Intrusion Detection in Computer Networks Using Combination of Machine Learning Techniques

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Abstract
Any intrusion detection system may use both misuse detection and abnormal approach to recognize possible detected attacks. Classification is the problem of intrusion detection. Classification of intrusion detection data is generally divided into two main parts: feature selection and learning algorithms. Various methods have been proposed in connection with feature selection techniques and learning algorithms. The aim in the proposed method is to increase the classification secure and to reach the highest productivity. In present study a hybrid approach is proposed which operates on the combined output of the classifier. The proposed method uses a training set of KDD-Cup99. The proposed method uses three main learning algorithms, SVM, Naive Bayes and J48 decision tree is implemented and evaluated separately. These algorithms are also implemented and evaluated individually as well. The results show the superiority of the proposed method with 97% efficiency using J48 learning algorithm and Adaboost classification by reducing the dimension IG method (feature selection).

Keywords
intrusion, intrusion detection systems, machine learning, attack

1. Introduction

Intrusion Detection Systems is one of the main elements of the security infrastructure in many organizations. These systems are hardware and software models and patterns that automate the process which processes for monitoring the events involved in the network or computer systems. Network-based Computer systems has growing role in modern societies and are targeted and influence by more attacks by enemies and criminals. In addition, intrusion prevention methods such as user authentication such as using passwords, using fire walls, data protection, such as encryption, intrusion detection as well as other wall is used to protect computer networks. The goal of intrusion detection is to identify unauthorized use, abuse or damage to computer systems and networks by both internal users and external attackers (Altwaijry, 2013).

In order to implement intrusion detection methods, several systems as intrusion Detection Systems are designed and manufactured. In the field of computer security, intrusion detection systems play a role in warning and it is announced every time that site security is at risk. Other entity that is responsible for site security is called Site Security Officer that can answer warnings and do appropriate provisions (Hanguang& Yu, 2012).

2. Intrusion Detection System

Over the past few years, different types of intrusion detection systems have been built. The initial intrusion detection systems worked by analyzing Log files by operating system and created application files. However, these complex systems were reviewed; they did not have access to identify the attacked data. Thus, concentrations were shifted to the more sophisticated data analysis or host-based methods of intrusion detection.
Intrusion detection systems try to identify the user activities either normal or anomalous transaction which are compared with the network connection and based on known patterns of intrusion that have been designed by experts to examine the intrusion. Traditional methods can't be useful in discovering previously unknown intrusion patterns because manpower during analysis of intrusion detection systems will face computer networks with high speed and complexity. Intelligent decisions about the techniques and technologies that are based on data mining are used to identify effective and efficient intrusion detection pattern or patterns (Hanguang& Yu, 2012).
Machine learning-based intrusion detection systems are divided into two parts. First is the discovery of abuse and the second is anomaly discovering. Detection systems build intrusion models using learning from labeled data. In this model, system can't identify new attacks. In contrast, anomaly detection systems can detect new and unknown strike (Hanguang& Yu, 2012).

3. Related Works

So far, a number of researchers inside and outside the country have studied intrusion using data mining techniques, artificial neural network and machine learning algorithms for Intrusion detection systems. Each of the studies is looking at achieving better results in intrusion detection systems. In reference (Altwaijry, 2013)

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presented a method by the selection of feature to improve the performance of the SVM algorithm. The results on KDD99 in intrusion detection system was evaluated that the results showed the model has high accuracy rate of intrusion detection and higher performance.
In reference (Zhang & Chen, 2012) presented a model using the algorithm of association rules in intrusion detection. The method of using association rules algorithm many of the attacks were identified and the use of coarse-grained algorithm sets theory for systems, intrusion detection and intrusion detection system overall performance was also mentioned.
In reference (Panda et al, 2012) discussed using a combination of class rather than an intrusion detection system in class.
(Srinivasu & Avadhani, 2012) presented a method for an intrusion detection system using genetic algorithms for deriving the weights of the neural network method.
(Khan et al., 2007) presented an intrusion detection system using support vector machine and hierarchical clustering. In this analysis, hierarchical clustering and DGSOT to shorten the time of learning model SVM is used in large data sets. Combination of SVM and DGSOT increases accuracy and decreases false positive and false negative rates.
(Yang et al., 2007) is used LVQ and neural network model to detect network intrusion. The plan is to start the process of feature selection and data normalization. Then, the model is used to the intrusion detection model.
(Horng et al., 2011) presented a combined approach based on hierarchical clustering algorithms and the function selecting a series of important and simple features and combined them with a series of vector machine techniques. The method reduced training time and increased efficiency and also in this paper KDD99 data is used to examine the functionality. The efficiency of this method was in the detection of attacks of Dos and Prob.
(Li et al., 2014) have created a method for the removal of features that seemed to make more efficient of intrusion detection system. This method is based on techniques of removing features and support vector machine. The method is a combination of the clustering methods, ant colony algorithm, and support vector machines and the results show that the algorithm has a very high accuracy.
(Salama et al., 2011) reduced feature space in a deep belief networks then used Support Vector Machines which tried to divide the sample into 5 categories. Researchers used NSL-KDD data set to train and test the proposed system and the accuracy and speed of the proposed method were calculated. (Muda et al., 2011) proposed Network Intrusion Detection combining with supervised learning methods. K-Means algorithm is used for unsupervised learning and Naive Bayes algorithm for supervised learning. The first step is the using the K-Means algorithm for dividing the data into normal mode or attack types.
Then, using Naive Bayes algorithm the results classification obtained to evaluate the attack of KDD99 data set. Detection rate improved to 99.6 percent. However, this solution is not practical for real networks because the K-Means algorithm requires more time to process huge data in real networks which can lead to bottlenecks and problems encountered in the system.
(Sangkatsanee et al., 2011) is presented in real-time intrusion detection method using a supervised learning technique which is a simple efficient approach and can be used in many machine learning techniques. Therefore, we further develop an intrusion detection system in real time (RT-IDS) using decision tree to classify data on the network as normal data or attack. Finally, a new post-processing method was developed to reduce false rate and also increase the reliability and accuracy of intrusion detection systems.

4. Method and Algorithms

A. J48 algorithms

Decision tree classification based on the measure of characteristic selection in decision nodes are divided into two groups: CART (classification and regression tree) and C4.5. CART is the algorithm of classification and regression. J48 decision tree crates an improved tree (pruning) of C4.5 or not pruning C4.5 (Moore et al, 2009)

B. Naïve Bayes algorithms

Naïve Bayes algorithm is an algorithm based on Bayes theorem, which can be used for classification datasets. This algorithm is based on simplifying assumptions on which in it attribute values with condition of independent of the target variable is considered to be. Naïve Bayes is a probabilistic model and provides a systematic method for data analysis process (Panda & Patra, 2007).Process of this method always starts with the probability distribution given analyzed dataset. Bayes theory is a theoretical background for the statistical approach to classification problems of statistical inference (Panda & Patra, 2007).

C. SVM Classification

The theory of SVM is from statistics and the basic principle of SVM is finding the optimal linear hyperplanein the feature space that maximally separates the two target classes. Geometrically, the SVM modeling

algorithm finds an optimal hyperplane with the maximal margin to separate two classes (Kim et al, 2003).

D. Hybrid classifiers:

Boosting method for classification algorithms, which is called a weak learning algorithm; several times with different training sets are executed (selected according to a previous run) and finally answer the most frequently selected. Although this method is time-consuming, but it sure would be the answer. AdaBoost (Adaptive Boosting) is an efficient boosting method (Bauer& Kohavi, 1999).

E. Feature Selection

Feature Selection refers to process of selection subset of features to increase performance. One of the most efficient feature selection methods is Information Gain (IG). This method calculates information obtained from a feature for predicting a class with identifying the presence or absence of a given feature in data (Lee & Xiang, 2001).Thus the entropy of the random variable X is defined as (1).

Number of classes is i:

$$H(x) = -\sum_{i} P(X_i)\log 2.P(X_i)$$

The entropy of the random variable after observing the amount of Y as follows (2):

$$H(x|Y) = -\sum_{j} P(Y_j)\sum_{i} P(x_i|y_j)\log 2.P(X_i|Y_j)$$

And calculated by (3):

IG (X|Y) =H(X)-H (X|Y)

5. The Results and Evaluation

To evaluate the results of our classification, confusion matrix was used. Confusion matrix may be used briefly to predict the performance of a classification in data. Usually two classes are mentioned but can be used for any number of classes. The result of a confusion matrix with four categories is shown below. We carried out analysis using the following terms:

TN (True negative): the percentage of valid records that are classified correctly.

TP (True positive): the percentage of attacked records that have been correctly classified.

FP (False positive): the percentage of records that were mistaken as attack while they were authentic activity.

FN (False negative): the percentage of records that wrongly are known as right activities while they are attacking.

Table I. Clutter Matrix to a Classification Problem with Two Hands

		Predicted Records	
		Category -	Category +
Actual Records	Category -	TN	FP
	Category +	FN	TP

Accuracy=(TP+TN)/(TP+FP+TN+FN) (4)

Precision=TP/(TP+FP) (5)

Recall=TP/(TP+FN) (6)

F-Measure=2? (Precision ? Recall)/(Precision + Recall) (7)

4 algorithms are widely used, compare and contrast analysis are done in this section. In this section we show that the features can significantly influence the performance of an algorithm.

A. Evaluate on the IG + SVM classifier

Table II. The Results of the Proposed Method Using IG + SVM Classifier

Category	Recall	Precision	F-measure
Normal	99.20	78.29	87.45
Dos	58.8	99	73.77
PRB	84.1	80.1	82.05
U2R	12.5	57.14	20.55
R2L	5.8	64.19	10.63
Accuracy: 93.90			
Average precision: 75.57			
Average recall: 52.08			
Average F-measure: 54.88			
Classification error: 6.1			

At this stage, SVM classifier is used to evaluate the proposed learning approach. Table 2 shows the results of using SVM classifier. The results show the high efficiency of the proposed method using a support vector machine classifier in the average accuracy of 75.72%, average call times of 52.08%, the average F-measure equal to 54.88%, gross basis equal to 93.90% and the classification error rate is 6.1%.

B. Evaluate on the IG + Naive Bayes classifier

Table III. Results of the Proposed Method Using IG + Naive Bayes Classifier

Category	Recall	Precision	F-measure
Normal	68	96	80
Dos	99	94	96
PRB	95	31	47
U2R	32	48	38
R2L	67	1	3
Accuracy: 83.80			
Average recall: 72.20			
Average precision: 54			
Average F-measure: 52.80			
Classification error: 16.20			

At this stage, Naive Bayes classifier is used to evaluate the proposed learning approach. Table 3 shows the results of using Naive Bayes classifier and 22 items. The results show the efficiency in the average accuracy of 54%, average call times of 72.20%, the average F-measure equal to 52.80%, gross basis equal to 83.80% and the classification error rate is 6.20%.

C. Evaluate the proposed approach on the classification of the IG + J48

Table IV.Evaluation of the Proposed Method on the Classification of the IG + J48

Category	Recall	Precision	F-measure
Normal	99	99	99
Dos	100	100	100
PRB	99	99	99
U2R	96	98	97
R2L	59	70	64
Accuracy: 95			
Average recall: 90.6			
Average precision: 93.2			
Average F-measure: 91.8			
Classification error: 5			

At this stage, J48 classifier is used to evaluate the proposed learning approach. Table 4 shows the results of using J48 classifier and 22 items. The results show high efficiency of J48 in the average accuracy of 90.6%, average call times of 93.2%, the average F-measure equal to 91.8%, gross basis equal to 95% and the classification error rate is 5%.

A. Evaluate the proposed approach on adaboost + *IG* + J48 Hybrid Classification

Table V. Evaluation of the Proposed Method on the Classification of the IG + J48 + Adaboost

Category	Recall	Precision	F-measure
Normal	99	99	99
Dos	100	100	100
PRB	99	99	99
U2R	95	98	97
R2L	76	61	68
Accuracy: 97			
Average recall: 93.8			
Average precision: 91.4			
Average F-measure: 92.6			
Classification error: 3			

At this stage, J48 classifier is used to evaluate the proposed learning approach. Table 5 shows the results of using J48 classifier. The results show high efficiency of J48 in the average accuracy of 91.8%, average call times of 93.8%, the average F-measure equal to 92.4%, gross basis equal to 97% and the classification error rate is 3%.

Table VI. Comparison of Model 2 with Single Models

	SVM	Naive Bayes	J48	The Proposed Method
The Final Accuracy	93.9	83.8	95	97
The Wrong Classification Rate	6.1	16.2	5	3

SVM Algorithm, Naive Bayes, J48, adaboost are ways used in this research project. The important thing is to study feature selection techniques that many studies have been able to extract 22 features valuable for prediction and classification with higher efficiency than other methods. The proposed method of decision tree adaboost with j48 based classifier combination and 22 characteristics in Table (4) has shown better performance.

6. Conclusion

Intrusion detection systems are the systems that must show security and alert or alarm sound. Security is a very important issue that should be designed in a higher probability of intrusion detection system. Sometimes hardware is not for computing the address of the person or organization and the required hardware can be made for the calculations. Therefore, methods and algorithms that have been introduced in the table above can be used. In order to achieve a high degree of confidence, a security policy is often considered. This policy controls the function of various parts of the system and defines the requirements for supervision. In each of the algorithms, strategies to optimize are presented. Reducing the rate of negative and positive alarm and intrusion detection should also be considered carefully. The positive and negative alarm rate means that sometimes the warnings are not real and there are just so many of them. This aspect should also be taken into account in any software designers and the accuracy and diagnosis should not reduce. Fig. 3 mapping nonlinear data to a higher dimensional feature space.

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