iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69352

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Effectiveness of Sentiment Analysis Methods: Insights from VADER, SentiArt, and Liu-Hu

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***Abstract:** In the field of ML-Machine Learning, classification is one of the most widely used prediction tasks. In recent era, ML is being widely deployed in almost every field of real-world applications including heathcare. When we use ML for healthcare applications, it should be our main goal to achieve highest possible accuracy. Accuracy of any model is dependent on training dataset and algorithm being implemented. Different characteristics of training dataset contribute significantly to achieve highest possible accuracy. If we talk about general observations then the healthcare applications related data are mainly numerical like test reports showing numerical values. Classification is a categorical task that is easy to understand by patients like whether someone is having a particular disease or not. In this research work, we have evaluated and compared performances of various classifiers to decide which classifier works best when the training data is exclusively numeõrical. Based on our experiments, we have observed that Logistic Regression, Neural Network and Naive Bayes perform more accurately for exclusively numerical data to predict diabetes.*

***Keywords:** Machine Learning, Sentiment Analysis, SentiArt, Liu-hu*

I. INTRODUCTION

NLP-Natural Language Processing is a field of computer science that focuses on making computers do the tasks related to human languages. NLP is involved in translations, summarizations, question-answering type of tasks. NLP is the basic for today's developments of large language models. With the faster growing usage of the internet and social media, users often express what they think and believe in the form of texts through messages. One another application of NLP is to analyse a text to identify the sentiment behind it. Sentiment analysis plays a crucial role to analyse internet based text messages. Sentiment analysis helps business owners to analyse customers' feedback as reviews or comments to identify how many liked the products and how many did not like the products. Sentiment analysis helps social media owners / safety officers / social workers to identify people at risk of mental health or crime to help them accordingly. Sentiment analysis is all about analysing given text by understanding what different words of a text are meant. Based on interpretation of individual words, final sentiment of a text can be identified mainly as positive, negative or neutral [1][2][3].

There are two main approaches to implement sentiment analysis: Dictionary based and pre-trained model based. Dictionary based methods have pre-defined words which are categorized mainly into positive, negative and neutral groups. These methods are count based where for a given text, individual words are compared with the dictionary categories to identify how many are from positive, negative and neutral groups are. Based on these counts, final sentiment count is calculated. These methods are fast but have less capability to have detailed context based understanding, specific to any given application. Pre-trained model based approaches use training datasets to build models mainly using ML-Machine Learning techniques. Later on these models are used for real-world applications. These methods are slow but have capability to have detailed context based understanding specific to any given application. Dictionary based methods are easy to implement, fast and domain independent so are widely used. In our research we are going to compare performances of three such methods: VADER, SentiArt and Liu-Hu [1][2][3].

This research paper is organized into various sections for detailed understanding. Section-II focuses on explaining various recent advancements in literature. Section-III discussed methods of sentiment analysis: VADER, SentiArt and Liu-Hu. This section also discusses our dataset. Section-IV discusses performance analysis of sentiment analysis and observations derived. This paper ends with conclusions and future directives.

II. LITERATURE REVIEW

This section discusses recent contributions by various researchers in the field of sentiment analysis. To limit the length of this research paper, we have included details about various research contributions by mentioning 1 recent approach of every type.

Here our primary goal is to highlight the recent trends in selection of algorithms for sentiment analysis of real world text data. There are some researchers who have reviewed existing work in a comprehensive manner. For example, There is a research paper that explains how various researchers have done sentiment analysis for depression using various techniques of Artificial Intelligence, Machine Learning and Deep Learning. They visually observed that combining multiple Deep Learning algorithms had given more precision specially CNN and LSTM [4]. Researchers have explained different methods of Sentiment Analysis as given in Figure-1 [5].

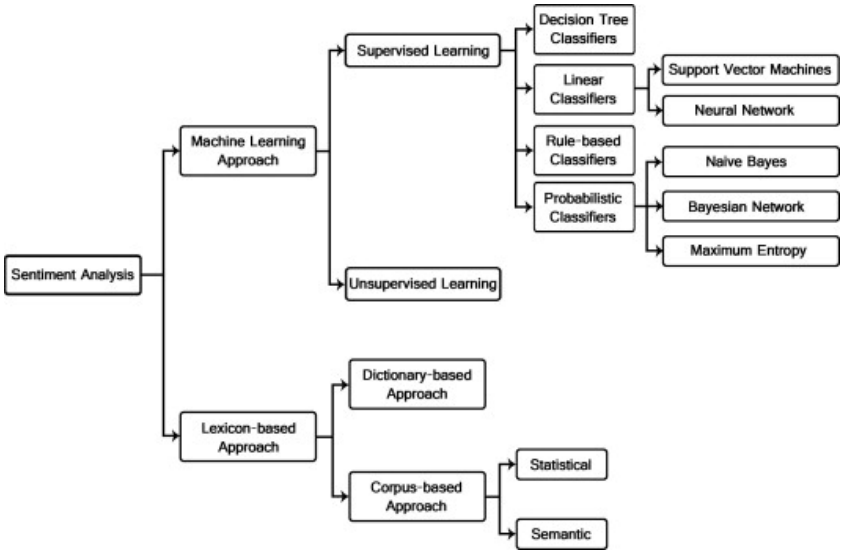

Figure – 1 Sentiment Analysis Methods [5]

1) Machine Learning Approaches: A discussion is given on applications of ML and Deep Learning for business domain applications specifically in the field of sentiment analysis [6]. Naive Bayes classifier is used to perform sentiment analysis for Covid-19 vaccines in Philippines [7]. Five classifiers: Naïve Bayes, k-NN, SVM, Decision Tree and Deep Learning are used to classify customers based on their skin products reviews. They observed that Decision Tree and Deep Learning based solutions were more accurate [8]. Twitter data was analysed for sentiments classification with CNN-Convolutional Neural Network and Long Short Term Memory. This research work gave satisfactory accuracy [9]. There are many more AI, ML, Deep Learning based solutions proposed for different types of data. These approaches are accurate but complex and resource consuming. They also need accurate and complete training datasets. These requirements may limit them to be used for large scale applications. For small scale applications, the other categories (Lexicon based approaches) may be used to get similar accurate solutions without complex and resource consuming implementations.

2) Lexicon based Approaches: Different approaches to build dictionaries for sentiment analysis are discussed mentioning that minimally supervised approach would be appropriate [10]. A corpus based approach is given to analyse students' opinions in a systematic manner [11]. VADER method is used to analyse public sentiments and opinions for SARS CoV-2 vaccination in Saurdi Arabia [12]. SentiArt method was used for the purpose of likeability analysis for German parties in election [13]. Liu Hu, VADER and Ekman methods are used to analyze public sentiments in the news of death of George Floyd [14]. There are many more approaches belonging to this category. The main advantage of these approaches are simplicity and less complex as compared to machine learning approaches. Three of the most widely used approaches: VADER, SentiArt and Liu-Hu are discussed in detail in Section-III as we have worked on these approaches.

III. IMPLEMENTATIONS

A. Sentiment Analysis Algorithms

Sentiment analysis is a sub field of NLP-Natural Language Processing that predicts the emotion behind a piece of text. In the field of social media, sentiment analysis widely used to analyze activities and behaviours of users on platforms such as twitter, Instagram etc. sentiment analysis can also be useful to identify people those are at risk based on their writing patterns. In the field of marketing, sentiment analysis can be used for the analysis of customer feedbacks and satisfactions. This is one of the most important field of NLP as it needs to identify the context behind a text rather than only interpreting word to word.

Different algorithms are designed to achieve sentiment analysis with various approaches like lexicon based methods, machine learning based methods, deep learning methods etc. In this research work, we have worked with three different most widely used algorithms VADER, SentiArt, Liu Hu.

1) VADER (Valence Aware Dictionary and sEntiment Reasoner): VADER is a lexicon and rule based method to analyze short text content to find a sentiment behind it. This method is improved as it used predefined dictionary of words as based for analysis. The words of text are compared from the dictionary. The output is four scores: positive, negative, neutral and compound in the range of -1 to 1. The positive, negative and neutral scores are calculated based on occurrences of those types of words in given text. The compound score is normalized measure of sentiment considering sentiments of all the worlds given in the sentence and so more informative. As this method is dictionary based, it may not handle context in all cases. This method has limited capability to handle sarcasm and metaphors [15].

2) SentiArt: This method differs from VADER as it is not lexicon based and has no sentiment dictionary. This method is based on using word embeddings where words are represented as vectors. For different types of sentiments, reference words are listed by this method. Various words of input are first represented as vectors and then their similarities are calculated with reference words to identify sentiment using cosine similarity or other distance measures. The output is seven scores: Anger, Fear, Disgust, Happiness, Sadness, Surprise and Sentiment. The Sentiment is the compound score. This method handles context, sarcasm and metaphors efficiently [16].

3) Liu-Hu: The Liu-Hu method, introduced by Bing Liu and Minqing Hu, is a lexicon-based method that has a dictionary of positive and negative words to use. The approach is similar to VADER but this method is faster as it given only one score: Sentiment score. the limitation is that it does not handle context, sarcasm and metaphors efficiently [17].

4) Interpretations of compound sentiment score for all three methods (VADER, SentiArt and Liu-Hu) are exactly same which is given in below table.

Compound Score of VADER / SentiArt / Liu-Hu	Sentiment Interpretation
≥ 0.05	Positive
≤ -0.05	Negative
Between -0.05 and 0.05	Neutral

B. Data Set

Any research should not be accomplished with small dataset to achieve effective outcomes. We have used a large and diverse dataset available on Kaggle[18]. This dataset has total 34791 text samples as shown in below table.

Sentiment Type	Total Number of Text Records
Anger	4297
Disgust	856
Fear	5410
Joy	11045
Neutral	2253
Sadness	6722
Shame	146
Surprise	4062

IV. RESULTS AND PERFORMANCE ANALYSIS

As discussed in Section-III, our research work is to analyse performances of VADER, SentiArt and Liu-Hu. A large dataset was used for this purpose. Further to our research work, we have formally noted observations for effectiveness of these methods for various sentiments. The purpose was to get insights of which method is capable to detecting which sentiments more effectively. The subsequent content of this section discusses sentiment wise performances of VADER, SentiArt and Liu-Hu along with our observations.

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Anger	Negative	Positive	482	1098	285	88.78	74.45	24.58
		Negative	3815	3199	1056			
		Neutral	0	0	2956			

Observation: We have observed that VADER performs best, SentiArt performs good and Liu-Hu performs to identify Anger (Negative Sentiment).

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Disgust	Negative	Positive	87	207	49	89.84	75.82	16.36
		Negative	769	649	140			
		Neutral	0	0	667			

Observation: We have observed that VADER performs best, SentiArt performs good and Liu-Hu performs to identify Disgust (Negative Sentiment).

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Fear	Negative	Positive	990	1377	340	81.70	74.55	21.79
		Negative	4420	4033	1179			
		Neutral	0	0	3891			

Observation: We have observed that VADER performs best, SentiArt performs good and Liu-Hu performs to identify Fear (Negative Sentiment). It should be noted that accuracy of VADER is less for Fear as compared to Anger and Disgust.

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Joy	Positive	Positive	2727	2832	2225	24.69	25.64	20.14
		Negative	8318	8213	639			
		Neutral	0	0	8181			

Observation: We have observed that though SentiArt has got highest accuracy, overall all three models are not accurate to identify Joy(Positive) even though sufficient records are there in the dataset.

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Neutral	Neutral	Positive	579	579	237	0.00	0.00	85.97
		Negative	1674	1674	79			
		Neutral	0	0	1937			

Observation: Only Liu-Hu could identify Neutral sentiment with satisfactory accuracy.

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Sadness	Negative	Positive	769	1632	433	88.56	75.72	19.44
		Negative	5953	5090	1307			
		Neutral	0	0	4982			

Observation: We have observed that VADER performs best, SentiArt performs good and Liu-Hu performs to identify Sadness (Negative Sentiment).

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Shame	Negative	Positive	20	32	11	86.30	78.08	35.62
		Negative	126	114	52			
		Neutral	0	0	83			

Observation: We have observed that VADER performs best, SentiArt performs good and Liu-Hu performs to identify Shame (Negative Sentiment).

Sentiment Analysis			Number of Predictions			Accuracy		
Actual Sentiment	Actual Sentiment Category	Predicted Sentiment	VADER	SentiArt	Liu-Hu	VADER	SentiArt	Liu-Hu
Surprise	Positive	Positive	704	1007	480	17.33	24.79	11.82
		Negative	3358	3055	256			
		Neutral	0	0	3326			

Observation: We have observed that though SentiArt has got highest accuracy, overall all three models are not accurate to identify Surprise (Positive) even though sufficient records are there in the dataset.

V. CONCLUSIONS

Our research work was primary focused on effective sentiment analysis from short text. We have used a large and diverse dataset of 34791 text samples that has records for 7 different sentiments. Our implementation was done with Orange tool to analyse performances of three widely used sentiment analysis approaches: VADER, SentiArt and Liu-Hu. Based on our analysis, we have observed that VADER performs best to identify negative sentiments such as anger, disgust, fear, sadness and shame. All three approaches perform with similar accuracies for positive sentiments such as joy and surprise. Only Liu-Hu could accurately identify Neutral sentiment. The main reasons might be the selection of dataset and threshold values of compound scores to classify sentiments. Further to this research work, a more complex and diverse dataset can be tested with different levels of compound scores to improve overall accuracy of sentiment analysis.

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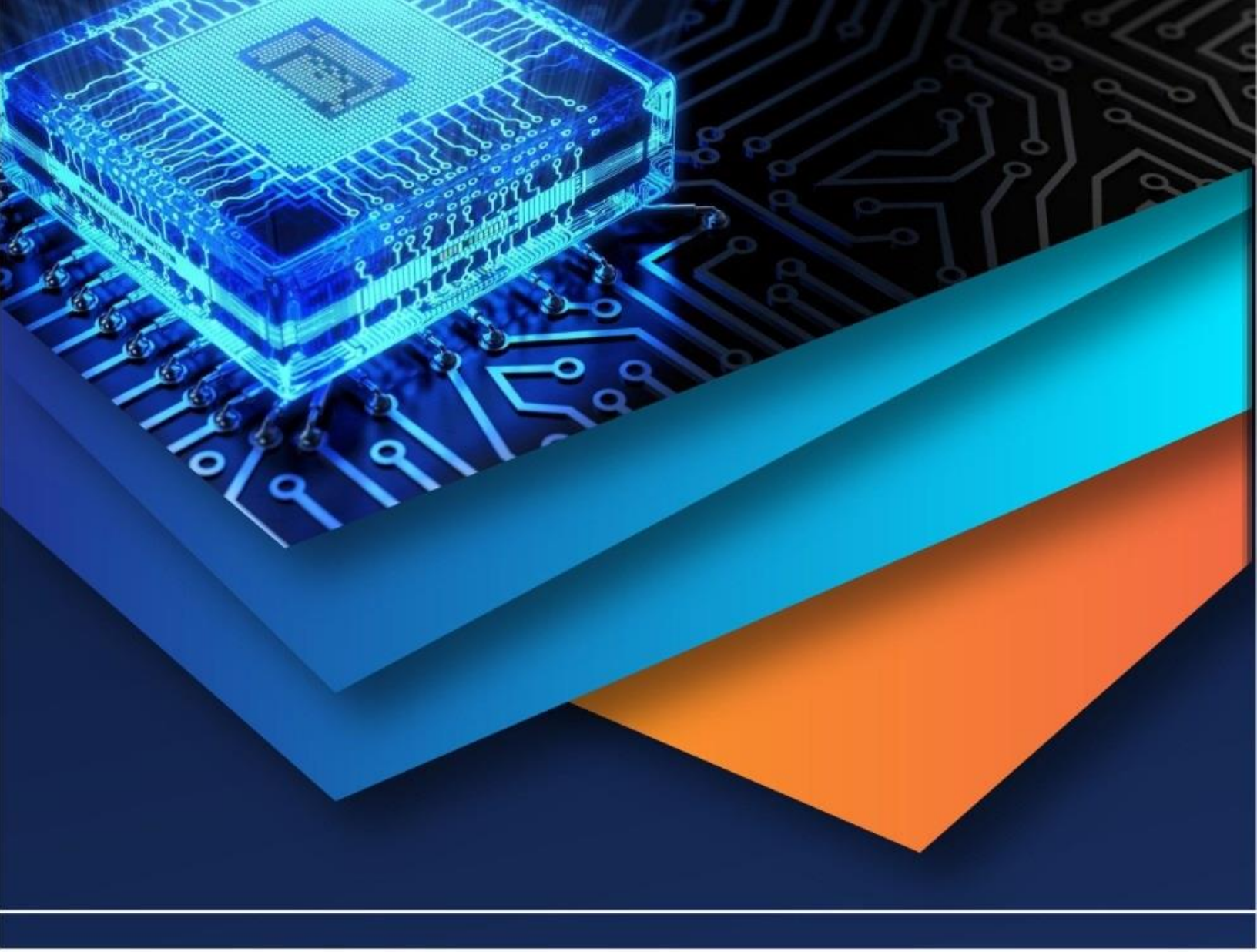

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