Sentiment Based Text Analysis on Social Media Brand Review Using Machine Learning

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Abstract –

Text Analysis requirements are increasing day by day due to expansion of application scope. Among them social media-based text is become popular in various human welfare task i.e., health care, disaster management and others. But automated accurate and reliable social media text analysis is a need of current applications. In this paper, we explored recent development on sentiment-based text analysis using social media data. Thus, first a review has been reported to identify popular area of application, feature selection techniques and classification methods. Then key issues in social media-based text analysis have been addressed. Further, a social media product review dataset has been considered for performing experimental study. The aim of this experimental study is to identify the suitable feature selection technique which is able to deal with the addressed issues. In addition, we involved some classical text classification approaches as well as deep learning technique to select the suitable technique of classification. According to our findings based on experiments the classical classifiers are less accurate in comparison with the deep learning-based techniques. In addition, the TF-IDF based features are more appropriate for classifying multi-class sentiment classification. However, the TF-IDF based features need some improvements to deal with the social media-based text analysis. Therefore, we also introduce the future extension plan.

Keywords: text analysis, text classification, text features, classifier, application, survey.

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1. INTRODUCTION

Sentiment based text analysis is a popular area of the NLP (Natural Language Processing) [1]. The text contains the feelings or emotions of the author in a text post or story. The text data leave the strong impressions on the reader's sentiments. The identification of hidden emotion in the part of text is termed as sentiment analysis. However, the sentiment-based text analysis now in these days utilized in a number of applications for example:

- In social media, sentiment analysis is performed for identifying the toxic or hate speech
- In e-commerce platform, sentiment analysis is performed for identifying the consumers feedback

Similarly, in other applications it is hugely contributing by evaluating text and obtaining the authors orientations. In this context different Machine Learning (ML) and text processing [2] are being used. However, in recent literature a significant amount of work is available for performing sentiment analysis. The available techniques are utilizing the different combinations of machine learning and text processing techniques for obtaining application centric consequences. But the suitable and effective combination of the methods will helpful to gain the required results. Therefore, in this paper we aimed to investigate different text feature selection methods, which may provide the effective results for different sentiment-based text analysis applications.

In this paper, we are providing the following work in support of sentiment-based text analysis:

1. Providing a brief review of recently contributed sentiment analysis-based techniques
2. Identification of data datasets, machine learning algorithms, and feature sets for analyzing sentiment from text
3. Experimental investigation of combination of feature selection techniques and different classification algorithms

In this section, we provide the overview of the involved work in this paper. Next section discusses different recent contributions based on sentiment analysis in recent years. Further we provide an experimental model for performing comparative study among different feature selection techniques and classification approaches. Next, we discuss the obtained performance in different experimental scenarios. Finally, the conclusion has been made and the future extension of the work has been highlighted.

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2. RELATED WORK

The amount of text is generated every day is increasing dramatically. Most of the textcannot be processed and perceived. ***M. Allahyari et al [5]*** describe text mining tasks and techniques including pre-processing, classification and clustering in biomedical and health care.According to author feature selection is important anddesigning effective feature is lengthyprocess.Thus, they recommend deep learning to acquire featurefrom text to automatically learnfeatures. ***H. Liang et al [6]*** outlines methods fortext feature extraction, and discuss frequently used deep learning methods and applications.***R. M. D'Addio et al [7]*** proposes a system that uses reviews ofitems based on the sentiment analysis. They focus on feature extraction, sentiment analysis, and attribute-awareneighborhood-based recommender algorithm. They compare four techniques in two scenarios and select the promising one.

R. Ahuja et al [8]analyse the impact of TF-IDF and N-Gram on sentiment analysis. They found TF-IDF provide 3-4% higher classification accuracy than N-gram, based on six classifiers.***A. O. Salau et al [9]*** present asurvey of the Feature Extraction techniques. According to findings most of the features can be extracted using features contrast, homogeneity, entropy, mean and energy. Additionally, these techniques are not applicationspecific.***Dr. R. D. Patil et al [10]*** have studied different data extraction techniques for text,audio, and video. Some unstructured data sources are analyzed andprepare comparative study of data extraction methods.***S. Narang et al [11]***, presented handwritten Devanagari ancientmanuscripts recognition system using statistical features. In featureextraction, intersection points, open endpoints, centroid, horizontal peak extent and vertical peak extentare used. For classification, CNN, Neural Network, MLP, RBF-SVM and random forest techniques are used. Authors have achieved higher accuracy using combinationof all features and a voting-based classification scheme.

According to ***T. Ahmad et al [12]***,it was difficult to find specific event in any part ofthe world. Thus, author offer a technique using Candidate Terms (Natural Language Tool Kit) and refining these Terms through (Pointwise mutual information) for features. Final Features and system increaseaccuracy up to 82%. ***A. S. Md. Tayeen et al [13]***was comparing multiple Feature Extraction methods and classifiers. Result shows thatno particular combination of Feature Extraction and classifier is the best,but choosing the right ones can improve accuracy by over 30%. ***M.Allahyari et al [14]*** review the processes for summarization and describe the effectiveness andshortcomings of the methods.***X. Mao et al [15]*** propose sentiment-awareword embedding for emotion classification. The emotional word vector is combined with theword embedding for hybrid representation. Results show that it can improve the accuracyof deep learning in feature extraction.

D. Wu et al [16] proposes a dual-channel CNN. It combined with emotion words, parts ofspeech (POS), degree adverbs, negative words, punctuation, and others. These features are provided to the CNN. Then Back propagation Network is used to normalize the network and padding is used to improve the features.The k-max pooling is used for dimensionality reduction. ***A. Purpura et al [17]*** propose a way to overcome limitations with asupervised approach based on TF-IDF and MultinomialLinear Regression to extract emotion lexicon and classify documents.They compare it fordocument representation and classification on heterogeneous data.***A. Rahman et al [18]*** propose a combination ofMultinomial Naive Bayesian (MNB) with BayesianNetworks (BN). The classifiers results are combinedby average probability. This approach showed better performance and accuracy. ***V. K. Jain et al [19],***offers a framework for detection of emotions in Multilanguage text based on multiple features for understanding of lexicons. A data collection model has been developed. Every word of emotionis importantin multilingual emotional words, and effective pre-processing has been used. Naïve Bayes and SVM are used for classification.

J. Hartmann et al [20]compares the performance of five lexicon-based, and five ML algorithms. It relies on SVM and Linguistic Inquiry and Word Count (LIWC). Across all tasks, random forest (RF) and naive Bayes (NB) performs best accuracy. RF exhibits consistently high performance, NB for small samples sizes. ***K. Liu et al [21]*** proposed a medical socialmedia text classification (MSMTC) using consumer health terminology. Subjects are divided into: consumer health terminologyextraction and classification. Text characteristics based on double channel structure are used, and terminology is extracted-based on adversarial network.The classification is implemented based on the terminology and doublechannel subtraction. The results show that algorithm outperforms.***H. Liu et al [22]*** focus on cyberhate classification, via social media. They propose a fuzzy approach with twostage training for dealing with text ambiguity and classifyingfour types of hate speech.Features are prepared using Bag-of-Words and Word Embedding with the correlation.***A. B. Prasetijo et al [23]*** develops Indonesian hoax filter based on TF-IDFand classification. SVM divides a word vector using linear function andStochastic Gradient Descent divides using nonlinear function. Each word in articles modeled as feature. The highest accuracy obtained from SGDclassifier using modified-huber.

J. V. deSouza et al [24] analyzes 87 publications, which covers eight years of research and presents the methods, text and user features, and datasets used.***O. Şerban et al [25]***describes a system builtupon ML and data processing. Thesystem is built from data processing pipelines. It applies deep learning to classifying health-relatedtweets. It can detect illness outbreaks, and provide awareness. It provides nowcasting functionality.The results are promising and nowcasting module improve prediction.

Table 1. Literature Survey

Ref.	Application	Classifier	Feature Type
[1]	Biomedical and health care	Classification & Clustering	Fundamental text mining tasks and pre-processing
[2]	Text mining and Retrieval	Deep Learning	Deep learning in feature extraction
[3]	Recommender systems	Recommender Algorithm	Feature Extraction, Allied with Sentiment analysis
[4]	Sentiment analysis	Six classifiers	TF-IDF word level, N-Gram
[5]	Image retrieval	N/A	Contrast, Homogeneity, Entropy, Mean and energy
[6]	Heterogeneous Data	SVM and Naïve Bayes	Data extraction for text, audio, and video
[7]	Devanagari Ancient Document Recognition	Five classifiers	Intersection points, Open endpoints, Centroid, Horizontal peak and vertical peak
[8]	To find events in the world	Supervised learning	Candidate Terms and Refining Terms
[9]	Sentiment Analysis, Topic Identification	Supervised learning	comparing multiple FE methods
[10]	Text Summarization	Processes of Summarization	Effectiveness and Shortcomings of the Methods
[11]	Emotion Classification	several ML models	Emotional knowledge, Lexicon, Emotional word vectors
[12]	deep learning in feature extraction	Dual-Channel CNN	Emotion words, POS, degree adverbs, negative words, punctuation
[13]	Out-of-vocabulary and heterogeneous data issues	Deep learning	TF-IDF and Multinomial Linear Regression with Elastic-Net regularization
[14]	Text classification	Combination of MNB and BN	The discriminating terms
[15]	Emotions Multilingual Text	NB and SVM	Multiple features for lexicons
[16]	Shifts in sentiment or categories	SVM, RF or NB	Linguistic Inquiry and Word Count (LIWC)
[17]	Medical social media text classification	Six classifiers	Consumer Health Terminology
[18]	cyberhate classification	Fuzzy two stage training	Bag-of-Words and Word Embedding
[19]	Early detection on hoaxes	SVM and SGD	Text vector representation Using TF-IDF
[20]	Rumor and Information Quality	N/A	Natural Language: Challenges, and Opportunities
[21]	detect disease outbreaks earlier	deep learning	clinical data combined with Twitter
[22]	rumors or fake news	deep learning	Text semantic and Emotional semantics features
[23]	text sentiment classification	deep neural network	hierarchically incorporating features
[24]	Polarity classification	semi-supervised learning	sentiment lexicon based on SentiWordNet
[25]	Target dependent sentiment classification	feature-enhanced attention network	unigram features, part of speech features and word position
[26]	Classification of sentiments	ANN	SVM is used to select the best features
[27]	Create Specific Feature	Supervised learning	POS to conduct feature selection

W. Lianwei et al [26] dividemessages into five types. A method is proposed based on deep learning for classifyingmessages. They use attention mechanism to obtainsemantic features and emotionalsemantics, meanwhile, construct universal metadata as auxiliary features, for classification. Experimentsdemonstratethat method outperforms.***L. Kong et al [27]***proposes sentiment classification that learns representation of texts by hierarchically incorporating features. They design different representationsfor sentiment words according to polarity and negation; and distinguish words with POS tags. They use a deep neural network to get a sentencelevel representation. For document, a hierarchical structure and a rule give more weight toimport sentences. Resultsdemonstrate that method could improve the sentimentclassification performance.***E. Asgarian et al [28]*** investigates the impact of NLP tools, sentiment features, andsentiment lexicon generation approaches.AWordNet(FerdowsNet) was developed. Using FerdowsNetand corpus of reviews, a sentiment lexiconwas developed using (i) mapping to SentiWordNet and (ii)a semi-supervised learning. For sentiment words,a set of features were extracted and applied to classification. ***M. Yang et al [29]*** propose a feature-enhanced attention network. First learn feature-enhanced word representations by unigram, POS and word position. Develop a multi-view co-attention network to learn better multi-view sentiment-aware and targetspecific sentence representation via context words, target words and sentimentwords. ***A. Tripathy et al [30]***, used the SVMto select best features. These features are input to ANN. Performanceparameters i.e., precision, recall, f-measure, accuracy have been considered.***E. S. Usop et al [31]***aimed to use POS to conduct feature selection. The result showed that thedocument has passed the POS-based feature cangive accuracy higher.

3. REVIEW SUMMARY

In this paper, 49 research articles were collected form Google Scholar among them 27 most relevant are selected, which machine are learning based.According to analysis we found these techniques are containing: data preprocessing, feature selection, training and classification.The preprocessing involves the steps to clean and refine text withoutloosing the essential features because, feature quality is directly impacting on the classifier's performance. Then the features are used with ML algorithms to learn and classify similar text. However,mostly features are constructed according to the application needs. Thus, selection of the specific type of features and context aware features can help in better learning.

In this paper, we are focused on text classification for sentiment analysis. During investigation we found that the ML methods for text classification frequently usages POS tags, TF-IDF, Sentimental words, Deep Learning, N-Gram, and word embedding. Additionally, some of the research work considers the combination of features.But, not always a fixed combination of classifier and features are suitable. The best combinations of both can improve the performance. According to explored articles we found SVM, k-NN, Deep learning, ANN, RF, BN, and NB are popular classifiers. Additionally, some of the researches are also using fuzzy

based techniques.Text technology is not only dealing with classical task such asi.e. text classification, categorization, linkage, and summarization. Now in these days text analysis is used in various other human welfare applications such as social media and educational system, social media and health care, social media and government.

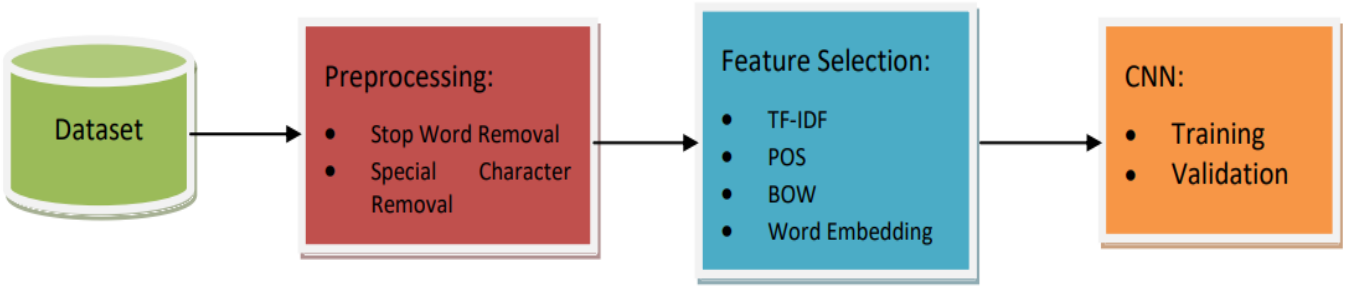

Figure 1 Proposed Model for Comparing Feature Selection Techniques

As the area of applications using text processing is increasing, we are encounter new challenges and opportunities. These applications are providing ease in different area of our life. However, in recent years the applicability of text processing in social media has increased. Thus, based on social media text analysis we have identified some key issues for finding the solution:

1. Noisy text
2. Use of punctuations and other symbols
3. Designer text writing
4. Very small set of information
5. Lake of suitable feature selection technique for accurate data analysis

4. PROPOSED WORK

Sometimes, emotions are expressed in fewer words but the selection of the words are very strong. Therefore, in social media every word in a sentence has importance. In this context, the feature selection from such kind of text is a key step, where the aim is to minimize the information loss and maximize the sentiment information. In this presented work we are trying to identify the suitable feature selection technique and a combination of classifier which provide reliable and effective results during the sentiment analysis task. in this context an experimental model has been created to perform experiments and identify the suitable combination of classifier and feature selection technique in their real working process. The proposed experiments are conducted in two scenarios such that:

- **Performance evaluation of feature selection techniques:** the aim of this experiment is to utilize the social media short text dataset and extract features with making any change in their working style and then utilize the supervised learning classifier to train and test the performance influence.
- **Performance analysis of classifiers:** by concluding the suitable feature selection approach from the previous described experimental scenario, some supervised and unsupervised learning techniques applied to know how the performance of classifier is influencing, with previously selected features.

A. Performance evaluation of feature selection techniques

The figure 1 demonstrates the proposed model for conducting experiments with different feature selection techniques. In this context a dataset from the Kaggle repository has been obtained. This dataset contains the review of different popular brands. The collection of the review content is not much longer thus need to treat the review information very carefully. Further to make clean the dataset the preprocessing has been adopted. During preprocessing we have utilized the two popular text preprocessing techniques for stop word removal and special character removal. After cleaning of the text information in the dataset we utilized four popular text feature selection techniques. The brief information of the feature selection technique is given as:

a. TF-IDF

The TF-IDF is abbreviated as Term Frequency and Inverted Document Frequency. The TF-IDF is used to identify the significant keywords from the entire documents where the TF part is used to identify the frequently occurred keywords and to find their relevancy the inverted document frequency will be used

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b. POS

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Table 2 Performance of Feature selection techniques with CNN classifier

		TF-IDF				POS				BOW				Word Embedding			
S. No	Parameters	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
1	Precision	0.85	0.83	0.70	0.79	0.30	0.39	041	0.37	0.73	0.45	0.72	0.78	0.00	0.30	0.00	0.00
2	Recall	0.76	0.82	0.78	0.78	0.02	0.42	0.40	0.56	0.35	0.89	0.47	0.44	0.00	1	0.00	0.00
3	F1-Score	0.80	0.82	0.74	0.79	0.04	0.40	0.41	0.45	0.47	0.60	0.57	0.56	0.00	0.46	0.00	0.00
4	Accuracy	0.79				0.39				0.57				0.30			

POS tagging is also called the Part of Speech tagging. It is used as the NLP feature and can be obtained by the NLTK library. The POS tagging is used to identify the part of speech information of the given sentence. In this model a parser is used which parse the sentences to their part of speech.

c. BOW

In the applications of the information retrieval the Bag of Words (BOW) is frequently used. It is also a part of NLP based data processing. In this model, a text is represented as the bag or multi-set of its words, disregarding grammar and even word order but keeping multiplicity.

d. Word embedding

The use of word embedding is frequently used in small text processing. That is also a part of NLP based text classification models. Word embeddings are a type of word representation that have similar meaning and similar representation of the words in a sentence.

Finally, after extracting the features from the above discussed techniques and then employed a Convolutional Neural Network (CNN). The CNN is a simple text classification model which is configured with three layers first an input layer. That layer is used with the "ReLu" activation function, second layer is built with the "ReLu" activation function and last layer which is an output layer is configured with the "Sigmoid" activation function. The model is compiled with the ADAM optimizer and the accuracy as the performance matrix is used.

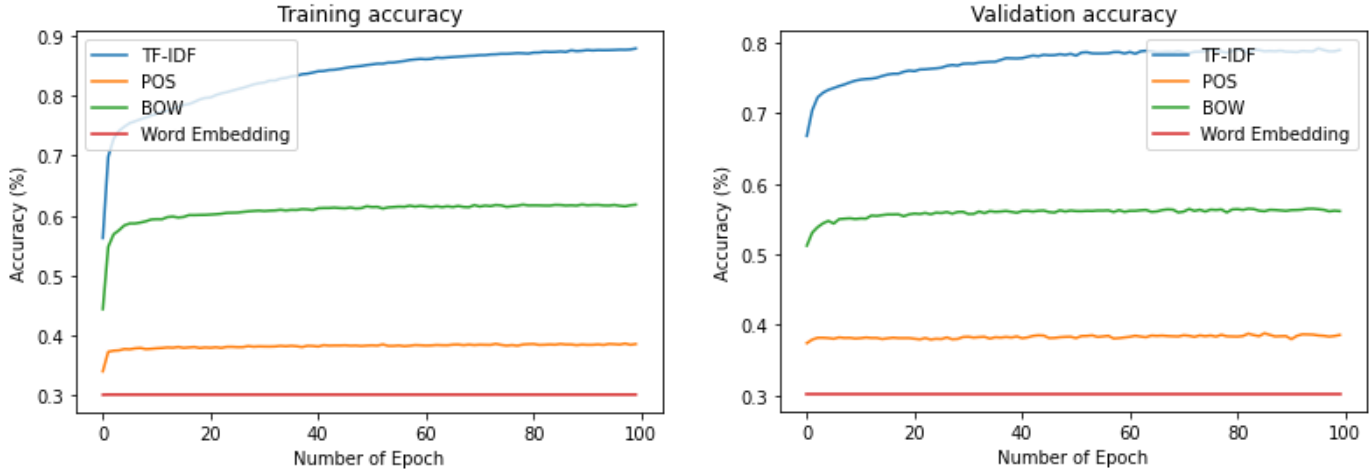
B. Performance evaluation

The figure 2 demonstrates the obtained performance by using the above discussed model additionally their values isdemonstrated in table 2. According to the given figure 2(A) the training accuracy of the TF-IDF based feature selection approach is higher as compared to other three implemented models. In addition, the performance of the POS and BOW is similar in performance. Finally, we have found the word embedding is not a good feature selection technique for small text classification. Similarly at the scenario of validation of the model which is demonstrated in figure 2(B) shows the similar performance as during the training of the model. Therefore, we can say the word embedding based feature selection technique is an appropriate solution for the small text classification and will better work with the deep learning-based models.

C. Performance analysis of classifiers

After obtaining the better performing feature selection technique, we are now involved three more data analysis techniques namely k-Nearest Neighbor (KNN), Gaussian Naïve Bays (GNB), and an unsupervised learning model K-Means clustering. All the classifiers are well known classification techniques utilized in classical text classification applications. All these algorithms are implemented with the help of python and their performance has been recorded with the TF-IDF based feature selection technique to compare them.The comparative performance of the TF-IDF based extracted features and with the combination of three classification techniques are demonstrated in table 3.

Additionally, the performance of these three algorithms and CNN algorithm is given in figure 3. According to the obtained results the CNN based classifier is providing high



(A) (B)

Figure 2 shows the comparative performance of feature selection techniques in terms of (A) Training (B) validation

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accurate results as compared to other classical machine learning techniques.Additionally, the GNB and KNN provides similar results.

Table 3 Comparison of classifiers with TF-IDF features

		K-Means				GNB				KNN			
S. No	Parameters	0	1	2	3	0	1	2	3	0	1	2	3
1	Precision	0.18	0.41	0.62	0.00	0.97	0.72	0.82	0.44	0.97	0.72	0.82	0.44
2	Recall	1	0.02	0.05	0.00	0.47	0.51	0.32	0.95	0.47	0.51	0.32	0.95
3	F1-Score	0.30	0.04	0.09	0.00	0.63	0.60	0.46	0.61	0.63	0.60	0.46	0.61
4	Accuracy	0.19				0.58				0.58			

In this discussed scenario the k-means algorithm is providing very low results. Thus, for classification task for short text the TF-IDF based features and CNN classifier provides the optimal results.

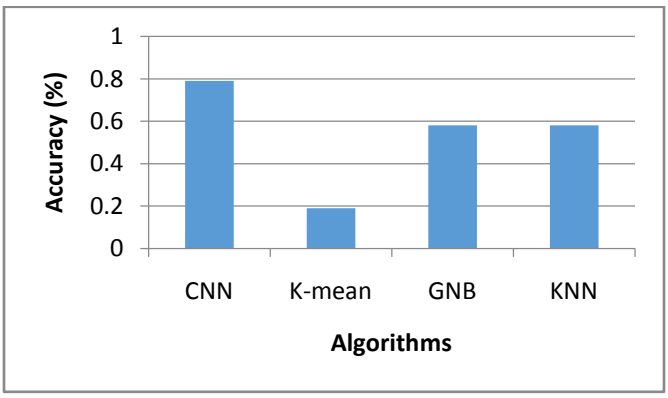

Figure 3 Comparison of the classifiers in terms of accuracy

5. CONCLUSION AND FUTURE WORK

In this paper, we explore the feature selection techniques and classification techniques which can be utilized for short text mining. In this context, the brand review dataset has been used, which consist of small amount of text, but the huge number of reviews. Therefore, suitable and reliable feature selection is an essential part of the entire text processing system. In this context,four text feature selection techniques have been implemented. These feature selection techniques are selected based on the studied literature. Thus, a review is also associated to the paper, which highlights the recent development on the field of text processing. Further, investigation includes the identification of essential classifierswhich will provide the optimal results with the combination of the selected features. During the investigation we have found among the four feature selection techniques TF-IDF, BOW, POS tagging and word embedding, the TF-IDF provides better yield. Additionally, in implemented four classifiers CNN, KNN, k-Means and GNB the CNN provides the most accurate results. Based on the findings the TF-IDF is a promising feature selection technique but in near future we are proposing some modification to enhance their yield. In addition, the CNN works better with all the reported feature selection techniques. Thus, in near future we carried out our experiments with the CNN based classification approach.

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