

# Content-based Approach for Vietnamese Spam SMS Filtering

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## Abstract

*Short Message Service (SMS) spam is a serious problem in Vietnam because of the availability of very cheap pre-paid SMS packages. There are some systems to detect and filter spam messages for English, most of which use machine learning techniques to analyze the content of messages and classify them. For Vietnamese, there is some research on spam email filtering but none focused on SMS. In this work, we propose the first system for filtering Vietnamese spam SMS. We propose an appropriate preprocessing method since existing tools for Vietnamese preprocessing cannot give good accuracy on our dataset. We then experiment with vector representations and classifiers to find the best model for this problem. Our system achieves an accuracy of 94% when labelling spam messages while the misclassification rate of legitimate messages is relatively small, about only 0.4%. This is an encouraging result compared to that of English and can serve as a strong baseline for future development of Vietnamese SMS spam prevention systems.*

## Keywords

*Vietnamese, Spam SMS, Filtering, Support Vector Machine, Maximum Entropy, Phrase collocation, Bag-of-word, Tf-idf.*

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## 1. Introduction

In recent years, the explosion of the mobile network in Vietnam stimulated the use of Short Message Service (SMS). Spam through SMS has increased because the cost to the spammer is low and the response rate is higher than email. SMS spam is a serious problem in Vietnam because of the availability of unlimited and very cheap pre-paid SMS packages.

According to a report in 2015 by BKAV<sup>1</sup> an information security firm, there were 13.9 million spam messages sent to mobile phone users every day in Vietnam, and one out of two people received spam messages (Bkav Corporation, 2016). Meanwhile, there were at least 120 million active mobile users in the market according to a report of the Ministry of Information and Communication, which was released in 2015 (Ministry of Information and Communication, 2015).

Spam SMS causes many issues for mobile users. They may suffer financial loss from these messages by reacting to them. Users may accidentally call to premium rate numbers or register for expensive services by replying to these messages. Moreover, they can be exposed to some risks by accessing harmful websites or downloading malwares. Mobile network operators also suffer financially because they may lose users or spend more on spam prevention.

There are many methods and systems for filtering spam messages for English in mobile networks (Guzella, 2009), (Delany, 2012). Most of them use machine learning approaches to analyze the content of messages and additional information to detect spam messages. One of the first systems was proposed by (Graham, 2002), using Naive Bayes classifier to get a good result. This work led to the development and application of other machine learning algorithms to spam filtering. The state-of-the-art system for English can detect spam SMS with an accuracy of 97.5% with a good false positive of only 0.2% (Almeida, 2011).

In this paper, we present the first system for Vietnamese spam SMS filtering with good accuracy. We first propose a method for the preprocessing step because existing tools for Vietnamese preprocessing cannot give good accuracy on our dataset. We then experiment with vector representations and different classifiers to find the best model for this problem. Our system achieves an accuracy of about 94% when labelling spam messages while the misclassification rate of legitimate messages is relatively small, about 0.4%. This is an encouraging result, applicable in real-world applications and serves as a good baseline for further improvement of future systems.

The paper is structured as follows. Section 2 introduces briefly the task of filtering spam SMS. Section 3 describes the methodology of our system. Section 4 presents our data and the evaluation results and discussion. Finally, Section 5 concludes the paper and suggests some directions for future work.

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<sup>1</sup> [www.bkav.com.vn](http://www.bkav.com.vn)

## 2. Background

### 2.1. Spam filtering system

A SMS is a short text message that contains only a limited number of characters. The structure of this message is divided into the header and the body. The header contains some information about the subject, sender, and recipient while the body is the actual content of the message that we see on mobile phones.

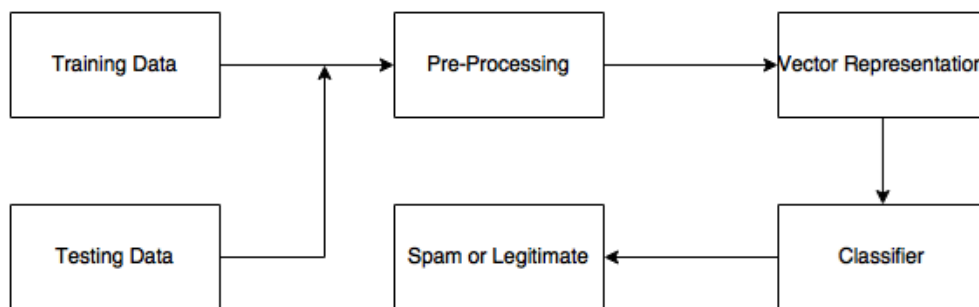


Figure 1: Pipeline of a usual spam filter

Figure 1 shows the pipeline of a usual spam filter. The processing chain of a filter can be divided into three components. The first is preprocessing, where documents are processed to extract data for later use. The common preprocessing steps are tokenization, lemmatization and removing stop words. After preprocessing the raw text is transformed to vectors, each representing the content of one message. The most popular representations are bag of words and term frequency-inverse document frequency. The vectors are inputs to a machine learning model. After training, the model is able to label each new message as spam or not.

### 2.2. Spam filtering system for Vietnamese

To our knowledge, there is some research on spam filtering for Vietnamese but none focused on SMS. Most of these systems are developed for filtering spam email (Lung, 2012), (Dinh, 2014). The best accuracy of these systems is about 92% but the false positive rate is not feasible in practical applications, about 6% (Lung, 2012). Moreover, email has many characteristics different from SMS, so applying these systems directly to our task cannot give the best results. For these reasons, we propose a system that focuses on filtering Vietnamese spam SMS.

### 3. Methodology

SMS has some different characteristics compared to regular text such as email, the task of labelling spam SMS is harder than for email. Firstly, the maximum length of an SMS message is only 160 characters, so the content-based approach for SMS is more difficult because there is less information. Secondly, subscribers do not usually use regular grammar when composing a message. They use abbreviations, phonetic contractions, wrong punctuations, emoticons, etc. It makes the data sparse, and some preprocessing tools cannot be applied. Also, linguistic characteristics of the Vietnamese language are different from occidental languages. Thus, applying methods for English directly or using existing systems for detecting Vietnamese spam email cannot give the best performance.

In the following subsections, we present our main method, including preprocessing step, featurization and machine learning models.

#### 3.1. Preprocessing

##### 3.1.1 Entity Tagging

The size of our corpus is relatively small and a lot of patterns in messages are not words in the dictionary. Thus, it is necessary to alleviate the sparseness of this data. We propose a new way to do this by grouping some similar patterns together. We define six groups, including *date*, *phone*, *link*, *currency*, *emoticon* and *number*. *Date* collects characters that describe time such as day, month, year, hour, etc. *Phone* detects phone numbers. *Link* and *currency* find and replace characters that represent web links and money. Mobile users use many *emoticons* in messages and we match them to similar emoticons of Facebook. After that, we replace all number in the corpus by the token *number*. Table 1 presents some common regular expressions for each group.

Type	Patterns
date	$\backslash d\{1,2\}/\backslash d\{1,2\}/\backslash d\{2,4\}$ $\backslash d\{1,2\}-\backslash d\{1,2\}-\backslash d\{2,4\}$ $\backslash +\backslash d\{1,2\}:\backslash d\{1,4\}$ $\backslash d\{1,2\}/\backslash d\{1,4\}$ $\backslash d\{1,2\}-\backslash d\{1,4\}$ $\backslash d\{1,2\}h\backslash d\{0,2\}$
phone	$\backslash +\backslash d\{10,12\}$ $\backslash d\{3,5\}\backslash .\backslash d\{3,4\}\backslash .\backslash d\{3,5\}$

	<code>\d{8,12}</code>
link	<code>www\..*</code> <code>http://.*</code>
currency	<code>[0-9 \, \. ]{3,}VND</code> <code>[0-9 \, \. ]{3,}VND</code> <code>[0-9 \, \. ]{3,}d</code> <code>[0-9 \, \. ]{3,}đ</code> <code>[0-9 \, \. ]{3,}tr</code> <code>[0-9 \, \. ]{3,}Tr</code> <code>[0-9 \, \. ]{3,}TR</code>
emoticon	<code>o.O</code> <code>\(y\)</code> <code>:v</code> <code>:3</code> <code>--</code>

Table 1: Common patterns for each group

### 3.1.2. Tokenization

Like many occidental languages, Vietnamese is based on the Latin alphabet. However, in Vietnamese, the space symbol is not only used to separate words but also to separate syllables within the same word. The task of word segmentation plays an important role when detecting spam message because it helps to extract features more accurately. There are tools to solve this problem by detecting word boundaries such as (Le-Hong, 2008), JVNsegmenter (Cam-Tu, 2006). These tools work well for regular text but they are not suitable for our dataset because SMS usually uses an idiosyncratic language. Thus, we propose to use the phrase collocation method for the segmentation task on our dataset

(Mikolov, 2013). The score of two syllables  $w_i, w_j$  that are parts of the same word is given

by:

$$score(w_i, w_j) = \frac{count(w_i w_j - \delta)}{count(w_i) * count(w_j)}$$

where  $\delta$  is used as a discounting coefficient to prevent too many phrases consisting of infrequent words to be formed.

For our system, we filter out all bigrams with total collected count lower than 10. The advantage of this method is that we need no pre-training data to train the tokenizer. It is

based on only the statistics of syllables in our corpus.

### 3.2. Vector Representation

The raw data type is text, so we need to transform it to vector form to use in machine learning models. There are two common methods for converting raw text to numeric vector - Bag of Words (BoW) and Term frequency - Inverse document frequency (Tf-Idf).

#### 3.2.1. Bag of Words

Given the vocabulary set  $T = \{t_1, t_2, \dots, t_N\}$ , each document  $d$  in the corpus is represented as a N-dimensional vector  $X = \{x_1, x_2, \dots, x_N\}$  where  $x_i$  is the number of occurrences of  $t_i$  in  $d$ .

#### 3.2.2. Term Frequency-Inverse Document Frequency

Tf-Idf is a numerical statistic that reflects how important a word is to a document in a collection or corpus. Each  $x_i$  in vector  $X$  is calculated by an equation:

$$x_i = n_{t_i,d} \log \left( \frac{|D|}{n_{t_i}} \right)$$

where  $D$  is a corpus,  $n_{t_i,d}$  is the number of occurrences of  $t_i$  in  $d$  and  $n_{t_i}$  denotes the number of documents in which  $t_i$  occurs.

#### 3.2.3. Feature Selection

Because the represented vector is sparse, it may negatively affect the performance of the classifier. To improve the accuracy of our system, we need a method to select the most representative features such as document frequency, information gain, term-frequency variance, etc. In our setting, we use document frequency because this common method has low computational cost.

#### 3.2.4. Length Feature

In our experiments, we found that the length feature is useful because the lengths of spam messages tend to be long.

### 3.3. Classifiers

#### 3.3.1. Baseline Classifier

Spam messages from mobile network operators are easy to detect because they have special tags in their contents. Thus, we collect these tags and label messages that have them as spam messages. Specifically, these tags are  $[QC^*]$ ,  $(QC^*)$ ,  $[TB^*]$ ,  $(TB^*)$  where  $*$  is a string or empty. We use this method as a baseline system for the evaluation task.

#### 3.3.2. Machine Learning Models

We trained some common machine learning models on our dataset and used them to detect spam messages. These models include Naive Bayes (NB), support vector machine (SVM), logistic regression (LR), decision tree (DT) and k-nearest neighbours (kNN).

## 4. Experiment

### 4.1. Dataset

We conduct experiments on a dataset containing 6,599 messages manually annotated with labels. Our dataset is a collection of messages from the two biggest mobile network operators in Vietnam - Viettel and Vinaphone. There are 5,557 legitimate messages and 1,042 spam messages in this dataset. Its dictionary has 7,334 unique words. Spam message could be sent from either mobile network operators or other sources. The former is easy to detect because it has special tags in their contents. In our dataset, about 70% of spam messages are from operators. The size of this corpus is comparable to some SMS datasets for English (Delany, 2012). This dataset is made available for research purpose<sup>2</sup>. Table 2 shows some example messages in our dataset

Message Type	Content
Spam Messages (From Mobile Operators)	<p><i>[QC] VIETTEL GIA HAN KM 2/9: Goi 29 phut noi mang tinh tien 1 phut. Dang ky, soan MP29 gui 109 (ap dung den 15/9). Cuoc tru vao TK goc, theo block 60s+1s. LH 198 (200d/p). Tu choi QC, soan TC gui 199.</i></p> <p><i>(QC) Co hoi MIEN PHI tu dich vu PTTD (Vinaphone) danh cho TB 84947261479 . Soan tin nhan : (DK6 gui 1535). Tai khoan 0 dong van</i></p>

<sup>2</sup> [github.com/pth1993](https://github.com/pth1993)

	<i>gui duoc tin.</i>
Spam Messages (Others)	<i>DatNen Cang Quoc Te Binh Duong,ngay Sthi Han Quoc, lo goc chi 388tr. Goi 012050 48717 gap Ms Nhan de so huu vi tri thanh khoan nhanh, dau tu de dang nhac.</i>  <i>That Tuyet Voi de So Huu CanHo Sieu CAOCAP ParkParoma Dep NHAT Vinhomes, Vi tri VANG gia Tot NHAT. Goi ngay e Long 090 282 5353 tham quan nha mau va giu cho</i>
Legitimate Messages	<i>Quy khach dang thuc hien gd Chuyen khoan trong HT VCB voi so tien 1,877,000VND tren VCB-iBanking. Ma giao dich cua Quy khach la 33143e03e8</i>  <i>Tir la thanh re len, di len xiu, qua cai den xanh dor, nhìn bên tay trái. H e cũng ra. Tới thì đợi e ha</i>

Table 2: Example messages in our dataset

## 4.2. Results and Discussions

### 4.2.1. Evaluation Method

We use 5-fold cross-validation to evaluate our system. The final accuracy score is the average scores of the five runs.

We use statistical measures of the performance of a binary classification test in decision theory as measures for our system. The reason for using this method is the asymmetry in the misclassification costs. The error that the system incorrectly classifies spam message as legitimate is a minor problem while the error of labelling legitimate message as spam can be unacceptable. Thus, there is a trade-off between two types of errors. The sound system must satisfy both of two constraints - the good performance for spam filtering and the misclassification of the legitimate message is minimal.

In decision theory, two classes are positive (spam) and negative (legitimate). We measure two types of error by false positive rate and false negative rate. The numbers of spam and legitimate messages in our dataset are  $n_S$  and  $n_L$ , the numbers of incorrect

messages are  $n_{S,L}$  and  $n_{L,S}$ , respectively. From these, the false positive

and negative rates are given by the following formulas:



$$FPR = \frac{n_{L,S}}{n_L}$$

$$FNR = \frac{n_{S,L}}{n_S}$$

#### 4.2.2. Baseline System

Our baseline system uses a simple rule to detect spam messages by finding special tags in their contents. Table 3 presents the accuracy of this system.

True Positive Rate	69.76%
True Negative Rate	100.00%
False Positive Rate	0.00%
False Negative Rate	30.24%

Table 3: Accuracy of baseline system

We see that this system can detect only about 70% of the number of spam messages because there are lots of spam messages that have no special tags in their contents.

#### 4.2.3. Preprocessing

In the second experiment, we compare the performance of the system with or without preprocessing. The classifier we use is Support Vector Machine, and the representation is BoW.

Without preprocessing, the vocabulary has 7,334 words, while using tokenization and entity tagging, the vocabulary size is reduced to 5,998 words. It makes our corpus less sparse and more accurate because its size is smaller and words in Vietnamese is combined from one or more syllables. Table 4 shows the improvement when using the preprocessing technique.

	Without Preprocessing	With Preprocessing
True Positive Rate	91.79%	93.40%
True Negative Rate	99.69%	99.60%
False Positive Rate	0.31%	0.40%
False Negative Rate	8.21%	6.60%

Table 4: Evaluation of preprocessing

We see that with preprocessing, the accuracy of labelling spam message increases by

about 1.6%.

#### 4.2.4. Vector Representations

In the third experiment, we evaluate the performance of SVM with two common methods for representing text -- BoW and Tf-Idf. The result is shown in Table 5.

	BoW	Tf-Idf
True Positive Rate	93.40%	84.66%
True Negative Rate	99.60%	99.58%
False Positive Rate	0.40%	0.42%
False Negative Rate	6.60%	15.34%

Table 5: Evaluation of vector representations

From the information in above table, we can conclude that BoW is more useful than Tf-Idf for this problem. Specifically, the accuracy when using BoW is better than using Tf-Idf by about 15%.

#### 4.2.5. Classifiers

In the fourth experiment, we compare some machine learning models to find the best models for this task. Classifiers that we compare are support vector machine (SVM), naive bayes (NB), decision tree (DT), logistic regression (LR) and k-nearest neighbours (kNN) and the vector representation in this experiment is BoW. Table 6 shows the accuracy of each model.

	SVM	NB	LR	DT	kNN
True Positive Rate	93.40%	95.15%	92.99%	92.18%	78.13%
True Negative Rate	99.60%	96.25%	99.64%	99.12%	99.64%
False Positive Rate	0.40%	3.75%	0.36%	0.88%	0.36%
False Negative Rate	6.60%	4.82%	7.01%	7.82%	21.87%

Table 6: Evaluation of classifiers

Naive Bayes gives the best result for labelling spam message but its false positive rate is very high, about 3.75%. It means that for every 100 legitimate messages, there are 3 messages that are labelled as spam. This rate is not acceptable in reality. In the rest, SVM gets the best result. Thus, we use SVM as a classifier for our system.

#### 4.2.6. Length feature and feature selection

We find that the length feature is useful for our system because the lengths of spam messages tend to be long. Document frequency is a good method to find the most useful features for classifying and make our system faster. Table 7 presents the accuracy of our system when adding length feature and setting document frequency as 3.

True Positive Rate	93.91%
True Negative Rate	99.55%
False Positive Rate	0.45%
False Negative Rate	6.09%

Table 7: Accuracy of our system

### 5. Conclusion and Outlook

In this paper, we have presented the first system for Vietnamese spam SMS filtering. Our system achieves a good accuracy of about 94% for detecting spam messages. This result is comparable to the accuracy of this task in English and outperforms some systems for labelling Vietnamese spam email although classifying SMS is more complicated.

In the future, we plan to improve our system by enlarging our corpus so as to provide more data for the system. We would like to use some deep learning models such as convolution neural network and long-short term memory for detecting spam messages because these models have been shown to give the best performance for many text classification problems (Johnson, 2016), (Zhang, 2015).

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<sup>3</sup> cyradar.com

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