

# An Ontology-based Sentiment Analysis Model towards Classification of Drug Reviews

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## Abstract

Due to the abundance of information that can be obtained through careful analysis of such data, the need to analyze user-generated data on the internet has recently gained significance. Mining and analyzing such data have become an important aspect for the companies to understand the opinion of the people on specific drug information. The purpose of this research project is to use deep learning models to analyze the feelings of patient reviews to determine the polarity of opinions expressed in reviews that may be positive or negative. All positive relation instances are combined into one class using a binary Support Vector Machine. Logistic regression and Long short-term memory (LSTM) networks are used for sentiment classification of the drug review collected from the Drug Reviews dataset. Logistic regression can be used for the prediction of a group membership. The power of prediction with the given features can be identified using the LSTM classification. The accuracy of 80% is achieved with LSTM classification method.

## Keywords

Sentiment Analysis, Opinion Mining, Deep Learning

## 1. Introduction

Data from social media offer useful information on general health conditions. This applies including in situations when clients of social networking sites are still not conscious of an improvement in personal wellbeing. Depression recently developed as the primary disorder for mental health concern among social scientists, because it is a fairly common mental illness and affects a variety of habits and trends. The advent and widespread acceptance of digital media make significant-time population growth-scale overall sentiment estimation possible, an exceptional ability that has important consequences for our understanding of the social activity. In automatic emotion analysis, it is crucial to consider the aspects of feeling dictionaries relate to their classification. The dictionary-based approaches will keep playing a positive role-they are easy and suitable for online-scale data set [16].

Because of its wide scope, social media is a valuable medium for exchanging knowledge relating to health. It makes it a strong choice for tasks of controlling public safety, especially for co-vigilance in pharmaceuticals. The extracted from social media about the adverse drug reaction study helps the people working in the healthcare sector [4]. The collection of technical knowledge from social platforms is difficult, primarily because of the brief and largely unstructured form of the document especially in comparison with more detailed and structured medical documents. The machine learning methods to determine the occurrence of mental illness and disorder-among participants on social media data [17]. The social media data were collected, feature extracted, and classified effectively between depressed and healthy material, and comparing

Depression is so prevalent in patients with a mental disorder that it can be difficult to determine whether a drug has directly induced depression, or whether the association is coincidental. We review the research on the relationship between treatment and depressive symptoms in this report. Mental illness is one of the psychiatric disorders which is widespread and

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enduring. This gives a real significant societal pressure, including spending on welfare and even rates of suicide. The applications for medicines, or drugs, can be a useful strategy for reducing the life cycle [6]. In this study we introduce a model of drug design by forecasting direction for a particular disorder based on profiling of drug expression, concentrating on psychological requirements. The sentiment analysis [14] received a general overview of the deep learning model. Sentiment analytics tools rely on collections of words and phrases that do have positively and negatively negative associations. The deep learning models that are focused on Sentiment Analysis with semantic ratings are provided with them to decide the final polarization of a document. The effective tool introduced for consumer-generated content predictive analytics on drug user reviews has not been thoroughly examined in comparison with other broader contexts, such as ratings and reviews [11]. A clause-level analysis methodology for opinion is established. The purpose of the analysis was to make models forecasting the author's depressiveness based on his / her written text's statistical semantic indicators. Effective identification of a patient at risk of depression is advantageous for both patient and family in the beginning stages and a severe case. The study presents the original method of monitoring disorder focused on an evaluation of what the participant uses the word to identify the possibility of mental illness. The objective of this to apply ontology to the drug reviews to analyze the sentiment analysis. This paper is organized as follows: Section 2 includes the related work. Section 3 describes the ontology-based sentiment analysis for drug reviews. Sentiment score implementation is described in Section 4. It further discusses the implementation of machine learning algorithms to improve the drug review classification. Concluding remarks are provided in Section 5.

## 2. Literature Study

Sentiment analysis on medical drugs in general collecting user experience data in particular is a complex research topic and the key challenge is the absence of labeled data, which is important for the classification of emotions. Opinion mining or sentiment analysis is used to handle cost-effective and detailed information related to extracting large volumes of data to help determine

product sentiment ratings. The Internet such as social media platforms, blogs, online reviews, and websites produces large amounts of information in the context of user perspective. Common consumer opinions on the internet have a major impact on authors, service suppliers, and decision-makers. It needs the unorganized kind of data. Digital medical forums offer a convenient way for patients to access health information and to communicate beyond clinical practice with doctors and users. Statistics show patients, specifically those recovering from serious illnesses, benefit greatly from the data provided in social media platforms and websites.

Throughout the study in [23], a classification system of attempts had been used to collect participant detail interests throughout online wellbeing platforms and also to uses the support vector Machine (SVM) which is a multiclass classifier to identify initial message articles as per their underlying purpose. Furthermore, large volumes of informal and consolidated content generated on those platforms make ingesting and retrieving relevant information challenging among participants. Ability to understand participant purposes will allow platforms to recognize and propose necessary information to participants by posting off topics that don't correspond to relevant intent and purpose. The aim of the work seems to be to build software techniques to make wellness digitally. Developing new applications for drug treatments, or repositioning drugs, can be a useful strategy for shortening the growth cycle. The drug review system [19] developed has taken the reviews of the patient and opinion identification on the review is extracted based on age and gender-wise classification. Within this analysis the work dealt with a drug discovery approach by identifying significance for a disorder based on features of drug content, depending on medical uses.

A tool [13] for polarity analysis of drug interactions of consumers using contextual information. Polarity identification is the key subtask of emotion evaluation and opinion mining, excellently-known issues in the analysis of natural language which have received growing interest in recent times. Current techniques rely on the contextual portion of the document by which feeling is conveyed directly by specific terms, called terms of emotion. Nevertheless, these methods are also far from being successful in the polarity classification of the observations of

patients. The word embedding method is commonly used in biomedical Natural Language Processing (NLP) technologies because it provides vector representations of words capturing the semantic features of words and the semantic association among terms [22]. Most biomedical applications use various textual tools to learn word embedding and extend this word embedding to biomedical implementations. The work [20] concentrated on forecasting the degree of drug interaction among the users who had encountered the drug influence already. Opinion mining on the drug feedback is evaluated and classification approaches output on drug reviews is completed. The work exploring the effects of social networking on patients' studies show social counseling results in a positive impact on certain health problems. The opinion mining approach used in this study focused on forecasting the degree of drug satisfaction between the other users who have felt the impact of a medication previously. Across certain disciplines, such as behavioral psychology, data sets derived from social media are of importance. However, technological resources are anything but sufficient and unique solutions are desperately needed. The research work of [21] explored applying data mining to the field of psychology to identify distressed users in social media networks. Next, a data analysis approach is suggested using vocabularies and laws to measure each blog's anxiety tendency. Furthermore, a design for depression detection is founded on the suggested approach and 10 characteristics of distressed users extracted from research studies. The author [15] suggested a module focused on sentiment analysis to receive emotions and thoughts through texts linked to the medical field at the analysis and entity level.

Contextual knowledge means the thoughts, values, emotions, and attitudes associated with people concerning various issues of concern. This category of knowledge is of great value to corporations, associations, or persons, as it helps others to engage in acts that support them. Furthermore, sentiment analysis is the domain where contextual knowledge is studied from language processing, analytical cognitive science, knowledge recovery, and machine learning strategies. Research of emotions is very beneficial in different areas, including economics, advertising, hospitality, etc. Also, the healthcare sector means a broad range of opportunities to receive resources through data analysis, including collecting knowledge as to the disposition of

individuals, illnesses, adverse drug reactions, and diseases. Nevertheless, there was very little research on the medical environment and numerous studies are provided to support the recommended framework.

Based on user feedback on different medications together with associated disorders and an overall patient experience score of 10 ratings [3]. The data was collected from drug analysis pages crawled websites. The aim has been to study awareness examines of drug experience across various dimensions, i.e. feelings experienced on particular aspects such as effectiveness. Many online retailer sites will write comments about purchasing goods for customers due to the advancement of online marketing and internet technology. Consumer feedback shared opinions on services or goods usually referred to as consumer input. Opinion analysis through consumer feedback regarding services has become an important area of study.

The work [18] suggested a great idea to effectively consider opinions or sentences of each element from user reviews. The research focus was on getting the processes of words sentiment about the brand aspect analysis on text. The features and opinions collected are beneficial for creating a concise description that provides a valuable insightful strategy to help both the customer and marketers manage the most suitable consumer option [19]. To promote analysis and interaction among emotional research and mental health diagnostics. The work [8] suggested and explored an ontological model for specifically describing the dynamic observable behaviors between emotional individuals and mental illnesses. The framework was based on improved sentiment, impact, and behavior classification within the predefined ontology, as well as psychological conditions in the Ontology of Mental illness. To attempt to formulate the linkages, this endeavor also builds on advances to conceptual ontology involving the relation between ordinary and abnormal. This conceptual analytical structure is important for requirements like classification of behavioral assessment criteria, health data analytics as well as the incorporation and transmission of study findings among domains. Social networking has become incredibly popular as a medium for exchanging information related to social safety. By the use of natural language processing (NLP) methods, this knowledge can be used for health promotion surveillance objectives, notably for pharmacovigilance. Nonetheless, social

networking sites terminology is extremely expressive and frequently non-technical, concise, and difficult to obtain user-expressed health terminology. Significant progress is made in overcoming such problems, and modern NLP methods focused on algorithms were underused. The study by [12] was developing a learning algorithm for extracting details of adverse drug reactions (ADRs) through largely unofficial social media text.

Starting from the DSM-5 definitions of several common mental illnesses has taken into consideration the domain of mental illnesses [1]. In this regard, the preference of a combined method to the interpretation of a behavioral study by integrating ontology method with a schematic interpretation of information based on semantic frames. Analysis of sentiment is the method of getting information from the thoughts, perceptions, and sentiments of the persons against individuals, situations. The work [2] suggested a study using the objective natural language processing approach of the rule-based domain. The approach suggested categorizes emotional and factual sentences from feedback and feedback on the forums. SentiWordNet extracts the semantic rating of subjective phrases to measure their sentiment analysis, depending on the conceptual sentence structure. The framework [10] incorporating CNN with bi-directional long-term memory (Bi-LSTM) to detect harmful drug effects based on user feedback through social media and wellbeing-related blogging.

### 3. Ontology-based Sentiment Analysis

The drug feedback studies at [www.askapatient.com](http://www.askapatient.com) show that approximately 40 percent of texts are polarized details that reflect the perceptions of people with good or negative symptoms. The above suggests how conventional solutions to the analysis of polarity, which focuses on qualitative assumptions, find only segments of the information and overlook a significant amount of useful knowledge. In this work set of reviews about the drugs are taken and gender-wise comments and opinion words in each review are extracted. The opinion words help in deciding the positive and negative sentences of the review. Mental depression is taken into the category of study. There are several different types of mental disorders and in this study e depression, anxiety disorders, and drug abuse are taken into

consideration. The reviews are categorized based on the different set of keywords related to mental disorders.

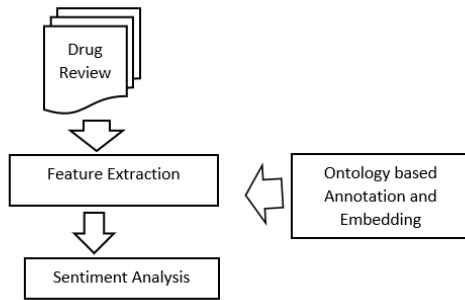
An ontological model is capable of expressing significant categories in the context of the entity or form of impact embodied by a ontology structure. Also, the terms that could be annotated include not only those that are ontologically activating but also those that the entity action based on influencing condition. It could also be that one factor may cause the formation of psychological disorders, while at the same time getting an excitatory fundamental role of phobias. Conceptual structures are therefore correlated with a structure of types of situations to reflect these various kinds of influence. The Mental Disease Ontology describe and classify mental disease given by OBO foundry organization. The main element of depression is fear, anxiety disorder, and panic disorder, social phobia is taken into account

An Emotion Ontology (EM) [7] constructed for the cognitive disorder's domain. The concepts it classifies and describes include sentiments, emotional states, and related to various identities such as behavioral conduct, body movements, personal beliefs, etc.,[9]. Emotion Ontology and Hamilton Anxiety Rating Scale (HAM-A) are used to classify a collection of sentences describing those feelings that individuals have [5]. Table .1 shows the words mapping with the emotions. Score patients by seeking the response that better explains the degree to which they have these problems. The key rating is given by the patient on a scale of 1 to 5. The low rating value is 1 which means that they have a negative opinion on the drug. If the rating is high then it's a positive rating and it means that the drug has helped or cured the patient.

**Table.1 Words mapping with emotions**

Concepts	Words
Emotional mental	Fear, anger, surprise
Emotional Action	Crying, smiling, laughing
Depressed/Dull	Lonely, Loss of interest, lack of pleasure in hobbies, depression.
Fears Anxious	Afraid, Abandon uncertainty, uneasiness, misery, suspense, panic, concern, doubt
Tension	Not relaxing, Feelings of tension, tears, shouting

The ontology-based sentiment analysis can be used to measure each post's average polarity and emotion. By extracting the concepts related to the ontology class. The sentences were annotated with an opinion based on the characteristics and with a polarity of opinion. A collection of feedback and a set of opinion terms associated with the feature in a sentence are mapped because of the set of emotion labels.



**Figure.1: Ontology-based sentiment analysis on drug review**

Figure 1 shows the ontology-based sentiment analysis method based on drug reviews. The sentiment lexicons need to be adapted to cope with the medical term due to different language usage clinical practices. Consider the "positive" word. This term is often used differently in clinical language from our normal use. A "positive finding" often results in negative consequences for a patient. Polarity classification, which identifies texts into different categories such as positive or negative is an important subtask of opinion mining. In recent times the concept of polarity has gained raising focus. Though much work had been done in this field, almost all of the current methods have focused on the contextual aspect of the document where the feeling is conveyed directly by using specific terms called emotion terms. The sentence gives a positive opinion or negative opinion. Furthermore, emotions are displayed not just in contextual declarations, but they can also be conveyed in fact-based phrases that are harder to deal with. In certain phrases, a descriptive paragraph can have polarization without even being contextual. The patient opinion can be labeled as positive or negative without any sentences of feeling also. Table 2 shows an example of polarity in drug reviews. Ontology of Drug Adverse Events (ODAE) is obtained from the ONTOBEE website and provides a representation of adverse effects. The ODAE serves as a knowledge base. The emotional category includes the classification of

opinion terms and the analysis of the direction of that word of view. The phrase Opinion inclination defines the review's positives and negatives. The task involved in polarity classification is to extract the opinion words from the review and to identify word is positive or negative.

**Table .2**

**Examples of polar facts about drugs.**

No	Facts about drug	Polarity
1	This antidepressant has helped me quite a bit. It works particularly well for my anxiety which has disappeared.	Positive
2	suicide thoughts permanently, worsening depression	Negative

The semantic analysis can be inferred from the wordnet dictionary. Based on opinion terms found in the phrase the + 1 score is determined for positive words and -1 for negative words. The final result is positive if the total score contains more positive words. Determine each sentence's final values, and evaluate to determine sentiment analysis. Thus, the importance of opinions for both phrase and review is measured by allocating the aggregate opinion weight to the phrase and evaluating it using Eq.1 and 2.

$$SentenceScore(S) = \frac{\sum_{i=1}^n Score(i)}{n} \quad (1)$$

where, SentimentScore (S), is the sentence positive score or or negative score. Score (i) is the word sentiment score of  $i^{th}$  word in sentence S. n is the total no. of words in Sentence S.

$$ReviewScore(R) = \frac{\sum_{i=1}^n Score(S)}{n} \quad (2)$$

#### 4. Experiment Results

The collection of data obtained from www.askapatient.com for the drug analysis. The databases were created by gathering common drug feedback such as Cymbalta, Celexa, Effexor xr, Lexapro, Wellbutrin. The selected drugs are used for treating people with depression. The preference for such medicines was selected at random from the review web site's list of its most highly ranked drugs. A total of 113,093 comments are collected and 4773 comments are extracted based on evaluations of depression and anxiety.

Figure 2 shows the distribution of men and women in the reviews. The drug reviews will contain the rating, side effects, duration, and dosage information. Figure 3 shows the rating and side effects based on the reviews. The problem was a multi-classification problem for the sentiment classification of the drug reviews on the AskaPatient forum. The sample sentence score is given in Table 3 is used for sentiment classification.

Long Short-Term Memory Network (LSTM) which is an RNN version solves the issue of categorizing opinions. Based on [8] contribution of the work is the integration of ontology information with a neural network classification model. The LSTM architecture for analysis of sentiments consists of a word embedding layer as data.

**Table.3 Sentiment score of the reviews**

Sentence ID	Sentence	Average Sentiment
1	Horrible medicine for me. Switched from lexapro which crapped out after 8 years	-0.2046324
2	Sweating. Weird dreams	-0.1364216
3	Mood swings, insomnia, depression, irritability	-0.6708204
4	Weight gain, brain zaps if dose missed	-0.2834734
5	suicide thoughts permanently, worsening depression	-1.118034
6	Improved in confidence	0.8660254
7	Slept and no fear	0.375

A domain-specific ontology is the included in the semantic embedding layer. The terms

represented as vectors is fed into the deep neural layer. LSTM framework describes layer parameter and level. The first layer is the embedded layer which represents each term using 32 length vectors. 100 units of memory units are included in the layer. The dense layer using the sigmoid activation function and the probability of each class output are given by SoftMax. For classification Dense output layer is for making 0 or 1 predictions using sigmoid activation function. The log loss function is used in this binary classification. The model is suitable for only 2 epochs since it overfits the problem quickly. Precision is the percentage of classified samples that are correct. The ratio of correctively classified to the total review is calculated for Recall. F-score is a measure that combines the score of precision and recall score. Table 4 and Table 5 show the F-score accuracy of the model and comparison of the models.

$$Precision = \frac{\text{No.of Correctly classified reviews}}{\text{Total no.of classified reviews}} \quad (3)$$

$$Recall = \frac{\text{No.of Correctly classified reviews}}{\text{Total no.of reviews}} \quad (4)$$

$$fScore = \frac{2 * (Precision * Recall)}{Precision + Recall} \quad (5)$$

**Table.4 Accuracy of the model**

Polarity	Precision	Recall	F-Score	Accuracy
Positive	0.63	0.63	0.63	0.63
Negative	0.56	0.64	0.60	
Neutral	0.67	0.62	0.65	

**Table. 5 Comparison of the models**

	Dataset (Predicted)		
	Positive	Negative	Neutral
Logistic regression (LR)	79.8	79.0	81.5
SVM	85.4	86.4	85.4
LSTM	92.3	88.0	85.4

**Table.6 Classification error**

Algorithm	Mean Absolute Error	Mean Squared Error
Logistic Regression	0.332	0.315
SVM	0.399	0.357
LSTM	0.171	0.178

Table 6 shows the classification errors of a different model. The success of the prediction model can be estimated using the classification table, 80% of the observations were correctly classified to the appropriate group. 12 out of 15 observations were classified correctly. Table 7 shows the sample new reviews classification success and failure

**Table .7 Actual and Predicted success and failure on new reviews**

	Predicted Results		
		Success	Failure
	Actual	Success	Failure
Result	Success	6	1
	Failure	2	6
		8	7

The observations that are correctly classified are 24.9%. A similar calculation of a failure gives 24.9%. 25% of the reported data combining success and failure is 62.2% which is obtained using classification prediction. The observed 80% is higher than the classification probability of 62.2%, which would support the usefulness of the classifier. Our method achieved 80% of the accuracy from the training set of 30% and appears consistent from the training set of 70%. The findings show that the size of the manually labeled data didn't affect our model. The results of the data set for the classification are given in the table. To determine the accuracy of the method, the overall misclassification rate is determined as well. SVM is better than logistic classification The LSTM is better than SVM. The improved LSTM performance may be due to deep architectures with hidden layers that more effectively reflect intelligent behavior than shallow architectures such as SVM.

## 5. Conclusion

Online review platforms and forums on emotional wellbeing are a huge pool of knowledge that traditional psychology has not yet tapped in. This paper demonstrates how natural text analysis of large databases can enable and speed up THE collection of information, analysis, and opinion extraction by thousands of thousands of people through millions of comments and posts. Becoming able to present many of the results of this study with previous studies in psychiatric research and even experience in a few cases shows the importance of text analysis on large public data is feasible. The effective method can make a significant shift in emotional wellbeing research and address the topic of counseling and care reform and administration. Data on drug analysis in social networking sites and health forums will provide us with useful resources. In future studies, our ongoing research will concentrate on examining possible drug review interactions and evaluating the effect of drug analysis technologies for adverse drug recognition, so that comprehensive online review data will better serve individuals' healthier lives.

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