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Multi-Label Email Classification Using RandomForest Classifier

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Abstract

Email categorization is a critical function in any email client since it allows you to manage and arrange your emails into semantic groupings. Following the success of statistical artificial intelligence and machine learning in many areas of information management, these methods have become a standard strategy for emailcategorization. Using multi-labelled emails, this article offers a method of classifying them and recommending additional labels to users. Under the labels used by the user's contacts, new labels are recommended. Not only would the labels be recommended,but it would also sort the new emails into the categories according to those labels. The Random Forest Classifier is more effective in all kinds of email categorizationthan other algorithms. As a result, we would base our primary method on RFC witha few minor modifications made. To forecast the categories of new emails, we would use the user's past emails and categories. When Nave Bayes applies to the testing dataset, the average recall is 63%, and the Random Forest Classifier is used, the average recall is 64 %, respectively.

DOI Number: 10.14704/nq.2022.20.9.NQ44562 **Neuro Quantology 2022; 20(9):4854-4861**

1 Introduction

Email is one of the most secure methods of online communication and transmission of data or messages over the internet, and it has become a necessary component of everyday life for most people these days. However, with a congesting increment in notoriety, the quantity of spontaneous information has likewise expanded quickly [1-3]. With the increasing dependency on email services, the data transfer and the size of information also generated increases, because of which it creates a need to managesuch a massive amount of data. The worst part of the emails is the spam messages. These messages are irrelevant and sometimes used for phishing sensitive data fromthe user. Hence, most clients have basic spam filtering mechanisms based on the sender and the data inside the message. Spams clog up the email services as they can be sent in bulk; they waste the network capacity and take unnecessary storage space. A study found that around 48 billion of the total 80 billion emails sent in a day are spam, so it is essential that we fight against these types of messages effectively. Most of the research conducted on pattern recognition and data mining has helped write algorithms recognizing spam messages [4-8]. But this does not end here; we feel that justremoving spam emails would not be that helpful[9-13].

2 Literature Survey

The author classifies email spam filtering approaches into two categories: machinelearning techniques and non-machine learning techniques. This article discusses machine learning methods such as Naive Bayes, Support Vector Machine (SVM), Decision Tree (CART), k-Nearest-Neighbor (KNN), Rule-Based Classification, andBack Propagation, rather than non-machine learning procedures such as Block-lists/Allowlists and Mail Header Checking. The writers of this paper want to conduct a performance study of several pre-existing classification techniques. The theoretical findings of their categorization consider both the classification idea of the algorithms and their limits. The authors conducted this research to evaluate a variety of existingalgorithms for spam mail filtering, which were then compared and their findings compiled to help in comprehending the vast array of classification techniques and selecting the optimal one for each need[14-20].

This paper discusses how Online Social Networks include a considerable amount of social information obtained via user contributions and how this OSN-based in- formation may detect spam and phishing emails. The authors suggest a method for identifying spam via various social networks, followed by the development of a plethora of standard metrics for describing OSN data. They investigate the impact of using social network data collected from an email corpus to improve phishing detection. They next compare their social data model to well-known spam data mod- els by developing and testing classifiers from both. They used the SVM (Support Vector Machine) Algorithm since their primary aim was to quickly assess the many data models available for spam detection. While succinct spam detectors may be constructed using just the unaccounted low-dimensional social data model, spam detectors built using accurate combinations of the preceding conventional and socialmodels seem to be more accurate than detectors made by isolating the models. They showed a novel but theoretical model and social network metrics that might be mod- ified to offer a uniform and consistent value for data extraction from various social network sources. It was claimed that the theoretical method had distinct benefits based on the social model's performance[21-26].

The authors of this paper concentrate on Deep algorithms based on classifying pat-terns as they incorporate a broad category of different classifiers. They apply Deep Belief Networks because they have displayed outstanding performance in similar domains and are also run by the efficient learning algorithm using the changed Re stricted Boltzmann Machine model and the improvement in the current and future computing power, which enables learning deep machine learning to learn-based neural networks in quick time. Out of the many datasets for spam separation, they choose one of the renowned ones, the Enron dataset. The machine learning-based Deep Belief Networks model is then applied to the base task of email classifica- tion while using the Enron dataset to train and test the designed model. The author proposes a Deep Artificial Neural Network classifier for classifying the emails. TheBN classifier is already trained using the BM model, and only after that is then fur- ther fine-tuned using backpropagation techniques. The network that resulted from the above was then directly used for classification. They also performed a system evaluation, and their thorough report showed that they identified improvements in the spam separation accuracy as their best-reported results[27-29].

This paper extends the work which examines the use of deep neural networks for predicting whether emails are spam or not while accounting for the fact that they will arrive in the future within a fixed-sized period. Next, the authors discuss two types of neural networks: multilayer perceptron (MLP) and long short-term memory(LSTM), which are both repeating neural networks. They next examine the impact of altering their default setup, including the number of layers of neurons in the network and the hyperparameters for both neural networks[30-41]. They conducted experi- ments utilizing email category sequences collected from 102,743 anonymous email users over 90 days. They used Mean Reciprocal Rank to determine the ranking of a forecast. They discovered that both MLPs and LSTMs substantially outperform current standards, with LSTMs somewhat outperforming MLPs due to their internal memory's increased capacity for time series analysis.

In its optimum configuration, the Markov chain model has a mean reciprocal rank of 0.840, whereas MLP and LSTM have values of 0.918 and

0.923, respectively. In this research, emails that didnot fall into any categories were not subjected to feature extraction. Including themin forecasts may improve forecast performance. I inferred no new labels based on the needs and use of the users.

3 Proposed Solution

Emails are usually filtered by the sender's identity and the type of content (text, graphics, headers) that the email message contains. Spams and machine-generated emails follow a set template or a pattern. Hence, the spam-filtering problem can alsobe tackled as a classification problem, i.e., pattern recognition.

The 'Detection of Phishing attacks: A Machine Learning Approach' applied different methods for detecting phishing emails using some commonly known and various unknown, or generated, features. Their approach was to classify phishing emails byincorporating

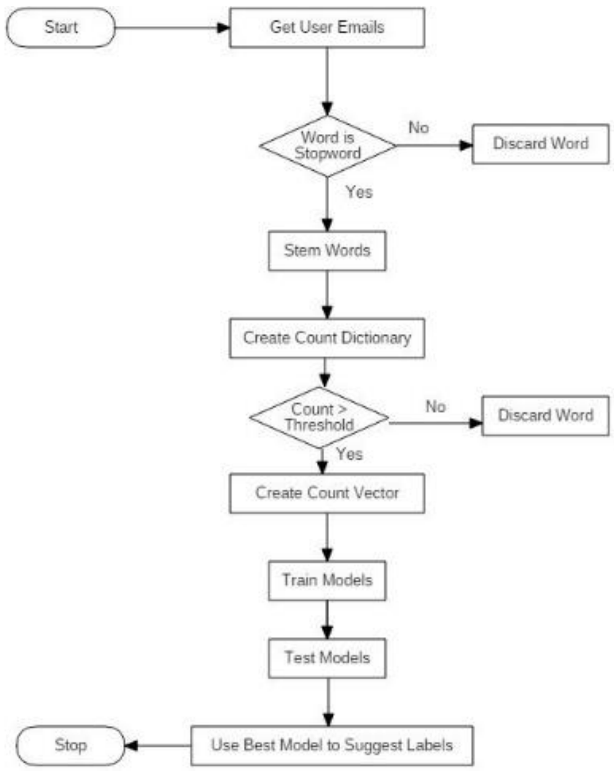

Fig 1: System Architecture

critical structural features in phishing emails and employing different machine learning algorithms to their dataset for the classification process. They used 16 features in their model. They created unique features based on keywords; for example, 'Update' and 'Confirm' were bundled as one feature. They used six groups of keywords as six different features. We would also use similar features for our model, but we would have a lot more classes (labels).Random Forest Classifier has proved to perform better in many email classifications. So, our base algorithm would be based on RFC with minor changes. We would use the user's previous emails and categories to predict the categories of new emails. We would also suggest new relevant labels to other users who are socially connected. For this, we would use the model of other users to find emails that are suitable for labels that other users are already using. This would be more realistic, and we would not have to guess new labels ourselves, which might be irrelevant to the user. A similar group of people would like to have similar labels if they have similar types of emails, and this solution would suggest to them precisely what they might need while automatically grouping new emails.

Initially, we collected labelled emails from the first user based on which we de- veloped our model. The contents from the 'Subject' and 'Message' were then used to develop features for our model. We used nltk corpus stop words to verify whether every word of the subject and message was in English and if it was not, the word was discarded. The next step was to group the words in pairs in order to keep the overall meaning. For example, the word 'good', if considered by itself, has a positive meaning. However, if it is preceded by 'not', the meaning is completely upturned. This is the reason behind grouping certain words together instead of considering them by themselves.

Algorithm 1 Algorithm **Input:**Labelled E-mails **Output:**Labels for unlabelled Emails.

Step 1: Begin Function SuggestLabel (dataframe)

Step 2: Check for Stopwords in messages

Step 3: Apply PorterStemmer on messages

Step 4: Create dictionary with counts of each word **Step 5:** Transform the messages using CountVectorizer**Step 6:** Split data into training and testing sample

Step 7: Apply SVM, Naive Bayes and Random Forest classifier

Step 8: Use the best model to suggest new labels to other users

Step 9: End

```
from sklearn.ensemble import RandomForestClassifier
forest = RandomForestClassifier(n_estimators=1000,random_state=0,n_jobs=-1)
forest.fit(X_train, y_train)
pred = forest.predict(X_test)
print(classification_report(y_test,pred))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	27
1	0.60	0.64	0.62	166
2	0.61	0.57	0.59	164
avg / total	0.64	0.64	0.64	357

Fig. 2 Vectorized output

Before applying any of the Machine Learning algorithms, we split our vectorized dataset into training and testing data. In our case, we maintained a ratio of 4:1 forthe training and testing data, respectively, in random order. The training data is used to train our model using SVM, Naive Bayes and Random Forest classifier. The best model concerning the recall on the testing data is Random Forest Classifier. The RFC based model is then used to suggest new and relevant labels to another user.

4 Results

```
from sklearn import svm
svc = svm.SVC()
svc.fit(X_train,y_train)
svcpred = svc.predict(X_test)
print(classification_report(y_test,svcpred))
```

	precision	recall	f1-score	support
0	0.00	0.00	0.00	27
1	0.46	1.00	0.63	166
2	0.00	0.00	0.00	164
avg / total	0.22	0.46	0.30	357

Fig. 3 SVM Result

```
from sklearn.metrics import classification_report
bayes = naive_bayes.MultinomialNB(alpha=0.2)
bayes.fit(X_train, y_train)
bayes_pred=bayes.predict(X_test)
print(classification_report(y_test,bayes_pred))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	27
1	0.61	0.58	0.59	166
2	0.59	0.62	0.61	164
avg / total	0.63	0.63	0.63	357

Fig. 4 Random Forest Classifier Results

```
suggested_labels

['Important',
 'Important',
 'Important',
 'starred',
 'Important',
 'Important',
 'starred',
 'starred',
 'Important',
 'starred',
 'Important',
 'spam',
 'spam',
 'starred',
 'starred',
 'Important',
 'Important',
 'starred',
 'Important',
 'Important'
```

Fig. 5 New Suggested Labelsfor another user

5 Conclusion

After applying Naive Bayes on the testing dataset, the average recall is 63%, and that after applying the Random Forest Classifier is 64%. Hence, we consider the model generated by RFC to be better and use that to predict and suggest new labelsto another user.

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