Security Evaluation of Pattern Classifiers under Attack

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Abstract: Pattern classification systems are commonly used in adversarial applications, like biometric authentication, network intrusion detection, and spam filtering, in which data can be purposely manipulated by humans to undetermine their operation. As this adversarial scenario is not taken into account by classical design methods, pattern classification systems may exhibit vulnerabilities, whose exploitation may severely affect their performance, and consequently limit their practical utility. Extending pattern classification theory and design methods to adversarial settings is thus a novel and very relevant research direction, which has not yet been pursued in a systematic way. In this paper, we address one of the main open issues: evaluating at design phase the security of pattern classifiers, namely, the performance degradation under potential attacks they may incur during operation. We propose a framework for empirical evaluation of classifier security that formalizes and generalizes the main ideas proposed in the literature, and give examples of its use in three real applications. Reported results show that security evaluation can provide a more complete understanding of the classifier's behaviour in adversarial environments, and lead to better design choices.

Keywords: **Pattern Classification, Adversarial Classification, Performance Evaluation, Security Evaluation, Robustness Evaluation.**

I.   INTRODUCTION

Generally, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information- information that can be used to increase revenue, cuts costs, or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases.

While large-scale information technology has been evolving separate transaction and analytical systems, data mining provides the link between the two. Data mining software analyzes relationships and patterns in stored transaction data based on open-ended user queries. Several types of analytical software are available: statistical, machine learning, and neural networks. Generally, any of four types of relationships are sought as Classes, Clusters, Associations, Sequential patterns. Data mining consists of five major elements: Extract, transform, and load transaction data onto the data warehouse system. Store and manage the data in a multidimensional database system. Provide data access to business analysts and information technology professionals. Analyze the data by application software. Present the data in a useful format, such as a graph or table. Different

levels of analysis are available artificial neural networks, Genetic algorithms, Decision trees, nearest neighbor method, Rule induction, Data visualization. . Characteristics of Data Mining are Large quantities of data, Noisy, incomplete data, Complex data structure, Heterogeneous data stored in legacy systems.

Benefits of Data Mining:

- ❖ It's one of the most effective services that are available today. With the help of data mining, one can discover precious information about the customers and their behavior for a specific set of products and evaluate and analyze, store, mine and load data related to them.
- ❖ An analytical CRM model and strategic business related decisions can be made with the help of data mining as it helps in providing a complete synopsis of customers.
- ❖ An endless number of organizations have installed data mining projects and it has helped them see their own companies make an unprecedented improvement in their marketing strategies (Campaigns).
- ❖ Data mining is generally used by organizations with a solid customer focus. For its flexible nature as far as applicability is concerned is being used vehemently in applications to foresee crucial data including industry analysis and consumer buying behaviors.

❖ Fast paced and prompt access to data along with economic processing techniques has made data mining one of the most suitable services that a company seeks.

II. SYSTEM ANALYSIS

Existing System:

Pattern classification systems based on classical theory and design methods do not take into account adversarial settings; they exhibit vulnerabilities to several potential attacks, allowing adversaries to undermine their effectiveness. A systematic and unified treatment of this issue is thus needed to allow the trusted adoption of pattern classifiers in adversarial environments, starting from the theoretical foundations up to novel design methods, extending the classical design cycle of. In particular, three main open issues can be identified: (i) analyze the vulnerabilities of classification algorithms, and the corresponding attacks. (ii) Developing novel methods to assess classifier security against these attacks, which are not possible using classical performance evaluation methods. (iii) Developing novel design methods to guarantee classifier security in adversarial environments.

Disadvantages of Existing System:

Poor analyzing the vulnerabilities of classification algorithms, and the corresponding attacks. A malicious web master may manipulate search engine rankings to artificially promote website.

Proposed System:

In this work we address issues above by developing a framework for the empirical evaluation of classifier security at design phase that extends the model selection and performance evaluation steps of the classical design cycle .We summarize previous work, and point out three main ideas that emerge from it. We then formalize and generalize them in our framework. First, to pursue security in the context of an arms race it is not sufficient to react to observed attacks, but it is also necessary to proactively anticipate the adversary by predicting the most relevant, potential attacks through a what-if analysis; this allows one to develop suitable countermeasures before the attack actually occurs, according to the principle of security by design. Second, to provide practical guidelines for simulating realistic attack scenarios, we define a general model of the adversary, in terms of her goal, knowledge, and capability, which encompass and generalize models proposed in previous work. Third, since the presence of carefully targeted attacks may affect the distribution of training and testing data separately, we propose a model of the data distribution that can formally characterize this behaviour, and that allows us to take into account a large number of potential attacks; we also propose

an algorithm for the generation of training and testing sets to be used for security evaluation, which can naturally accommodate application-specific and heuristic techniques for simulating attacks.

Advantages of Proposed System:

Proposed system prevents developing novel methods to assess classifier security against these attacks. The presence of an intelligent and adaptive adversary makes the classification problem highly non-stationary.

III. SYSTEM DESIGN

System Architecture:

Fig 1: System Architecture

Data Flow Diagram:

The DFD is also called as bubble chart. It is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system. The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system. DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output. DFD is also
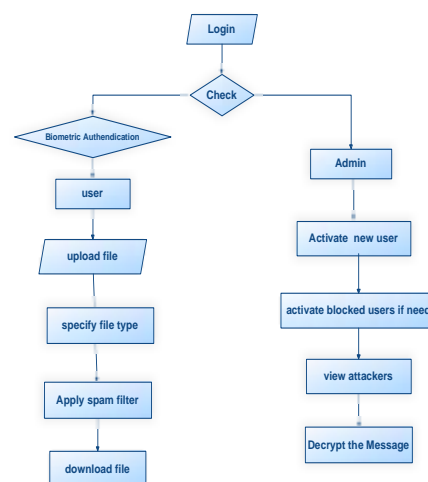

Fig 2: Data Flow Diagram

Known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail.

Activity Diagram:
Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.
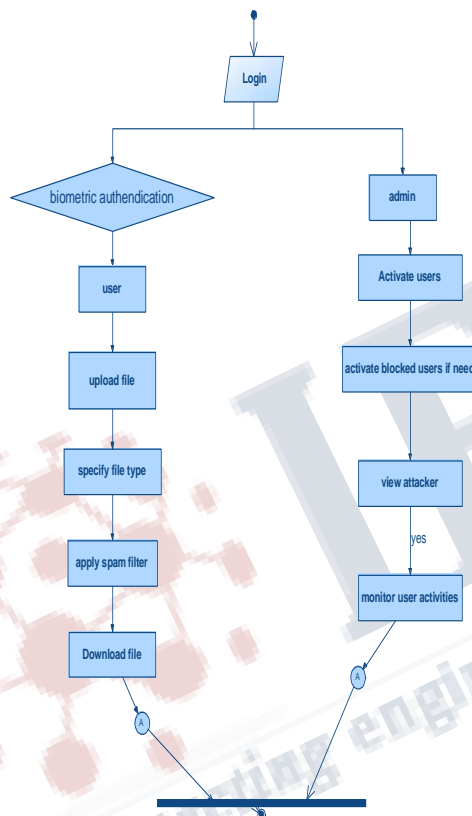

Fig 3: Activity Diagram

Modules:

The modules involved in the proposed system are Attack Scenario and Model of the Adversary, Pattern Classification, Adversarial classification and Security modules.

Attack Scenario and Model of the Adversary:
Although the definition of attack scenarios is ultimately an application-specific issue, it is possible to give general guidelines that can help the designer of a pattern recognition system. Here we propose to specify the attack scenario in terms of a conceptual model of the adversary that encompasses, unifies, and extends different ideas from previous work. Our model is based on the

assumption that the adversary acts rationally to attain a given goal, according to her knowledge of the classifier, and her capability of manipulating data. This allows one to derive the corresponding optimal attack strategy.

Pattern Classification:
Multimodal biometric systems for personal identity recognition have received great interest in the past few years. It has been shown that combining information coming from different biometric traits can overcome the limits and the weaknesses inherent in every individual biometric, resulting in a higher accuracy. Moreover, it is commonly believed that multimodal systems also improve security against Spoofing attacks, which consist of claiming a false identity and submitting at least one fake biometric trait to the system (e.g., a "gummy" fingerprint or a photograph of a user's face). The reason is that, to evade multimodal system, one expects that the adversary should spoof all the corresponding biometric traits. In this application example, we show how the designer of a multimodal system can verify if this hypothesis holds, before deploying the system, by simulating spoofing attacks against each of the matchers.

Adversarial classification:
Assume that a classifier has to discriminate between legitimate and spam emails on the basis of their textual content, and that the bag-of-words feature representation has been chosen, with binary features denoting the occurrence of a given set of words.

Security modules:
Intrusion detection systems analyze network traffic to prevent and detect malicious activities like intrusion attempts, ROC curves of the considered multimodal biometric system under a simulated spoof attack against the fingerprint or the face matcher. Port scans, and denial-of-service attacks. When suspected malicious traffic is detected, an alarm is raised by the IDS and subsequently handled by the system administrator. Two main kinds of IDSs exist: misuse detectors and anomaly-based ones. Misuse detectors match the analyzed network traffic against a database of signatures of known malicious activities. The main drawback is that they are not able to detect never-before-seen malicious activities, or even variants of known ones. To overcome this issue, anomaly-based detectors have been proposed. They build a statistical model of the normal traffic using machine learning techniques, usually one-class classifiers, and raise an alarm when anomalous traffic is detected. Their training set is constructed, and periodically updated to follow the changes of normal traffic, by collecting unsupervised network

traffic during operation, assuming that it is normal (it can be filtered by a misuse detector, and should).

Screen Shots:
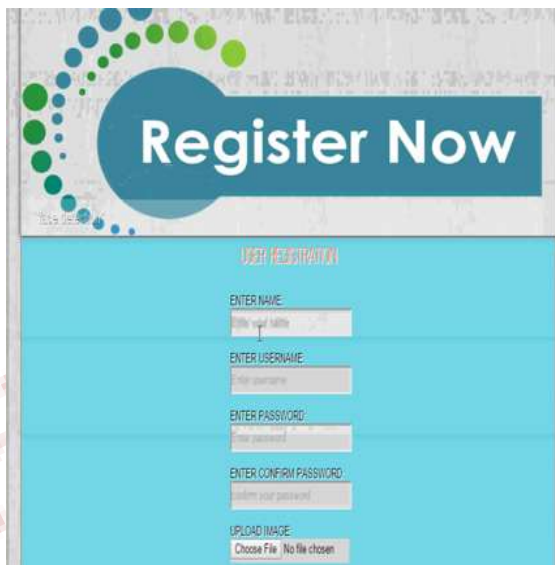

Fig 4: Home Page

Fig 7: Admin Page

Fig 5: User Registration Page

Fig 8: In Admin New Users List

Fig 6: Admin Login Page
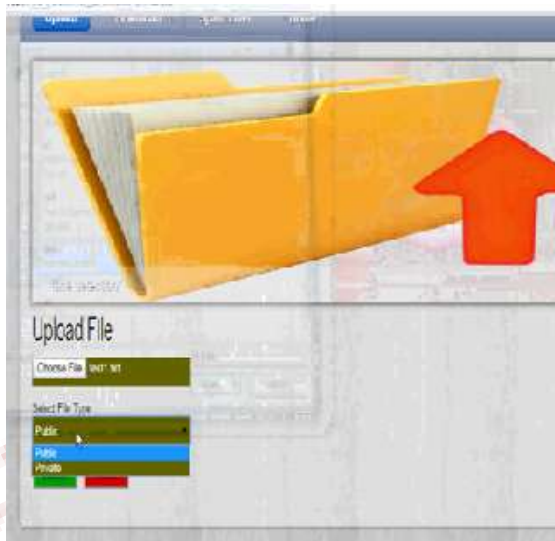

Fig 9: Upload Page

Fig 10: User Page

Fig 11: Uploading Files

Fig 12: Spam Message

Fig 13: Blocked Message
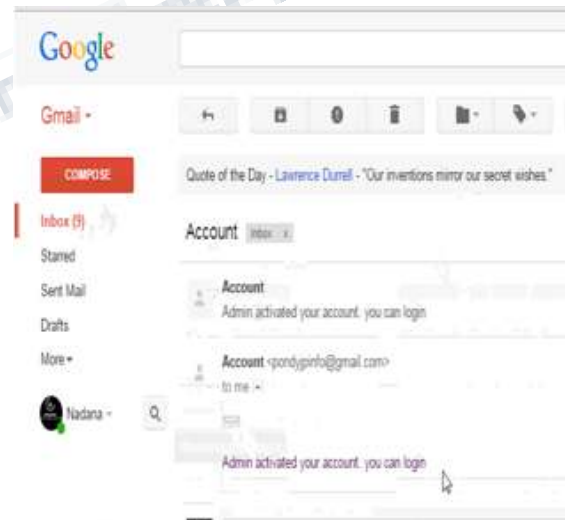

Fig 14: Attackers List

Fig 15: Mail to Users

IV. CONCLUSION

The paper focused on empirical security evaluation of pattern classifiers that have to be deployed in adversarial environments, and proposed how to revise the classical performance evaluation design step, which is not suitable for this purpose. The main contribution is a framework for

empirical security evaluation that formalizes and generalizes ideas from previous work, and can be applied to different classifiers, learning algorithms, and classification tasks. It is grounded on a formal model of the adversary, and on a model of data distribution that can represent all the attacks considered in previous work; provides a systematic method for the generation of training and testing sets that enables security evaluation; and can accommodate application-specific techniques for attack simulation. This is a clear advancement with respect to previous work, since without a general framework most of the proposed techniques (often tailored to a given classifier model, attack, and application) could not be directly applied to other problems. An intrinsic limitation of our work is that security evaluation is carried out empirically, and it is thus datadependent; on the other hand, model-driven analyses require a full analytical model of the problem and of the adversary's behavior, that may be very difficult to develop for real-world applications. Another intrinsic limitation is due to fact that our method is not application-specific, and, therefore, provides only high-level guidelines for simulating attacks. Indeed, detailed guidelines require one to take into account application-specific constraints and adversary models. Our future work will be devoted to develop techniques for simulating attacks for different applications. Although the design of secure classifiers is a distinct problem than security evaluation, our framework could be also exploited to this end. For instance, simulated attack samples can be included into the training data to improve security of discriminative classifiers (e.g., SVMs), while the proposed data model can be exploited to design more secure generative classifiers. We obtained encouraging preliminary results on this topic.

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