentiment analysis. Sentiment polarity can be positive, negative or neutral. Polarity depends on the sentimental words in the input text. Sentiment polarity is the output of the sentiment analysis system.

V. CONCLUSION

In this survey paper, we have discussed the various approaches for polarity shift detection in sentiment analysis and the overview of the sentiment analysis system. Polarity shift in the sentiment analysis can be detected by five different approaches; Dual sentiment analysis model, Polarity shift detection, elimination and ensemble approach, Term counting with polarity shifting approach, Sentence polarity shift algorithm and Sentiment classification with polarity shifting detection approach. Polarity shift detection, elimination and ensemble model can detect and eliminate all the types of polarity shifts. Hence polarity shift can be easily detected and eliminated by different polarity shift detection approaches. It helps to improve the performance of the machine learning classification algorithms.

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