A Product Review System using Sentiment Analysis with Cuckoo Search and Deep Learning Technique

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Abstract: *In last two decades, the explosion of e-commerce websites provide a lot of information to users for better analysis about anything. Millions of people express uninhibited opinions in terms of text about various product based on their features and e-commerce company status. This process forms an active feedback system which is of importance not only to the companies developing the products, but also to their rivals and several other potential customers those are trusted on online shopping. In this research, we present a method to analyze the product review based on available sentiment and model is known as a product review system using sentiment analysis with Swarm-based Cuckoo Search (SCS) and Artificial Neural Network (ANN) as deep learning technique. The objective of this research is identifying a set of potential features form text review data using the Lexicon-based feature extraction and SCS helps to select a set of optimal feature using the novel fitness function. Sentiment analysis in e-commerce company play a vital role to automatic extra the review polarity and arrange the review according to the polarity such as positive, negative and neutral. The extraction subjective information from reviews on the e-commerce site, social sites have gained greater attention from the data mining community but there management and fast response is still a big problem. To solve this problem, we present an intelligent system, which used a lexicon dictionary for text data polarity extraction and then SCS helps to select optimal feature form these and the experimental analysis shows that the effectiveness of system by comparing with state-of arts works in terms of performance.*

Keywords: *Sentiment Analysis, Product Review, E-commerce Company, Lexicon Dictionary, Swarm-based Cuckoo Search, Artificial Neural Network*

I. INTRODUCTION

The instantaneous growth of Internet-based applications such as social media, e-commerce sites, recommendation system, etc. has paved the way for one of the interesting areas called the opinion or sentiment analysis [1]. Here, the sentiment analysis is referred as the processing of the classification of human or users feelings, attitudes, perspectives and emotions in a fragment of text towards entity such as products, movies, books, blogs topics, individuals, or events and determine the text polarity to exact analysis. In modern days, the usages of e commerce website on the peak and all users buy products from these platforms by analyzing the reviews and note that commenting on a review about the particular products has a great impact in the decision making process for a user, Polarity-based sentiment analysis system has a great impact towards the data mining research areas. Data mining is well-described as a process of information extraction from large datasets and it can also be said that data mining is a method of mining knowledge from the database based on available information's. Large amount of data takes place in the industry of information [2]. Such data cannot be utilized further for processing, unless that data is transformed into valuable information. Here, we considered sentiment analysis for products review analysis as data mining concept that is also known as sentiment mining. The sentiment mining is used to extract the useful information from the context and it can be categorized into three types according to below given Fig. 1.

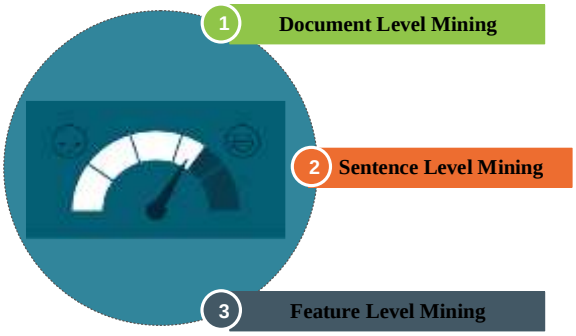

Fig 1: Types of Sentiment Mining

In recent years, the e-commerce sites are becoming extremely popular around the globe and also the privilege of freedom of speech drives more users to put forth their valuable feedbacks on various entities. The users who buy the products online leaves their feedback which helps other people to know about the product and also gives idea about whether the product is good or bad. These online reviews not only help the customers but also help the manufactures to know what exactly the customer likes or dislikes and thereby they can improve the quality of products according to their feedback. So, it is very essential for making quality decisions in the current market research [3]. In this research, the application of sentiment mining to analyze the product reviews on e-commerce website is proposed. Here, we focused on the polarity-based sentiment analysis [4]. The goal of this research is to develop a product review system using sentiment analysis with Swarm-based Cuckoo Search (SCS) and deep learning technique. Here, the combination of text analysis with sentiment analysis is designed to classify the polarity of reviews and the main contributions in this research is listed below:

- A brief survey related to product review system for e-commerce website is discussed to find out better possibilities.
- We proposed a Lexicon dictionary for text reviews feature extraction based on their polarities with SCS algorithm to select a set of appropriate features with novel objective or fitness function to discard the irrelevant features.
- Here, the concept of Artificial Neural Network (ANN) is used as machine learning approach to train or classify the sentiment related to product review in terms of positive, negative and neutral. Because, in recent years, machine learning gain lots of attention and there are two type of machine learning approach that is shown in the Fig. 2.

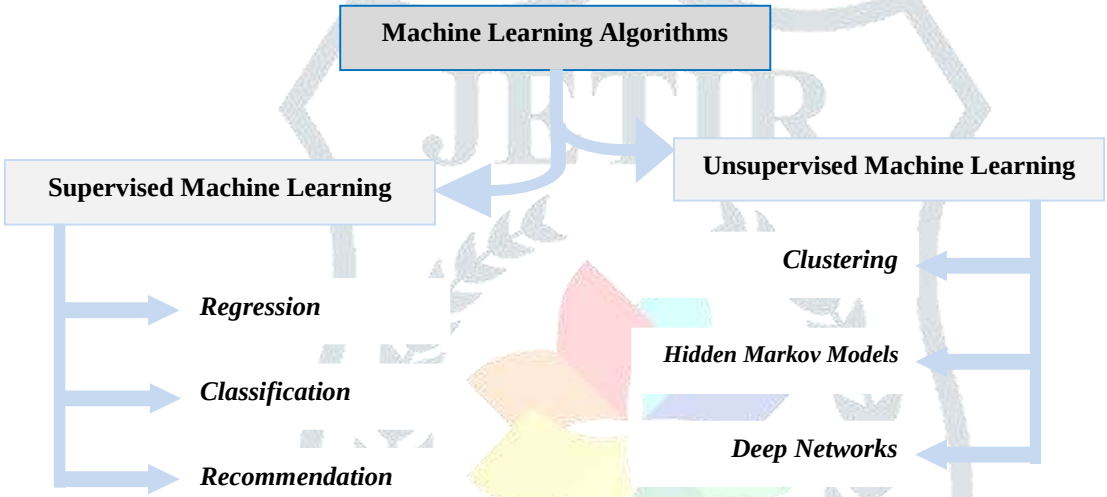

Fig 2: Types of Machine Learning

- To validate the sentiment analysis-based product review system, the performance metrics like Precision, Recall, F-score, execution time, error and classification accuracy is calculated and compare with existing

The rest article is systematized as follows. Survey is discussed in the Section 2 and model architecture is introduces with basic concepts in Section 3. Section 4 describes the experimental results analysis of proposed research and we conclude and suggest several future directions in Section 5.

II. LITERATURE STUDY

This section demonstrated the existing work done by several authors in the field of sentiment analysis based product review system or related works to identify the challenging factors and problems. In 2019, ***R S Jagdale et al.*** had conducted a research on sentiment analysis on product reviews using machine learning techniques. In this research, authors used the Amazon dataset has taken from Amazon e-commerce website which contains reviews of Camera, Laptops, Mobile phones, tablets, TVs, video surveillance. Firstly, they apply some pre-processing and then applied machine learning algorithms to train and classify reviews in terms of positive or negative. This paper concludes that, machine learning techniques gives best results to classify the Products Reviews. Naïve Bayes got accuracy 98.17% and Support Vector machine got accuracy 93.54% for Camera Reviews. In this research, aspect level sentiment analysis was not used to obtained an improve results and need to consider a neutral category also [5]. ***Ali et al.*** in 2019 have introduced a sentiment analysis model using deep learning networks and also provide comparative results of different deep learning networks. Multilayer Perceptron (MLP) has been developed as a baseline for other networks results. Long short-term memory (LSTM) recurrent neural network, Convolutional Neural Network (CNN) in addition to a hybrid model of LSTM and CNN have been developed and applied on IMDB dataset consists of 50K movies reviews files. Dataset was divided to 50% positive reviews and 50% negative reviews. The data is initially pre-processed using Word2Vec and word embedding techniques. The results have shown that, the hybrid CNN_LSTM model have outperformed the MLP and singular CNN and LSTM networks. CNN_LSTM have reported the accuracy of 89.2% while CNN has given accuracy of 87.7%, while MLP and LSTM have reported accuracy of 86.74% and 86.64

respectively. Moreover, the results have elaborated that the proposed deep learning models have also outperformed SVM, Naïve Bayes and RNTN that were published in other works using English datasets [6]. ***Chowdhury et al.*** in 2019 have proposed a process of sentiment analysis of movie reviews written in Bangla language. This process can automate the analysis of audience's reaction towards a specific movie or TV show. With more and more people expressing their opinions openly in the social networking sites, analyzing the sentiment of comments made about a specific movie can indicate how well the movie is being accepted by the general public. The dataset used in this experiment was collected and labeled manually from publicly available comments and posts from social media websites. Using Support Vector Machine algorithm, this model achieves 88.90% accuracy on the test set and by using Long Short Term Memory network the model manages to achieve 82.42% accuracy. Furthermore, a comparison with some other machine learning approaches is presented in this paper [7]. In 2019, ***Jagdale et al.*** have worked on dataset that has taken from Amazon which contains reviews of camera, Laptops, Mobile phones, tablets, TVs, Video surveillance. After pre-processing have applied machine learning algorithms to classify reviews that are positive or negative. In this work authors have concluded that, Machine Learning Techniques provides best results to classify the Products reviews. Naïve Bayes got accuracy 98.17% and Support Vector Machine (SVM) got accuracy 93.54% for camera Reviews [8]. ***Sharma et al.*** in 2018 presented a web based application that helps to visualize present sentiments that are related to the keywords namely hash-tag, phrase or words respectively. The sentiments as well as the geography intensity have been measured. The code has been developed in "Python" software. The sentiments have been plotted on the real tweet map of the world as well as on USA. Hence the tweets sentiments has been analyzed and plotted on the map as per the location [9]. ***Clark et al.*** in 2018 proposed a scheme to recognition technique to identify tweets which is associated to the cancer patients experienced and helps to monitor public health. The data has been gathered about 53 million "breast cancer" tweets posted in September, 2016. Supervised learning scheme in combination with Natural language processing have been utilized so that important data related to breast cancer patient has been experienced [10]. ***Yoo et al.*** in 2018 proposed a structure for learning and guess users sentiments for objects that are evaluated in actual time outside of enormous social media content, and demonstrate the outcomes of the initial verification work. The same trajectory and emotion analysis have been created for the sake of user's perspective. Furthermore, the accuracy of emotional and predictive learning system has been increased by using the latest deep learning methods [11]. In 2018, ***Majumder et al.*** proposed a novel feature fusion strategy, which is carried out in a layered manner, initially the modularity have been integrated and then merging the entire three modes. In the "multimodal sentiment analysis of person's discourses, the used policy is 1% better than the traditional features, which is equivalent to a 5% lessening in error rate. In discourse-level multimodal sentiment analysis of multi-discourse video clips, existing technology combines appropriate data from other discourses of the similar segment, and our layered fusion provides up to 2.4% and observed that there is an reduction of almost 10% in the error rate [12]. ***El Alaoui et al.*** in 2018 also proposed an adaptable sentiment analysis approach that analyses social media posts and extracts user's opinion in real-time. The proposed approach consists of first constructing a dynamic dictionary of words' polarity based on a selected set of hashtags related to a given topic, then, classifying the tweets under several classes by introducing new features that strongly fine-tune the polarity degree of a post. The results of prototype tests have performed a good accuracy in detecting positive and negative classes and their sub-classes [13]. ***Pandey et al.*** in 2017 proposed a new "metaheuristic scheme" that utilizing the K-mean algorithm along with Cuckoo search technique. The appropriate CH (Cluster heads) has been determined from the sentimental information of the "Twitter dataset". The accuracy of the proposed model has been examined on various "Twitter datasets" and comparison has been performed with various optimization techniques such as PSO ("Particle Swarm optimization"), DE ("differential evolution") CS ("cuckoo search") and two n-gram schemes [14].

From the analysis of several existing work in sentiment analysis field, we observed that the accuracy of model is not up to mark because the lack of best feature selection according to the sentiment class. The uniqueness and proper feature selection algorithm is necessary steps to achieve better classification accuracy with ANN as a classifier.

III. PROPOSED MODEL

To design and develop a framework for the simulation of proposed a product review system using sentiment analysis SCS algorithm and ANN as deep learning technique. Where, mainly four phases are conducted such as: I Pre-processing, II Feature extraction III Optimization and IV Training or Classification and their procedure is written as:

Step 1. Design a framework and upload text data with different type's product reviews like positive, negative and neutral for training and testing of proposed sentiment analysis-based product review system. The algorithm of data uploading is written as:

Algorithm 1: Product Reviews Uploading

Reviews Data = Product Reviews Uploading (File)

Start
N_{FILE} = Number of files for uploading
For k = 1→ N_{FILE}
    [File, Path] = Browse (Reviews Folder)
    Full path = concatenate (Path, File)
    Reviews Data [k] = import (Full path)
End – For
Return: Reviews Data
End – Algorithm

Based on the above algorithm, we upload text data for training as well as testing but in testing only single text file is uploaded and the flow of algorithm is shown in the Fig. 3.

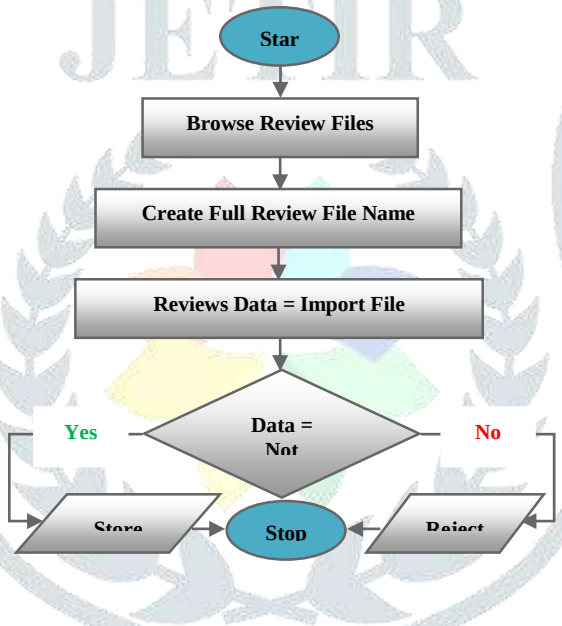

Fig 3: Algorithm-1 Flowchart

Step 2. Apply pre-processing on uploaded data in both section. In the pre-processing several basic steps are involved to make a data according to the requirements. Pre-processing may have impressive positive effects on the quality of feature extraction and the results of sentiment analysis. The pre-processing steps which are applied on uploaded data to generate a compatible data for proposed work are given as:

Data Normalization: It is a basic and essential steps because written words may be in different way but with have same meaning that need normalization processed. It make sure that these words are treated equally. During this process, the text is converted into a common case may be lower/upper case. Here, we convert in lower case and an example, the text is:

"Wow! Best mid-range camera in the market."

When normalization process is applied to this review submitted by user regarding the camera, all the letters are converted into lower case and the text becomes like:

"wow! best mid-range camera in the market."

After that we apply next pre-processing on the normalized review data.

Punctuation Removal: In this process, we removes all types of punctuation from the text and the text is converted punctuation free data that is shown in below given sample.

"wow best midrange camera in the market"

Stop Words Removal: During this phase, we remove all types of stop words present in the sentence and the new data is given as:

"wow best midrange camera market"

Here, all stops words all eliminated from the sentence and a stop word free review data obtained and the sample of stops words is shown in the Fig. 4.

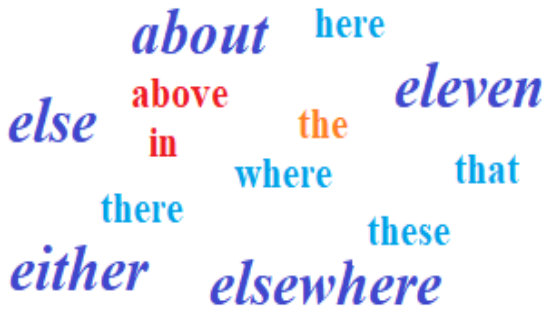

Fig 4: Sample of Stop Words

Tokenization: The processing of string or text data is difficult, so we need to convert into numeric data using the ASCII code. Algorithm of pre-processing is written below:

Algorithm 2: Product Reviews Pre-processing

Pre-processed Reviews Data = Pre-processing (Reviews Data)

Start
RD = Reviews Data
PRD = [] // Pre-processed Reviews Data
N_{FILE} = Number of files for uploading
M_{WORDS} = Number of words in N_{FILE}
For k = 1→ N_{FILE}
  For m = 1→ M_{WORDS}
    PRD [k, m] = Normalization (RD)
    PRD [k, m] = Remove Punctuation (RD)
    PRD [k, m] = Remove Stop Words (RD)
    PRD [k, m] = Tokenization (RD)
  End – For
End – For
Return: PRD as a Pre-processed Review Data
End – Function

Step 3. Pre-processing is applied in both training and testing section. After that, Lexicon-based feature extraction technique is used on the pre-processed review data to extract the feature sets in terms of positive, negative and neutral. The Lexicon-based feature extraction approach is depend on the polarity of a sentence or words and a collection. So, firstly we create a lexicon dictionary manually that is shown in the Fig 5.

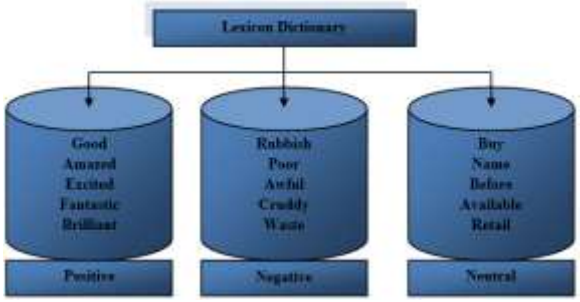

Fig 5: Lexicon Dictionary

In this step, the features of the uploaded product review text data is extracted based on their polarity such as +VE, -VE and Neutral using the Lexicon dictionary.

Step 4. Apply SCS algorithm as a feature selection or optimization technique to select the unique feature from feature sets for each categories based on the objective function (fitness function) of optimization technique. So define a novel objective function for SCS algorithm. The algorithm of feature selection using SCS is written as:

Algorithm 3: Feature Selection using SCS

Selected Features = Pre-processing (Features)

Start

Setup of SCS:

Population of Egg (E) – According to Features

SF – Select Features

Fitness Function:

$$F(f) = \begin{cases} 1; & if\ S_P \geq Threshold_P \\ 0; & Otherwise \end{cases}$$

Where, S_P : It is current feature and

$Threshold_P$: It is the threshold feature and calculated using average of features

S = Size (Features)

For k = 1→ S

C_{EGG} = Features (k) = S_P

$T_{EGG} = Threshold_P = \frac{\sum_{k=1}^{S} Features(k)}{S}$

$F(f) = Fit\ Fun\ (C_{Egg}, T_{Egg})$

SF = CSA (C_{EGG}, T_{EGG}, F (f))

End – For

Return: SF as a selected features

End – Function

Step 5. To achieve better accuracy of proposed sentiment analysis-based product review system, AN) as deep learning classifier is used to train the system, after feature optimization process. In the Fig. 6, a diagram of ANN processing is shown having input, hidden and output layer.

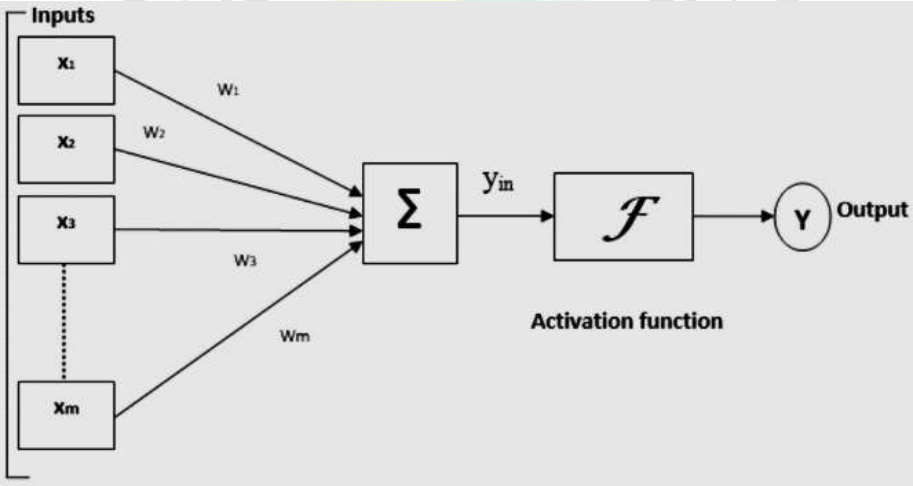

Fig 6: Working of ANN

In Fig. 6, the input of ANN is considered in terms of X and W represents the weight value and the algorithm of ANN is written as:

Algorithm 4: ANN Classifier

Structure = ANN (Selected Features, Types of Review (+VE, -VE & Neutral), Neurons)

Start
Initialize parameters of ANN – Epochs (E), Neurons (N), Random Division, and Trainlm (Levenberg Marquardt)
Compute Size, [N, M] = Size (Selected Data)
For k = 1→ N × M
  If Selected Data from +VE
    Consider as G (1)
  Else if Selected Data from –VE
    Consider as G (2)
  Else if Selected Data from Neutral
    Consider as G (3)
  End – If
End – For
Call ANN with "Selected Data" as a Training data and "G" as Group
Structure = newff (Selected Data, G, N)
Structure = Train (Structure, Selected Data, G)
Results = simulate (Structure, Test Data)
If Results == 1
  Test Data is Positive
Else if Results == 1
  Test Data is Negative
Else
  Test Data is Neutral
End – If
Return: Structure with Results
End – Function

Step 6. After that in the classification section, classify the test data according to the trained structure of classifiers.

Step 7. At last of module, performance parameters of proposed sentiment analysis-based product review system like Precision, Recall, F-measure, Execution Time and Accuracy will be calculated to validate the system. The sample of used Amazon dataset is given in the Table I.

Table I: Used Amazon Dataset Sample

Positive	Got this for my son and apparently it was soo good he won't use anything else now
Negative	Don't buy this product its rubbish!
Neutral	Buy before the stocks run out.

The simulation results of proposed a product review system using sentiment analysis with SCS and ANN as a deep learning technique is described in the below section of paper.

IV. RESULTS AND ANALYSIS

The proposed work mainly carried out in two phases named as training and testing. Once training is done then we perform testing on different data having different polarities. The simulation results of the classification process is depicted in Table II. We have shown the result of proposed sentiment analysis-based product review system and compare with work presented by ***R S Jagdale et al.*** [5] in 2019. Basically, they had conducted a similar research on sentiment analysis for product reviews using machine learning techniques and compute their parameters in terms of precision, recall, f-score, execution time, and error and classification accuracy. Below Table II represents the experimental results for the proposed system for ten sample data having different polarities like negative, positive and neutral to validate the model. The experiment is conducted using a high level programming language named as MATLAB 2016a with various toolboxes such as:

- ***Data Acquisition***
- ***Computer Vision***
- ***Curve Fitting***
- ***Neural Network***

❖ ***Optimization***

MATLAB is abbreviated as Matrix Laboratory. And it is a high performance language for technical analysis. In it computation, visualization and programming has done collectively. It also consist editing and debugging tools, and support object oriented programming using sophisticated data structure. It is an excellent tool used by the researchers, developers and teachers. It has many advantages over conventional computer languages like C, C++ etc. for solving technical problem. The basic data element of MATLAB is an array which cannot need dimensioning. It has been come in the market since 1984 and the experimented results are shown in below Table II for ten different data related to the product reviews from Amazon.

Table II: Evaluated Simulation Results of Proposed Model

No. of Samples	Upload Review Data	Pre-processed Data	Feature	Results	Evaluation Parameters	
1	Got this for my son and aparantly it was so good he wont use anything else now	got son apparently so good wont use	330 333 336 337 425 456 972	Positive	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	97.96 2.04 0.983 0.892 0.935 1.53
2	Bought this for my son and he tells me it's the best thing ever	Bought son tells best things	336 430 538 548 649	Positive	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	98.34 1.66 0.989 0.898 0.941 2.01
3	Don't buy this product its rubbish!	Don't but product rubbish	336 437 751 769	Negative	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	99.37 0.63 0.992 0.901 0.944 1.93
4	I think this is a shoddy design	think shoddy design	542 634 651	Negative	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	97.99 2.01 0.985 0.894 0.937 1.04
5	Buy before the stocks run out	Buy stocks run	336 341 663	Neutral	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	98.23 1.77 0.986 0.895 0.938 1.83
6	Get 20% of what you buy 2 of these	20 buy 2	50 98 336	Neutral	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	97.32 2.68 0.973 0.882 0.925 1.38
7	Love it great add to collection and i loved it - so attractive and very nice	love great add collection loved attractive nice	297 415 438 531 538 1068 1079	Positive	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	98.71 1.29 0.992 0.901 0.944 1.58
8	To keep together, had to use crazy glue	use crazy glue	333 429 553	Neutral	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	99.27 0.73 0.995 0.984 0.989 1.63
	Color is slightly shaded	black good satisfied	425	Neutral	Accuracy (%)	99.93

9	,it's not pure black but It is good but I am not satisfied with this product	product	444 509 543 617 769 880 956		Error (%) Precision Recall F-measure Time (s)	0.07 0.998 0.907 0.950 2.41
10	Very Bad experience. Redmi store reps stated that there is issue with set.	bad experience redmi store reps stated issue set	295 329 529 532 553 557 637 645	Negative	Accuracy (%) Error (%) Precision Recall F-measure Time (s)	98.91 1.09 0.994 0.914 0.952 1.34

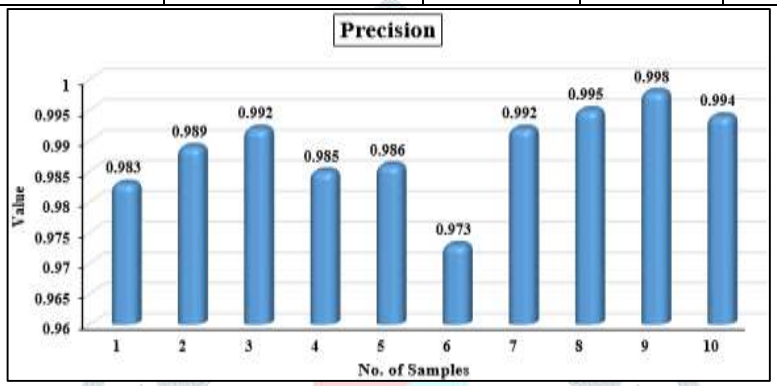

Fig 7: Precision of System

Fig. 7 illustrated the obtained precision of proposed system using only SCS with ANN. In this research, the average value of precision is measured near to the 0.988 using hybrid approach that helps to provide better system training.

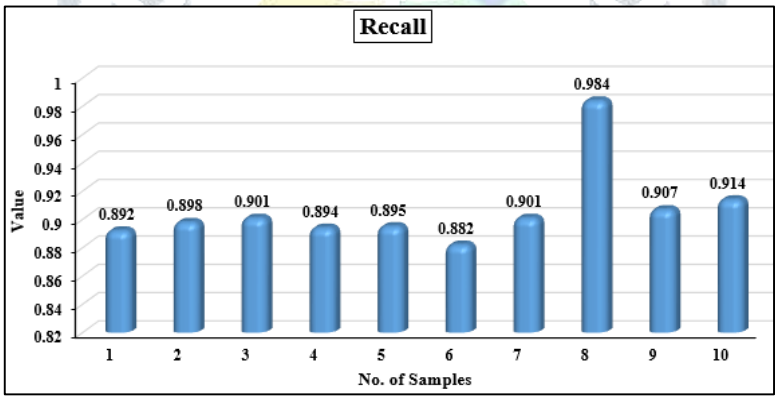

Fig 8: Recall of System

The obtained recall for proposed system using SCS along with the ANN is illustrated in above Fig. 8 where the average value of recall is measured near to the 0.906 for product review sentiment classification.

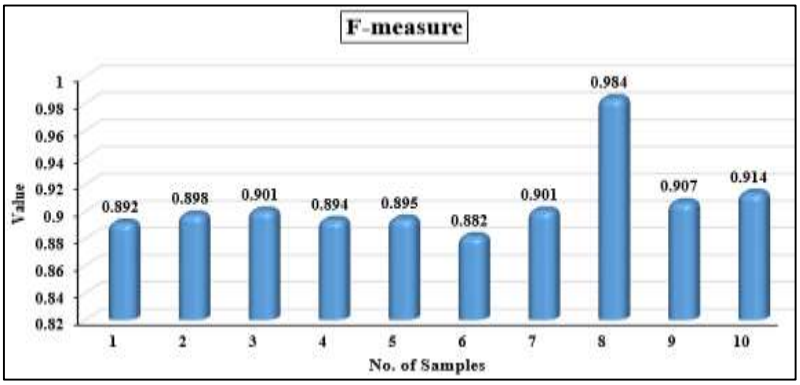

Fig 9: F-measure of System

F-measure of the proposed model is shown in the Fig. 9 and the average value of f-measure is near to the 0.945.

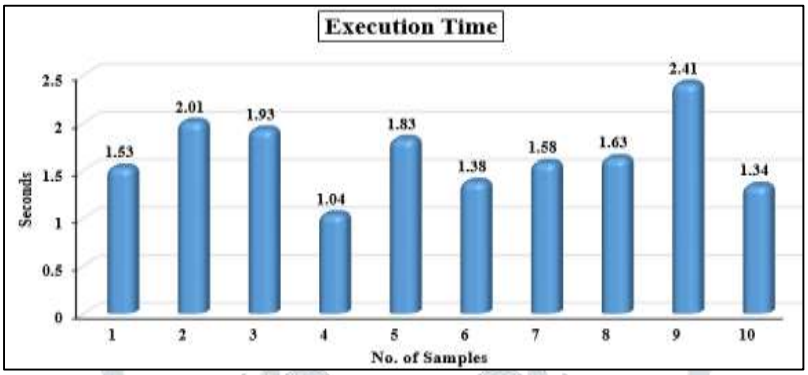

Fig 10: Execution Time of System

The comparison of the execution time for proposed system is shown in the Fig. 10 and the execution time of system is optimal.

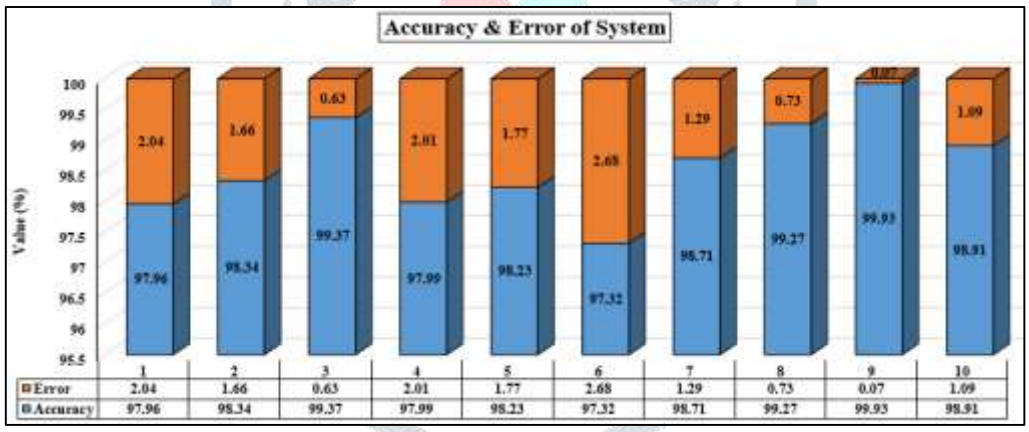

Fig 11: Accuracy of System

The obtained accuracy and error of proposed model is illustrated in above Fig. 11. In this research, the average value of accuracy and error is measured as 98.603% and 1.397% for system using SCS with ANN respectively. But, to validate the proposed system, we need to compare with the existing work scenario. So, we compare the proposed model efficiency with work presented by the ***R S Jagdale et al.*** [5] in terms of accuracy, precision and f-measure in Table III.

Table III: Comparison with Existing Work

Parameters	Proposed	R S Jagdale et al.	
Accuracy	**98.60**	**Naïve Bayes**	**93.28**
		SVM	**87.76**
Precision	**98.87**	**Naïve Bayes**	**93.13**
		SVM	**87.97**
F-Measure	**92.80**	**Naïve Bayes**	**96.19**
		SVM	**93.30**

Above Table III shows the comparison of proposed sentiment analysis-based product review system model SCS and ANN as deep learning technique. The effectiveness of proposed system is clearly shown in the Table III and in below Fig. 12.

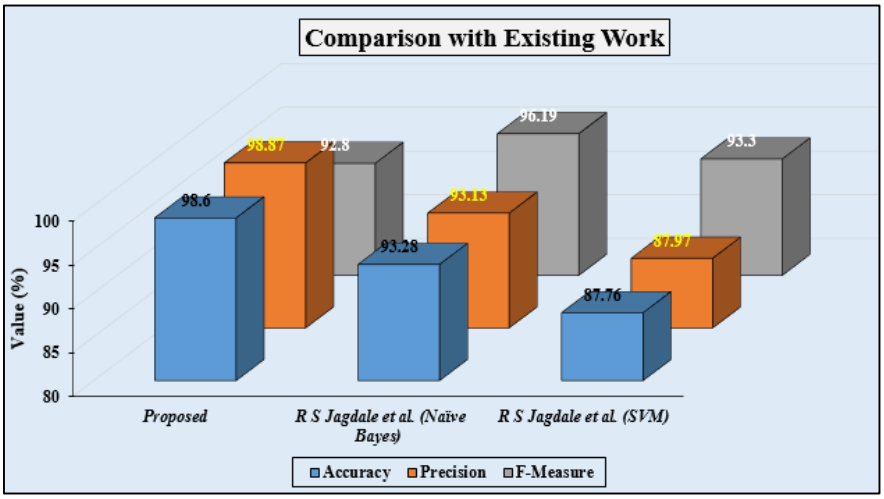

Fig 12: Comparison-based on System Accuracy

Here, we compare the accuracy, precision and f-measure based on the average value of the proposed work and existing work in above Fig. 12. Figure represents the comparison of proposed system with ***R S Jagdale et al.*** [5] on the basis of attained accuracy, precision and f-measure and the significant increase in these parameters is recorded from existing work.

V. CONCLUSION AND FUTURE WORK

In this research, we proposed a product review system using sentiment analysis SCS and ANN as deep learning technique and the major focus of research is identifying a set of potential features form text review data using the Lexicon-based feature extraction and SCS helps to select a set of optimal feature using the novel fitness function. Sentiment analysis in e-commerce company play a vital role to automatic extra the review polarity and arrange the review according to the polarity such as positive, negative and neutral. The extraction subjective information from reviews on the e-commerce site, social sites have gained greater attention from the data mining community but there management and fast response is still a big problem. Form the experimental analysis, where we compare the proposed model with existing work by ***R S Jagdale et al.*** [5] in terms of accuracy, precision and f-measure. The performance of the proposed model is far better than the existing work and an improvement in accuracy is near to the 5.32% but in case of larges dataset, accuracy slightly decreased but execution or classification time is remain invariant. So, in future work, the concept of Convolutional Neural Network (CNN) would we used with soft computing techniques to achieved better accuracy for large data or big data.

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