Role of Support Vector Machine, Fuzzy K-Means and Naive Bayes Classification in Intrusion Detection System

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Abstract:- An Intrusion can be defined as the access to unauthorised user, a breach in a security, misuse of the information or the system which can be done both internally and externally of the organization. So, Intrusion Detection is basically providing the security or managing the flow of data, information, managing the access of the system to only authorised user. In a network which is widely distributed requires high end security, only authorised user can access the system in a network. So, it requires more than authentication, providing passwords or certificates. An Intrusion Detection system is used to detect and monitor the number of happenings and episode in a network or a system. It will gather the information and analyse that information. If, it finds any unauthorized access or misuse it will detect it as Intrusion and will follow provided instructions. So, If Intrusion is the violation of security, then Detection is the management and taking necessary action against that Intrusion. For detecting any Intrusion in a network or system there are number of techniques which are used and can be developed to prevent.

Keywords:- *Intrusion Detection, Fuzzy K-Mean, SVM. Naïve Bayes, KDD*

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I. INTRODUCTION

Today Network Managers are facing one of the greatest problem, i.e. Intrusion. Intrusion has been affecting the network and misuse of the system information. The system in a network is authorised to defined users. Only those users who have been authorised can access the data. But it is very necessary to detect and manage the network. There are many circumstances when unauthorised users or others try to access the information which leads to security breach. This security breach can be done from within or from outside the organization. So it is necessary to keep track of the network. So, the intrusion detection will manage and detect if any intrusion takes place. Although there are certain measure have been taken but the fact these measure can not be properly defined as security. This paper defines the role of support vector machine, naive bayes and Fuzzy k-means in detecting any intrusion in a network. . The support vector machine is optimal partitioning based linear classifier and at least theoretically better other classifier also because only small numbers of classes required during classification SVM with one against one technique can be the best option whereas the K-means clustering filters the un-useful similar data points hence reduces the training time also hence provides an overall enhanced performance by reducing the training time while maintaining the accuracy. The fuzzy K-means have the clusters which are produced by the k-means and its procedure and are sometimes known as the hard clusters and are also known as crisp clusters, since any feature vector **x** either is or is not a member of a particular cluster. This is in contrast to "soft" or "fuzzy" clusters, in which a feature vector **x** can have a degree of membership in each cluster

The algorithm, which is proposed further, will be tested using KDD99 dataset and results show the effectiveness of the algorithm. The paper also analysed the effect of different input parameters on classification accuracy.

Intrusion Detection System

INSTRUSION detection System monitors the violation of management and security policy and malicious activities in the computerized network [1]. The intrusion can be caused by inside (legal users), or outside (illegal users) in the system [2]. Nowadays recognition and prevention of intrusion is one of the most important mechanisms that provides security in networks and computer systems, and generally is used as a complemented security for firewalls [3]. IDS systems created as a software and hardware system that each one has its specific properties [1]. Hardware systems have been preferred to software system because of their speed and accuracy. But software systems are more common because of high compatibility with several operating systems [4]. James P. Anderson is known as a first person who propounded the investigation about registered events in the system in the field of security. Anderson demonstrated a report in 1980 which was the first activity about the recognition of intrusion [5, 6]. IDS generally have three main functions: monitoring and evaluation, detection and response [7].

Intrusion detection techniques are usually classified into misuse detection and anomaly detection. Anomaly detection focuses on detecting unusual activity patterns in the observed data. Misuse detection methods are intended to recognize known attack patterns.

Intrusion Detection Techniques

Intrusion detection techniques are divided into two groups and there are several algorithms which are described for supervised and unsupervised learning

Supervised Learning Algorithms

1. k-Nearest Neighbour - The k-Nearest neighbour is a classical algorithm [8] that finds k examples in training data that are closest to the test example and assigns the most frequent label among these examples to the new example. The only free parameter is the size k of the neighbourhood.
2. Multi-Layer Perceptron - Training of a multi-layer perceptron involves optimizing the weights for the activation function of neurons organized in a network architecture. The global objective function is minimized using the RPROP algorithm [9]. The free parameter is the number of hidden neurons.
3. Regularized discriminant analysis - Assuming both classes of examples are normally distributed, a Bayes-optimal separating surface is a hyperplane (LDA), if covariance matrices are the same, or a quadratic surface otherwise (QDA). A gradual morph between the two cases can be implemented by using a regularization parameter [10]. Another free parameter ¸ controls the addition of identity matrix to covariance matrices.
4. Fisher Linear Discriminate - Fisher Linear Discriminate constructs a separating hyper plane using a direction that maximizes inter-class variance and minimized the intra-class variance for the projection of the training points on this direction [8]. The free parameter is the trade-off between the norm of the direction and the “strictness” of projection.
5. Linear Programming Machine and Support Vector Machine - Linear Programming Machine (LPM) and Support Vector Machine (SVM) construct a hyper plane of the minimal norm which separates the two classes of training examples [11]. LPM uses the 1-norm, SVM uses the 2-norm. Furthermore, SVM apply a non-linear mapping to construct a hyper plane in a feature space. In our experiments, radial basis functions are used, their complexity controlled by the width parameter w. Another parameter C controls the trade-off between the norm of a hyper plane and the separation accuracy.

Unsupervised Learning Algorithms

1. k-Means Clustering - k-Means clustering is a classical clustering algorithm [8]. After an initial random assignment of example to k clusters, the centres of clusters are computed and the examples are assigned to the clusters with the closest centres. The process is repeated until the cluster centres do not significantly change. Once the cluster assignment is fixed, the mean distance of an example to cluster centres is used as the score. The free parameter is k.
2. Single Linkage Clustering - Single linkage clustering [12] is similar to k-Means clustering except that the number of clusters is controlled by the distance parameter W: if the distance from an example to the nearest cluster center exceeds W a new cluster is set.
3. Quarter-sphere Support Vector Machine - The quarter-sphere SVM [13] is an anomaly detection method based on the idea of fitting a sphere onto the center of mass of data. An anomaly score is defined by the distance of a data point from the center of the sphere. Choosing a threshold for the attack scores determines the radius of the sphere enclosing normal data points.

II. RELATED WORK

Evaluation of Fuzzy K-Means And K-Means Clustering Algorithms In Intrusion Detection Systems [14]

According to the growth of the Internet technology, there is a need to develop strategies in order to maintain security of system. One of the most effective techniques is Intrusion Detection System (IDS). This system is created to make a complete security in a computerized system, in order to pass the Intrusion system through the firewall, antivirus and other security devices detect and deal with it. The Intrusion detection techniques are divided into two groups which includes supervised learning and unsupervised learning. Clustering which is commonly used to detect possible attacks is one of the branches of unsupervised learning. Fuzzy sets play an important role to reduce spurious alarms and Intrusion detection, which have uncertain quality. This paper investigates k-means fuzzy and k-means algorithm in order to recognize Intrusion detection in system which both of the algorithms use clustering method.

An Improved Techniques Based on Naive Bayesian for Attack Detection [15]

With the enormous growth of computer networks and the huge increase in the number of applications that rely on it, network security is gaining increasing importance. Moreover, almost all computer systems suffer from security vulnerabilities which are both technically difficult and economically costly to be solved by the manufacturers. Therefore, the role of Intrusion Detection Systems (IDSs), as special-purpose devices to detect anomalies and attacks in a network, is becoming more important. The naive Bayesian Classification is use for intrusion detection system. One of the most important deficiencies in the KDD99 data set is the huge number of redundant records, which causes the learning algorithms to be biased towards the frequent records, and thus prevent them from learning infrequent records, which are usually more harmful to networks such as U2R and R2L attacks.NSL KDD data set have less redundant record .

Data Mining for Network Intrusion Detection [16]

This paper gives an overview of our research in building rare class prediction models for identifying known intrusions and their variations and anomaly/outlier detection schemes for detecting novel attacks whose nature is unknown. Experimental results on the KDDCup'99 data set have demonstrated that our rare class predictive models are much more efficient in the detection of intrusive behavior than standard classification techniques. Experimental results on the DARPA 1998 data set, as well as on live network traffic at the University of Minnesota, show that the new techniques show great promise in detecting novel intrusions. In particular, during the past few months our techniques have been successful in automatically identifying several novel intrusions that could not be detected using state-of-the-art tools such as SNORT. In fact, many of these have been on the CERT/CC list of recent advisories and incident notes.

Intrusion Detection based on Boosting and Naïve Bayesian Classifier [17]

In this paper, we introduce a new learning algorithm for adaptive intrusion detection using boosting and naïve Bayesian classifier, which considers a series of classifiers and combines the votes of each individual classifier for classifying an unknown or known example. The proposed algorithm generates the probability set for each round using naïve Bayesian classifier and updates the weights of training examples based on the misclassification error rate that produced by the training examples in each round.

Network Intrusion Detection Using Tree Augmented Naive-Bayes [18]

Computer networks are nowadays subject to an increasing number of attacks. Intrusion Detection Systems (IDS) are designed to protect them by identifying malicious behaviours or improper uses. Since the scope is different in each case (register already-known menaces to later recognize them or model legitimate uses to trigger when a variation is detected), IDS have failed so far to respond against both kind of attacks. In this paper, we apply two of the ancient data mining algorithms called Naive Bayes and tree augmented Naive Bayes for network intrusion detection and compares them with decision tree and support vector machine. We present experimental results on NSL-KDD data set and then observe that our intrusion detection system has higher detection rate and lower false positive rate.

Hybrid Approach using Fuzzy K means and Naïve Bayes Classification

The Naive Bayesian classifier is based on Bayes' theorem with independence assumptions between predictors. A Naive Bayesian model is easy to build, with no complicated iterative parameter estimation which makes it particularly useful for very large datasets. Despite its simplicity, the Naive Bayesian classifier often does surprisingly well and is widely use because it often outperforms more sophisticated classification methods. The fuzzy k-means will have crisp i.e hard value and soft values which can be used to detect intrusion in a network using naïve bayes classification.

Naïve Bayes Classification Algorithm

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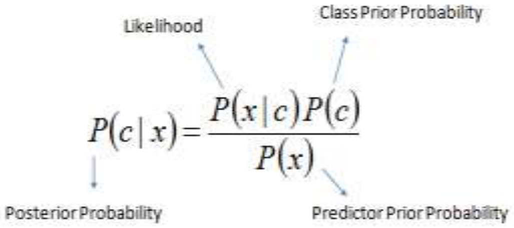
Algorithm

Bayes theorem provides a way of calculating the posterior probability, P(c|x), from P(c), P(x), and P(x|c). Naive Bayes classifier assume that the effect of the value of a predictor (x) on a given class (c) is independent of the values of other predictors. This assumption is called class conditional independence.



$$P(c \mid \mathrm{X}) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

→P(c|x) is the posterior probability of class (target) given predictor (attribute).

→P(c) is the prior probability of class.

→P(x|c) is the likelihood which is the probability of predictor given class.

→P(x) is the prior probability of predictor.

Support Vector Machine

Support Vector Machines (SVM's) are a relatively new learning method used for binary classification. The basic idea is to find a hyper-plane which separates the d-dimensional data perfectly into its two classes. However, since example data is often not linearly separable, SVM's introduce the notion of a "kernel induced feature space" which casts the data into a higher dimensional space where the data is separable [9].

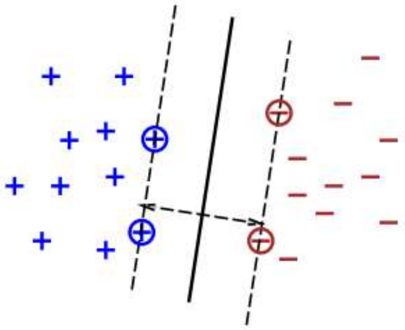


Figure1: SVM Hyper plane

Algorithm

Let we have L training points, where each input xi has D attributes (i.e. is of dimensionality D) and is in one of two classes $yi = -1\ or + 1$, i.e our training data is of the form:

$$xi, yi\ where\ i = 1 \ldots L, yi \in -1,1 , x \in RD$$

Here we assume the data is linearly separable, meaning that we can draw a line on a graph of $x1\ vs\ x2$ separating the two classes when $D = 2$ and a hyper-plane on graphs of $x1$, $x2. . . xD$ for when $D > 2$.

This hyper-plane can be described by $w \cdot x + b = 0, where$:

- w is normal to the hyperplane.
- $b\ w$ is the perpendicular distance from the hyper plane to the origin.

Support Vectors are the examples closest to the separating hyper-plane and the aim of Support Vector Machines (SVM) is to orientate this hyper-plane in such a way as to be as far as possible from the closest members of both classes.

Implementing a SVM boils down to selecting the variables w and b so that our training data can be described by:

$$w \cdot x\ i + b \geq +1\ for\ yi = +1 \ldots \ldots . . (1.1)$$

$$w \cdot x\ i + b \leq +1\ for\ yi = -1 \ldots \ldots . . (1.2)$$

$These\ equation\ can\ be\ combine\ into$:

Hybrid Approach using Fuzzy K means and Support vector machine

Combining two data mining technique called Fuzzy K-means and Support vector machine and form hybrid technique. We are combining this technique because the existing rules are the knowledge from experts knowledge or other system. The different methods will measure different aspects of intrusions.

III. PROPOSED SYSTEM ARCHITECTURE

The proposed algorithm uses the support vector machine for the IDS and can be describe as follows:

Step 1: Read the KDD99 dataset.

Step 2: Preprocess the data by selecting the only attributes which are needed for testing from the feature vectors.

Step 3: Group the feature vectors according to their attack type.

Step 4: Now partition the above feature vectors into training and testing groups.

Step 5: Now cluster the training data using fuzzy K-means Clustering.

Step 6: From each cluster select the given percentage of data points as possible as away from the centroid of the cluster.

Step 7: Estimate the total classes in the Training dataset and form $N * (N - 1)/2$ (N is the number of classes in dataset) feature vectors group.

Step 8: Train the SVMs for $N * (N - 1)/2$ datasets and form similar numbers of SVM.

IV. CONCLUSION

In this paper we are trying to define the roles of the various techniques which can be used to detect the intrusion and specific algorithms can be formulated to use them. There are so many solution provided by the researchers for detection of intruder in the network. Like Pattern Matching, Measure Based method, Data Mining method and Machine Learning Method.

Here we detected intrusion through data mining method by combining two data mining technique fuzzy K means, Naïve Bayes and Support Vector machine classification and formed a hybrid technique.

We combined these different methods for measured different aspects of intrusions. Combined these rules find the intruder attack more quickly from the exiting one.

V. FUTURE ASPECT

Further, one can use the association rule based approach can be proved to be very effective or IF – Then rule can also be proved to be very effective in classification of traffic in different classes. The detection of intrusion mostly depends on the accuracy of the algorithm. More the accuracy of the algorithm, more the intrusion can de detected easily. An hybrid approach can be determined which can result in detecting of intrusion and resolving that intrusion in a specific period of time as defined by the algorithm.

REFERENCES

[1] Pormohseni , Review and identify the computer Network intrusion detection systems , 2011 (Language in Persian).

[2] R. Heady , G. Luger , A. Maccabe , M. Sevilla.‖ The Architecture of a Network - level Intrusion Detection System, Technical report , CS90-20. Dept. of Computer Science, University of New Mexico, Albuquerque, NM 87131.pp:1-18, 1990.

[3] K . Scarfone and p . Mell , Guid to intrusion detection and prevention systems (idps), National Institude of Standard and Technology , Special publication 800 - 94 , page 127, 2007 . Availabel : http://csrc.nist.gov/publications/nistpubs/800- 94/SP800-94.pdf ,Last Available: 23.08.2012.

[4] Bro IDS homepage, Available: www.bro-ids.org Last Available: 23.07.2012.

[5] A . A . horbani , W. Lu, M.Tavallaee, Network Intrusion Detection and Prevention : Concepts and Techniques , Springerpublisher , pages 234, 2009.

[6] J . P Anderson , Computer Security Threat monitoring and surveillance , (1980), Availabel: http://csrc.nist.gov/publications/history/ande80.pdf Last Availabel: 05.08.2012.

[7] A . hamidi , M . rezai , Introduction to Intrusion Detection System (Part I) , Technical report, Mashad University ,Iran,(language in Persian)

[8] Duda, R., P.E.Hart, D.G.Stork: Pattern classiffication. second edn. John Wiley & Sons (2001)

[9] Rojas, R.: Neural Networks: A Systematic Approach Springer-Verlag, Berlin, Deutschland (1996)

[10] Friedman , J. Regularized discriminant analysis . Journal of the American Statistical Association 84 (1989) 165-175

[11] SchÄolkopf, B., Smola, A.: Learning with Kernels. MIT Press, Cambridge, MA(2002)

[12] Portnoy, L., Eskin, E., Stolfo, S.: Intrusion detection with unlabeled data using clustering. In: Proc. ACM CSS Workshop on Data Mining Applied to Security. (2001)

[13] Laskov, P., SchÄafer, C., Kotenko, I.: Intrusion detection in unlabeled data with quarter sphere support vector machines. In: Proc. DIMVA. (2004) 71-82

[14] P.Garcia -Teodoro, J.Diaz- Verdejo, “ Anomalyy network intrusion detection : Techniques, systems and challenges”, www.elsevier.com , 2009.

[15] Mr. Manish Jain , Prof. Vineet Richariya “ An Improved Techniques Based on Naïve Bayesian for Attack Detection ” International Journal of Emerging Technology and Advanced Engineering Website : www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 1, January 2012)

[16] Paul Dokas, Levent Ertoz, Vipin Kumar, Aleksandar Lazarevic, Jaideep Srivastava, Pang- Nig Tan ” Data Mining for Network Intrusion Detection” Computer Science Department, 200 Union Street SE, 4-192, EE/CSC Building University of Minnesota, Minneapolis, MN 55455, USA .

[17] Dewan Md. Farid, Mohammad Zahidur Rahman, Chowdhury Mofizur Rahman “ Intrusion Detection based on Boosting and Naïve Bayesian Classifier International Journal of Computer Applications (0975 – 8887) Volume 24– No.3, June 2011.

[18] R.Naja, Mohsen Afsharsfi , “ Network Intrusion Detection Using Tree Augmented Naïve Bayes” CICIS'12, IASBS, Zanjan, Iran, May 29-31, 2012.

[19] “Network Intrusion Detection Using Tree Augmented Naive-Bayes” ,CICIS'12, IASBS, Zanjan, Iran, May 29-31, 2012