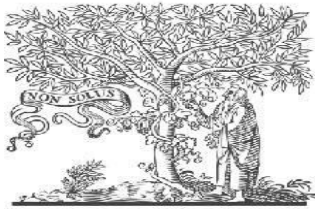


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Fake Reviews Detection using Ensemble Learning of Recurrent Neural Networks and Random Forest

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Abstract:

In recent days, the businesses are running based on E-commerce technologies. The customers are purchasing the products by considering the previous reviews given by other persons. The problem here is some times the customers are feeling that sellers are given fake reviews to gain the fame of their products and increasing the profits. To solve this problem of spam reviews detection several machine learning techniques like SVM, Extreme learning machine, decision tree and other methods are used. By using these methods some issues like imbalance data and unlabeled data are arrived. To solve these problems we use deep learning in spam detection. We proposed the Random forest(RF) and Recurrent neural networks(RNN) with attention mechanism for solving the above mentioned imbalanced data problems. We conducted experiments of proposed methods with other existing machine learning techniques on Amazon reviews data set with evaluated using measures like accuracy, AUC and F1score. Our proposed method given the better evaluation results than other mentioned machine learning methods.

Key words: Spam detection, Imbalanced data, RF, RNN, Word Embeddings, Informed Sampling.

1. Introduction

The introduction of World Wide Web generating several applications to give people better livingstyles[1]. The E-commerce is one of the area in WWW used by several people around the world. The main problem of WWW revolution facing is multiple spams like spam reviews in marketing, Websites, E-mail, Gambling and Pornography etc. It is observed that this unwanted information in WWW is do very harm to people. The customers in online applications reading reviews before purchasing. We consider the better reviews on bad products and vice versa is doing awful to the customers using E-Commerce sites for purchasing items[2][6].

The spamming messages used by the marketers to sell products fastly and quickly gain the profits. Then the customers sometimes losing money by purchasing wrong things then observe the sudden decrease in cost of a product. Because of advantage of communication technologies the spam is spreading now a day. The spam messages

gives the mistrust and affect financially among the businesses[8][1]. The Amazon and Yelp developed some spam detection techniques and progressively updating these depending on the issues [1]. Whenever a growth in spam methods is increasing then the researchers are striving for preparing Anti spam techniques and methodologies. Several vendors are developed their anti-spam technologies like Symantec cloud, Kasper sky and McAfee build on all computing platforms. They prepared many classification methods for their rule based systems to filter spam messages [5].

To detect these spams in information by applying classification several researchers given contributions using machine learning and deep learning techniques[2]. They applied several classification techniques to find reviews that are spam or non spam [10]. Some of the techniques used are TF-IDF, Word Embedding, NLP and MLP are the prominent among them. Also the machine learning techniques like Decision tree, KNN and SVM used to

classify the spam and notspam[8].

By the motivation gained from the Artificial intelligence techniques in spam detection we are interested use deep leaning. The Convolutional neural networks (CNN) and Recurrent neural networks are the better methods to do spam detection in reviews[5][7].By the introduction of attention network in deep learning we can apply this mechanism with CNN and RNN. Several machine Learning techniques and deep learning techniques proposed by[12][26].By the motivation of [20] we introduce ensemble learning techniques by combining Random forest(RF) classification from machine learning and Recurrent Neural Networks from deep learning.

Literature Review

In this section we describe several existing techniques of spam detection.

X. Wang *et al*[7] proposed the testing the spam in twitter data using K-L divergence and explain the context extraction using neural networks. D. Liu, J.-H. Lee[6]proposed the spam websites using convolutional neural networks. They consider image of a website and extracting features and apply convolutinal layer finally give decision it is malicious or not.

A. Karim *et al*. [4] study the several machine learning methods of supervised and unsupervised that are SVM, Logistic regression, Nave bayes, Adaboost and K-means applied on E-mail spam detection. By extracting the parts of the e mail then finding the spam and non spam mails and messages. Z. Zhang *et al*. [3] introduced the spam detection in online social networks by utilizing fuzzy logic in extreme learning machine. And applied the technique in the twitter content and coined the dealing of unbalanced data sets.

T. Xia [5] given the several methods like hash forest to detect spam in rule based filtering. He used in SMS spam detection and suggested as one time compression methods with incremental rules as a future work and worked on drifted twitter spam data set. Shahariar *et al*. [9] applied various techniques in machine and deep learning are CNN, LSTM, KNN, SVM and NB to classify the spam in reviews using word2vec technique. The experimental evaluation done using Yelp and OTT data sets.

N. Hussain *et al*. [1] used the Linguistic and Behavioral methods in Spam review detection for large data sets. They used Amazon reviews data set for experimental evaluation. In our proposed system we also use Amazon reviews data set for evaluating our technigues Convolution neural networks and Recurrent neural networks with attention mechanism for getting better results than[1].

Jindal N and Liu B [14] Regression is one of the important technique used to detect fake news. Several types of regression techniques in machine learning among them Logistic regression(LR) is used to detect fake and truth reviews effectively by finding the probability of likelihood.

Barushka A and Hajek P [15] The conventional machine learning techniques of regression having the dimensionality problem whenever th large data is arrived. Normally, the review data contains huge number of features of words. To overcome the dimensionality and scarcity problems in reviews the researchers proposed classification techniques.

Li F. *et al* [16]., Li H *et al* [17]., Mukherjee A *et al* [18]. Introduces the classification techniques SVM, Naïve Bayes for solving the dimensionality and scarcity problems of regression techniques in large data.

Pandey AC and Rajpoot DS[19] used evolutionary algorithms to find fake and truth reviews. Barbado et.al[23], Rout et.al[20] proposed the ensemble methods by combining the methods of machine learning and improve the results. The traditional machine learning models are studied clearly and improve the results of these techniques further study the deep learning methods.

Hamzah and Zhu[12], Martens and Maalej[13]. Regarding the introduction of deep learning techniques used in the classification of fake and truthful reviews. Proposed the Word Embeddings, Convolutional Neural Networks(CNN), Recurrent neural networks(RNN) for fake reviews detection.

The following are the Contributions of our proposed system based on the literature discussed.

1. We design and develop efficient approach for fake and truthful review classification using ensemble learning of RNN and RF
2. We did several experiments on Amazon Reviews, Hotel, Restaurant datasets.
3. Evaluate our proposed system using measures like AUC, Accuracy and F1 score.

Proposed system

In this section, we describe our proposed system using several components including word embeddings, BoW, Emotion mining. We develop the components with CNN and RNN with Attention mechanism. The combination of components of NLP and techniques of Deep Learning used in our model.

Word Embeddings: This one of the popular technique in Natural Language Processing. It is used to find the meaning of the words depending on the context or situation. Embedding play important role to convert

numeric data to text data and vice versa. There are two types of word embeddings that are frequency based and prediction based. The frequency based embeddings are classified into Count vector, TF-IDF and Co-occurrence vector models. The Prediction based are Skip-gram and CBoW. To do creation of embeddings we use the skip-gram model. This model takes words and maps to vocabulary. The numerical vectors are prepared and semantic similarity is calculated. The word embeddings algorithms contain the objective or embedding function and softmax activation function as represented as below:

Algorithm 1: Word Embedding for fake review detection
Input: Set of words : $w_1, w_2, \dots, w_n$. (Review text)
Output: Predict Context of words (Fake or not Fake)

1. Use one hot encoder for convert text into numbers.
2. Apply the objective function on number vector.
3. Apply softmax activation function.
4. Test the with different embeddings.

Ensemble Learning: Rout et.al[20] proposed the ensemble learning model for fake reviews detection. In this proposed system we ensemble the RNN and RF for improving the accuracy of the fake review detection. First we use the RNN for training our data and for detection of review we use the machine learning method RF.

RNN for data training and activation: It is a one of the deep learning model for used in classification applications. In our proposed method we are using this model for review detection for better accuracy than CNN and word embeddings. The RNN with

embedding techniques having two models that are LSTM and GRU. For better results LSTM with embedding model is used. RNN is used to overcome the gradient problem in CNN. The NLP with word2vec model worked on review data set that has the embedding sizes of 50,100,200. The LSTM worked on embedding sizes of 50,100,150,200,250 respectively. The activation function used here is Adam. The output layer prepared with softmax and MLP in our proposed system to attain better accuracy. The Algorithm 3 represents the LSTM.

Algorithm 2: RNN for data training and activation
Input: Set of sentences : $s_1, s_2, \dots, s_n$. (Review text)
Output: Predict Context of sentences (Fake or not Fake)

1. Apply n-grams and TF-IDF model on input sentences
2. LSTM layer with Adam activation
3. Embedding weight matrix for document representation
4. Average word embeddings for each document.
5. Hidden layer with Relu activation function
6. Softmax with MLP as output layer.

Random forest for fake review prediction: RF[27] is the popular machine learning algorithm for prediction and classification problems. The following are the steps of RF algorithm used after RNN training and Activation steps.

1. Extract the features from train data of RNN ($we_1, we_2, we_3 \dots we_n$)

2. Train the ($we_1, we_2, we_3 \dots we_n$) using RF.
3. Compute the Avg. Point for the selected features.
4. Build the decision tree using the Avg. points.
5. Find the number of decision trees.
6. Find the prediction whenever a new data point arrived from decision tree.

Architecture of Proposed system: The following fig.1 represents the our proposed system

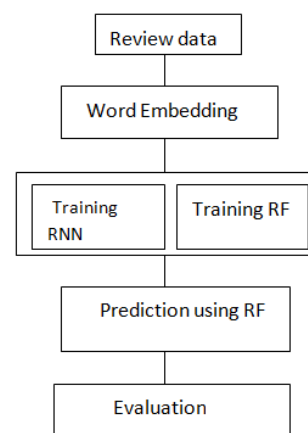


Fig.1. Architecture of proposed ensemble learning.

The above architecture shows the process of ensemble learning using RF and RNN. The review data flow to the word embedding. In this part some operations like TF-IDF is performed. Next data is trained using RNN then RF. Finally predictions are performed using RF. Finally our model is evaluated using AUC metrics.

Flowchart: Proposed system for experimental study.

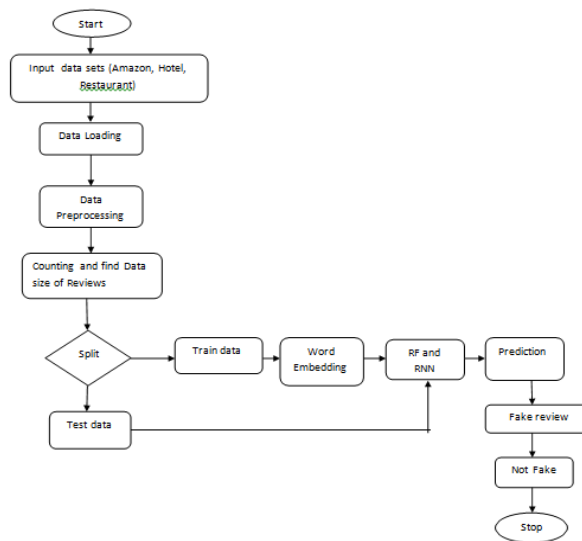


Fig 2. Flow chart for Experimental process.

The Fig.2. Shows the flow chart for Experimental study. Here the data sets are process to data preprocessing. After that the data set is splitting in to 80% training and 20% Testing data. Then the proposed models are executed one by one. After that evaluation is completed using AUC, **Imbalanced data:** In general, the regular and fake reviews are imbalanced Hamzah and Zhu.[12]. The imbalanced data is the main problem to work with machine learning algorithm. Some users are concentrated in imbalanced data. The learning of the algorithm started after splitting the data into classes. Problem here is some classes are having more examples and some classes are having less examples. To work with these data sets the algorithms are compromised. And the classification performance is less with imbalanced data sets. Technically speaking. The minority class examples are 25% lesser than total examples then our data set ids called highly imbalanced. Extrinsic (directly work with data space) and intrinsic (not directly work with data space) are the types of imbalanced data.

Whenever we are doing classification

experiments with imbalanced data is not giving better accuracy He et.al.[13]. We identify the problem of learning procedure that the algorithm is working with class containing major examples and not consider the class of minor examples. We understand that the classification measures for imbalanced data are not only the accuracy but also consider AUC and F1 score.

There are several existing techniques to solve the imbalanced data problem. Among mainly used are sampling and re-weighting. The sampling is used at preprocessing step. It is done by using filter to remove noise from data set and check influence on minor data class. The following are the some of the sampling techniques used on imbalanced data sets Hamzah and Zhu.[12].

Informed sampling: These techniques are used in hybrid algorithms to remove examples from major classes.

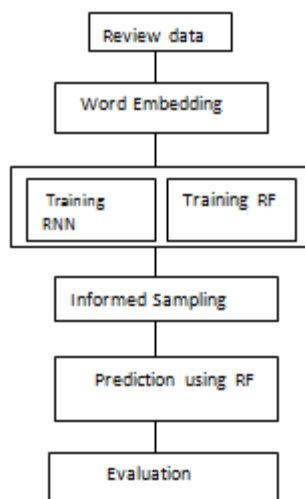
Random Over sampling and understanding: This technique create duplicates examples of the minority classes and increases size and balance with majority example classes.

Synthetic Sampling with Data Generation: This type of sampling creates the examples in the minor classes based on the similarity of examples of the majority classes.

Adaptive synthetic sampling: This type of sampling creates the examples based on the similarity between majority class examples and neighbor examples.

Cleaning based sampling: It removes the noise occurred during the overlapping of the examples. Accuracy and F1 Score measures.

Architecture of Proposed system for imbalanced data: The following fig.3.represents the our proposed system



Article I. Fig.3. Architecture of proposed ensemble learning for imbalanced data.

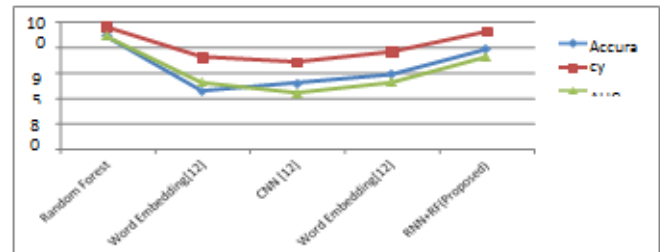
The above architecture shows the process of ensemble learning using RF and RNN. The review data flow to the word embedding. In this part some operations like TF-IDF is performed. Next data is trained using RNN then RF. Informed sampling used for imbalanced data operations. Finally predictions are performed using RF. Finally our model is evaluated using AUC metrics.

Results and Discussions: To evaluate our proposed system we are using Amazon reviews data set, Hotel reviews data set and Restaurant dataset. The three evaluation measures we considered are AUC, Accuracy and F1-Score. The following Table 1, 2, 3 represents the evaluation measure experimental values on Amazon, Hotel and Restaurant data sets respectively.

Method / Evaluation Measure	Accuracy	AUC	F1 Score
Random Forest	97.00	98.90	97.00
Word Embedding[12]	86.19	93.00	88.00
CNN [12]	87.81	92.00	86.00
Word Embedding[12]	89.45	94.00	88.00

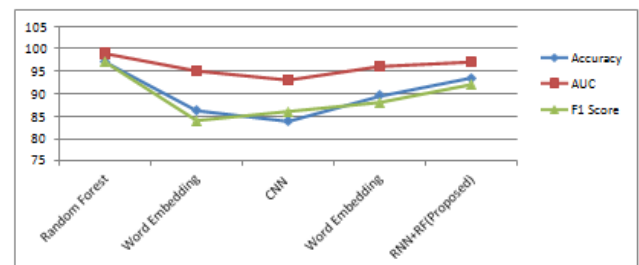
RNN+RF(Proposed)	94.45	98.00	93.00
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Table 1: Evaluation measures on Amazon Data set.



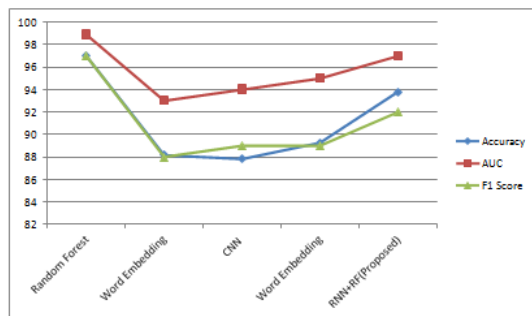
Method/ Evaluation Measure	Accuracy	AUC	F1 Score
Random Forest	97.00	98.90	97.00
Word Embedding	86.20	95.00	84.00
CNN	83.81	93.00	86.00
Word Embedding	89.45	96.00	88.00
RNN+RF(Proposed)	93.45	97.00	92.00

Table 2: Evaluation measures on Hotel Data set.



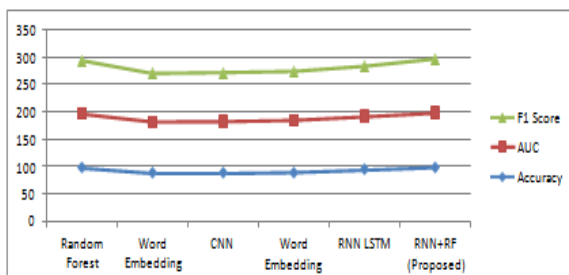
Method/ Evaluation Measure	Accuracy	AUC	F1 Score
Random Forest	97.00	98.90	97.00
Word Embedding	88.15	93.00	88.00
CNN	87.81	94.00	89.00
Word Embedding	89.25	95.00	89.00
RNN+RF(Proposed)	93.80	97.00	92.00

Table 3: Evaluation measures on Restaurant Data set.



Imbalanced data classification results:

Method / Evaluation Measure	Accuracy	AUC	F1 Score
Random Forest	97.00	98.90	97.00
Word Embedding	88.15	93.40	88.30
CNN	87.81	94.30	89.30
Word Embedding	89.25	95.20	89.50
RNN LSTM	93.80	97.30	92.30
RNN+RF (Proposed)	98.52	99.25	98.55



Conclusions: In this study we proposed the one machine learning model word embedding for fake review detection. And also proposed the two deep learning models CNN and LSTM for improving the accuracy of the machine learning model. We describe our models with the help of algorithms in proposed system. Our process is different in the exiting algorithms in the literature. Our evaluation results are outperforming than existing systems in measures of AUC, Accuracy and F1 score. In future we implement more deep learning models for fake review detection.

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