



## Hybrid GA-AIS for Efficient Feature Extraction in E-mail Spam Detection

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### Abstract

Spam is a serious universal problem which causes problems for almost all computer users. This issue affects not only normal users of the internet, but also causes a big problem for companies and organizations since it costs a huge amount of money in lost productivity, wasting users' time and network bandwidth. Many studies on spam indicate that spam cost organizations billions of dollars yearly. In this paper, Spam Detection using Combination of GA-AIS Algorithm and Classification using SVM (support vector machine). The proposed approach is based on the characteristics of the spam e-mails. The spam e-mails are categorized into 5500 features and then the ensemble approach is performed to classify them, also increase of the number of input features, it has the lowest run-time. Also the suggested method has acceptable accuracy for 10000 data compared to the similar methods, and also less computation time and complexity.

**Keywords:** Spam, Feature Extraction, Genetic Algorithm, Immune System Algorithm, Support Vector Machine.

### 1. Introduction

E-mails are one of the most important forms of communication; e-mails are simple, effective, and a cheap type of communication for almost all computer users. This simplicity and cheapness are attacked by several threats. One of the most important threats is spam; spam e-mails are a problem that almost every e-mail user suffers from. The word "spam" usually denoted a particular brand of luncheon meat, but in recent times, spam is used to represent a variety of junk, unwanted e-mails. It is now possible to send thousands of unsolicited messages to those and of users all over the world with approximately no cost. As a result, it is becoming common for all users around worldwide to receive hundreds of spam messages daily. Spam messages are annoying to e-mail users as they waste time, money, and bandwidth. There are several approaches which try to stop or reduce the huge amount of spam which are received by individuals. These approaches include legislative measures such as antispam laws and origin-based filters which are based on using network information and IP addresses in order to detect whether a message is a spam or not [2]. The most common techniques are filtering techniques, attempting to identify whether a message is spam or not based on the content and other characteristics of the message [3]. In spite of the large number of methods and techniques available to combat spam, the volumes of spam on the internet are still rising. Nowadays; spam has the potential ability to become a serious problem for the internet community, antispam vendors offer a wide array of products designed to help us to keep spam out. They are implemented in various ways (software, hardware), several techniques (content, rule-based) and at various levels (server and user) [1, 4]. The introduction of new technologies, such as Bayesian filtering, SVM, Artificial Neural Network (ANN), Artificial Immune system (AIS), etc. can improve the accuracy of filters. The implementation of machine

learning algorithms is likely to represent the next step in the continuous fight against spam. This work presents a new solution for spam inspired by Artificial Immune System Model (AIS). The remainder of this paper is organized as follows. The related works and researches are reviewed in Section 2. Then in section 3 the proposed method are reviewed in section 4, the results of the proposed method and finally, the conclusions and recommendations are presented in Section 5.

## 2. Related Works

This section provides a brief description about the evolutionary algorithms. A summary of the studied algorithms are shown in Table 1.

### 2.1 The Selection Features Using the Genetic Algorithm

Genetic algorithm was invented by John Holland in 1967. Later, this method was found its place by efforts of Goldberengin 1989, and nowadays it has appropriate place among other methods in light of its capabilities. Optimization process in the genetic algorithm is based on a directed randomized process. This method has been developed based Darwin's evolution theory and fundamental ideas. In this method, a set of target parameters are generated firstly for fixed number called as population. After implementing the numerical simulator software representing the standard of deviation and/or fitness of the set of information, we assign it to that member of the mentioned population and we iterate this process for every member of the generated member.

#### 2.1.1 Designing of Chromosome

Firstly, we select a set of features. In other words, we extract the feature. For this purpose, we extract all unique words available in data warehouse. Then, we calculate the number of repetition of each word for each E-mail and we consider it as the vector feature for each of the E-mails. In the next stage, we should select a set of appropriate features among all extracted features. As genetic algorithm is one of the most efficient and appropriate optimization algorithms and it is used for selection of feature in many cases, we gave feature set obtained from the previous stage per every Email to genetic algorithm mso that the best appropriate feature subset to be selected. In the genetic algorithm, each of feature vector was considered as a chromosome [9].

#### 2.1.2 Crossover

To operate the crossover, the arithmetic operator was considered. In this operator, the children are generated from mean weight of two parents.

#### 2.1.3 Mutation

To practice the mutation, there has been used the uniform mutation. In this mutation, the selected gene is replaced by a random uniform amount specified lower and upper limits by the user.

#### 2.1.4 Fitness Function

The value of each chromosome is evaluated by the fitness function. The best chromosome would be the chromosome with the minimum error.

## 2.2 The Algorithm of Immune System

This algorithm was introduced by Dasgupta in 1999. The immune system algorithm is based on non-gender selection principle and it is population-based algorithm. The immune system algorithm is inspired by human immune system. It is a distributed compatible system, which have capacities of immunity diagnosing, reinforcement education, extraction of property, immune memory, diversity,

and strength. The main search power in the immune system is based on the mutation operator [8]. Therefore, it is considered as decision-making factor in this technique. Steps of this algorithm are defined as follows:

Initialization of the antibodies is performed in the first stage. Antigens represent the value of the objective function to be optimized.

Generation in which proportion or proximity of any antibody is determined. According to this proportion, antibodies are reproduced that the best reproduction took place at the best state. Super mutation is the final step of this algorithm. Clones are linked to a super mutation process in which the clones are mutated in an inverse proportion for affiliation (dependency). The best antibody clones are muted lowly and the clones with worse antibodies have the greatest mutation. Then, the clones are evaluated in line with their main antibodies, which the best antibodies are selected for the next iteration.

**Table 1.** A Summary Related Works of the Studied Algorithms

Author	The method used	Result	Advantages	Disadvantages
[5] J. Shrivastava and et al(2014)	using the adaptive genetic algorithm	Using genetic algorithms, the feature extraction leads to increase the accuracy.	The spaces of solutions are checked in several routes. The coding of parameters has been performed. This method works with domestic law	If proportion extraction is not selected properly. Optimal solution for problem will not provide. It has premature convergence problem.
[7] S. Jiang and et al (2012)	Method improve K-NN	By combining clustering at the Training Stage in the K-NN method, better efficiency can be obtained	Increase the performance	Dependence on the training set. There is no weight difference between samples
[6] H. Drucker [2012]	Svm for spam categorization	There has been used the support vector machine to classify E-mails with regard to contents. It can increase the speed of identification of the spam	Has very high accuracy for dataset of emails data	has low accuracy for dataset with high dimensional
[16]R. Zitar [2011]	Application of genetic optimized artificial immune system and neural networks in spam detection	High percentage of false positive and false negative value appeared	computationally efficient	Lack of optimization methods is observed in the immune system

### 3. The Process of Evolutionary Algorithm

Evolutionary algorithms are algorithms for searching, in which searching is done from multiple points in the response space. There are many problems that conventional solutions are not remedial for them because there is no analysis for them or their analytical solution is very difficult, and/or complexity of variables and bulk of parameters of solutions and not necessarily the answer of the problem, so evaluation of all solutions is not possible. Evolutionary algorithms are methods based on random search, modeled from modeling of natural biological evolution. They work on possible answers which possess a superior feature and enjoy more generation survival, hence, providing a closer approximation of the optimal response. Evolutionary algorithms use preliminary mechanisms and operations for problem solving and arrive at an appropriate solution during a series of iterations.

These algorithms often start from a population of random solutions, and try to improve the solution set during each iteration stage. At the beginning, a number of people are randomly guessed, and then the fitness function is calculated for each of these individuals, and the first generation is created. If none of the criteria to end the optimization is established, a new generation will begin to be created. People are selected in terms of their competency to children. These people are considered as parents and children crossover. All children face genetic with a certain amount of probability, mutation. Then, the children's competence is determined by the fitness function, and they are replaced by parents in the community, and a new generation is created. This cycle is repeated until one of the optimization end criteria is achieved. In this study, clonal and genetic evolutionary algorithms were used [8].

### 3.1 The Proposed Method

Optimized algorithms of immune and genetic systems have been proposed as hybrid and parallel algorithms for feature selection process. Genetic algorithm has been utilized to find the optimal set of features weights that improve the accuracy of classification [13]. The immune system algorithm has been taken into account because of the similar structure to genetic algorithm and in fact these algorithms are complementary. According to this technique, the algorithm is started with a group of randomly producing initial population and uses proportion value to assess the population. In both the genetic and immune systems, search methods are dependent combination of deterministic and probabilistic rules. These two algorithms are efficient and adaptive. They also own powerful search processes, produce desirable solutions and are executed in parallel, explicit and unconditional way.

The main difference between immune and genetic systems is that immune system algorithm does not have the operators of genetic algorithm such as crossover and mutation. Antibodies and antigens can update themselves with eligibility rules of an external agent. Compared to genetic algorithm, it owns very important Memory. It is more intelligent and can easily be implemented [14]. Instead, the parameters used in the genetic algorithm are fewer but it benefits from the higher convergence speed. However, if the parameters are properly set, the results can easily be optimized. The decision on the parameters of the immune system with trade-off exploration is heavily dependent on the objective function. Successful feature selection is acquired by using the memory values of immune system algorithm for the basic parameters [15].

According to Figure 1, in the initial phase in combination of immune system and genetic algorithm, the first set of outcomes of immune system (by the implementation of the first stage of the algorithm) are used as the first generation in genetic algorithm. Values of outcome Set of the immune system algorithm are searched and answers are found locally while a series of the results of genetic algorithm are queried and discovered globally in a wide variety of domains. These two algorithms choose effective features based on evaluation criterion of the adaptability in parallel with the exchange of their set of outcomes. In particular, an important advantage of immune system algorithm is that it performs only local search to achieve the optimal solution. So, the local optimality search can cause the coverage of global search with its detailed perspective that leads to optimization of ultimate solution. On the other hand, genetic algorithm covers populations and collection of all the features

from the outset with a global view into performance accounts. So by combining these two methods, the algorithm can cover each other's weaknesses.

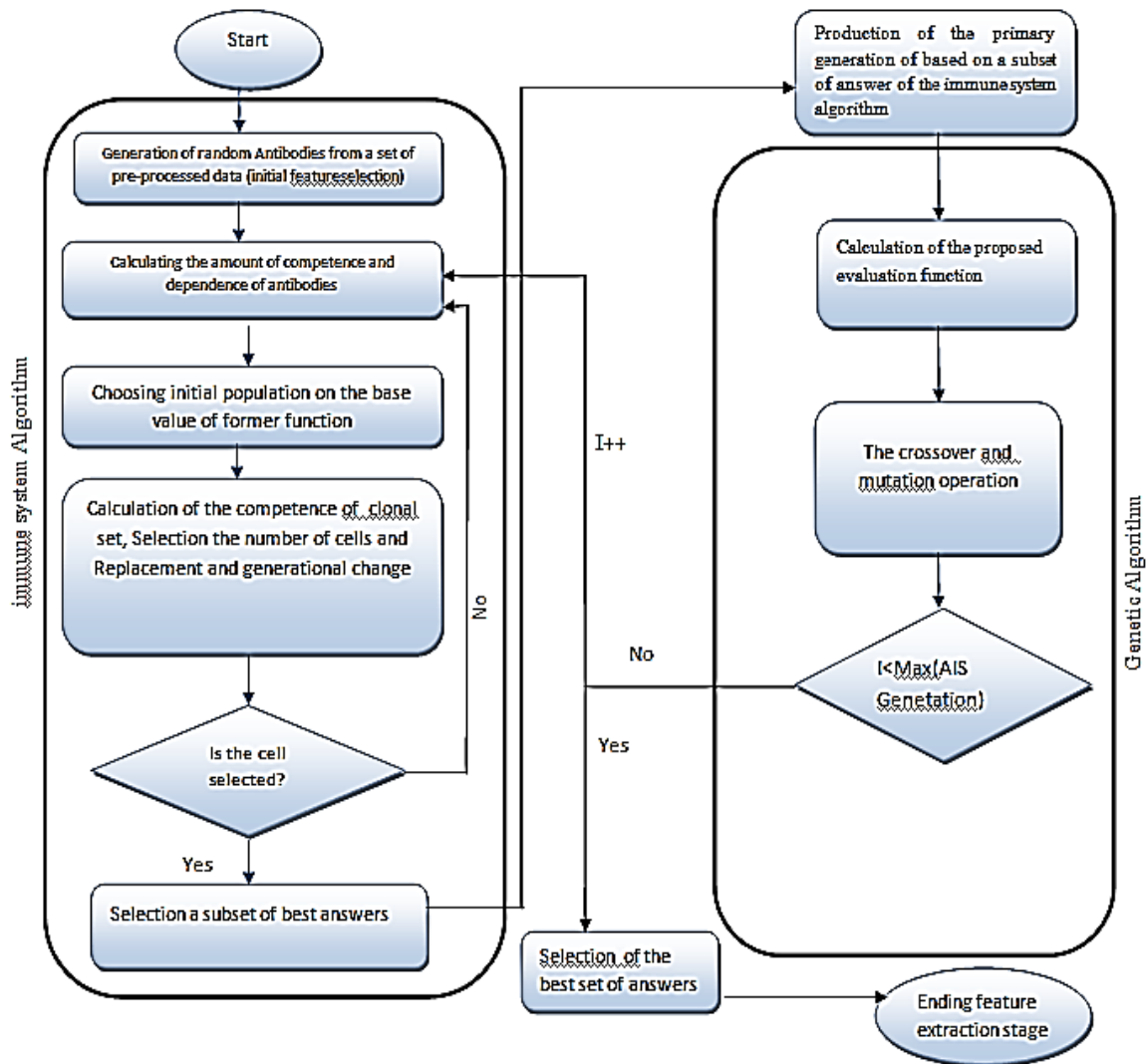


Figure 1: The Flowchart of the Proposed Algorithm

#### 4. Experimental Results

In the proposed system, criteria of accuracy and error are used for evaluating system performance which has been presented in equations of (1) [10].

$$Accuracy = \frac{TP+TN}{N} \tag{1}$$

**TP:** The number of records that their actual group is positive and classifying algorithm has diagnosed positive.

**TN:** The number of records that their real group is negative and classifying algorithm has correctly diagnosed negative.

The results of experiments showed the accuracy of the proposed method compared with SVM-GA, PSO-SVM, KNN, Naïve Bayes, and NN SVM algorithms and were assessed and compared on dataset of 1000 Spam Assassin email samples (Figure 2). The results revealed that the accuracy of the proposed

method was more when features increased. In this study, in order to extract features from sample emails, the combination of GA-AIS algorithms with SVM algorithm was used for classification. The quantitative results of the proposed algorithm, compared with a number of conventional algorithms in this field, including neural network and Bayesian algorithm, indicate the acceptable accuracy and speed of this algorithm.

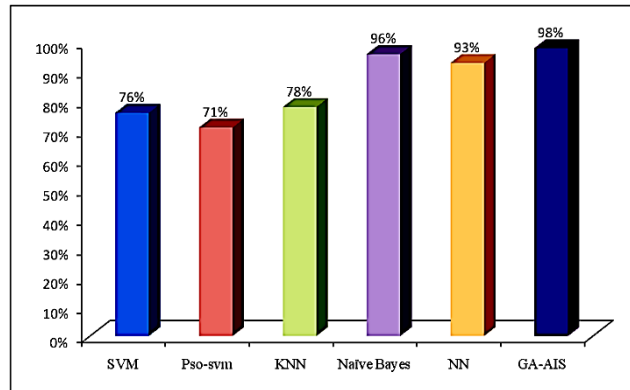


Figure 2: Comparing the Proposed Models with Other Algorithms

The figures 3, 4 and 5 demonstrate the convergence of factors in GA-AIS, PSO and GA algorithms in 100 iterations. The results indicate the high speed of convergence of the proposed algorithm for extracting features.

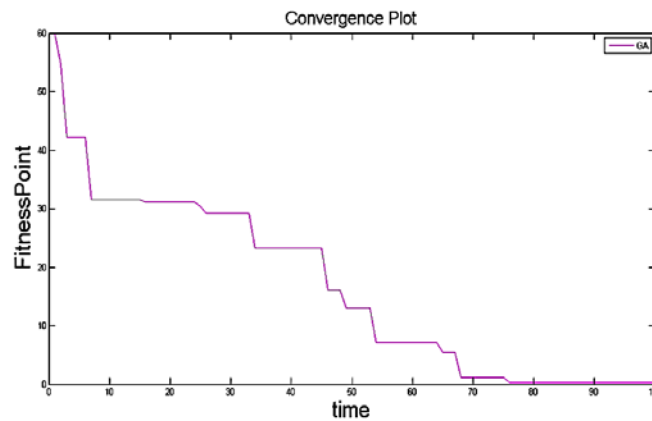


Figure 3: The Convergence of GA Algorithm in Order to Features Extraction

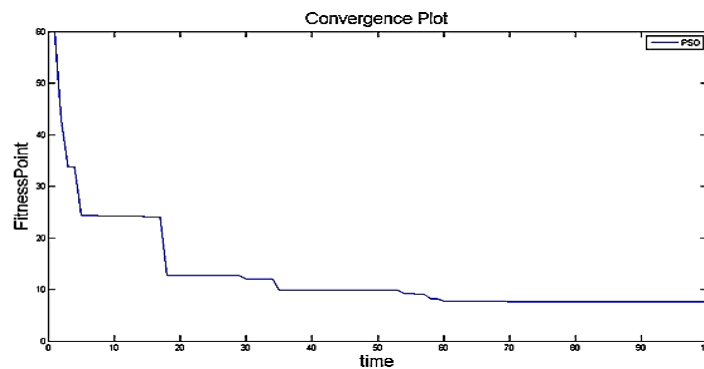
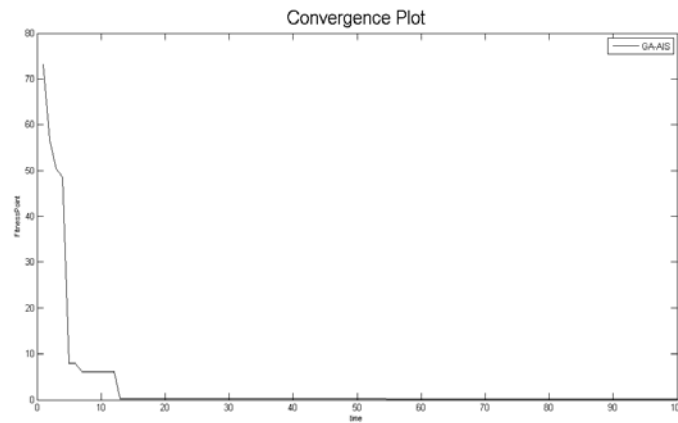
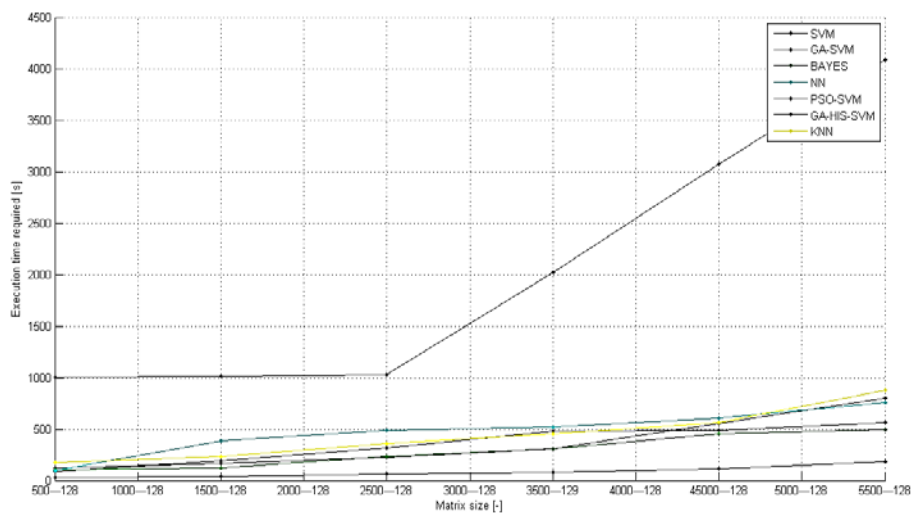


Figure 4: The Convergence of PSO Algorithm in order to Features Extraction



**Figure 5:** Convergence of Genetic Algorithm and Immune System in order to Features Extraction

Figure 6 shows the runtime of algorithms at the training and testing phase and the number of features' entries in various aspects. With increase of the number of features, computational complexity of features extraction increases, hence, algorithms' running time increases. For example, although the accuracy of Bayesian algorithm is assumed high, with increase of the number of input features, its run-time increases significantly. In contrast, assuming the high accuracy of the proposed algorithm, with increase of the number of input features, it has the lowest run-time.



**Figure 6:** Run time Algorithms (feature dimensions is 5500)

### 5. Conclusion and Future Works

In the current study, the combination of two genetic and immune system algorithms for 5500 feature extraction and SVM for classification were presented. This approach was evaluated considering a number of other algorithms and standard datasets of Spam Assassin. The evaluation results showed that the proposed methodology for the dataset has the best performance compared to these algorithms. Finally, the results of several other algorithms, applied to the data, were compared with the outcomes obtained. Experimental results showed that Proposed Method beside high speed of Convergence in features extraction has acceptable accuracy about is 98%. Future work includes using the Artificial Neural Networks (ANN) and Simulated Annealing (SA) in enhancing the performance of this hybrid system.

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