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Machine Learning on Encrypted Data: Analyzing Efficiency and Accuracy Trade-Offs

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ABSTRACT

In this modern era, phishing has become a great problem. Because of this, it can be observed that the personal information of people is leaked from emails & websites. Hence, it is needed that these instances of phishing are to be reduced. In doing one of the best tools that can be used is Machine Learning. This is a process of using historical data for making prediction of future scenarios. In this project, the details of the approached that can be used for the detection of phishing are analyzed. Moreover, the algorithms that are used by ML for this purpose are also envisaged here. The description of the process of collection of data is presented here. In addition to this, the results that shows the effectiveness of ML in the detection of phishing is also discussed here.

Keywords- Machine Learning, Neural Network, Decision Tree, Random Forest, Feature Engineering.

I. INTRODUCTION

One of the most critical threats that are observed these days is the threat of the stealing of information through websites. In this way, the personal info of the users gets stolen. One of the traditional methods for the detection of this problem is the blacklisting of such sites. However, it has become irrelevant as the number of sites has increased a lot over the past few years. The best tool that can be used in this current scenario is "Machine Learning".

This has the feature of checking a huge amount of data and analyzing them to find out the websites that are pure and have no risks of leaking information. The things that are analyzed in this process are the content present in the email, URLs, & the source codes. Here, the details of the process of "phishing detection" are discussed. For this, literature based on the detection of phishing was studied in order to identify the processes of this.

II. LITERATURE REVIEW

2.1 Machine Learning-based solutions for phishing website detection

According to Tang & Mahmoud, 2021, the use of ML shows good results in terms of detecting phishing on websites. It is considered to be one of the most critical threats or the users. There are different models of ML that can be used for this purpose. This contains both "supervised" & "unsupervised" models. The data that these models analyses are collected from the URLs, and content of the websites. "Supervised learning" has attained success in the detection of "phishing websites". The approaches that it uses are "decision tree", "neural network", and SVM. This is based on the datasets with the help of which it is predicted that how often a website can be phishing (Tang & Mahmoud, 2021). These processes can easily be interpreted and their accuracy is fair enough. In the current era, the use of CNNs & RNNs has become very popular. The results are good in terms of detection of phishing. The main benefit of these is that they are able to collect necessary information from the existing data. This lowers the need for "feature engineering". The main

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characteristic of CNN is that it can differentiate a good and a phishing website visually. On the other hand, the use of RNN is mainly observed in the processing of "sequential data".

2.2 Phishing URL detection using lexical-based machine learning in a real-time environment

According to Gupta *et al*. 2021, the prime focus of this method is on finding out the composition & structure of URLs. In this way, phishing is detected. The process includes checking out the length of the URL, looking for the presence of keywords that are suspicious in nature and also the presence of "special characters". The "lexical features" are such things that can easily be extracted and also analysed for the detection of phishing in real-time. Internet phishing detection based on log data According to Obaid *et al*. 2021, there can be different forms of "log data". These are logs of the activities of the user, logs of accessing the servers, and the log of traffic. These all are data that can provide enough information on the activities of phishing. ML is a crucial tool that can analyse these "log data" for the identification of the patterns of phishing (Obaid *et al*. 2021). The insights that "log data" provides are accessing attempts that are not usual attempts, failure in the process of login, and abnormality in the volume of data to be transferred.

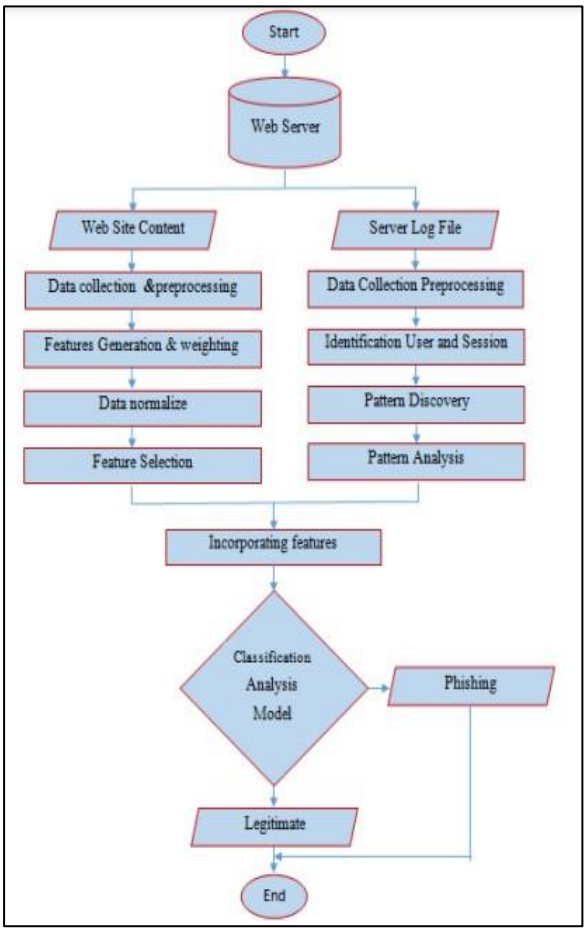

Figure 1: System, Flowchart
(Source: Obaid *et al*. 2021)

One of the best methods that are used for the detection of phishing is "clustering", and "outliner detection". These are helpful in distinguishing between the usual behaviour and unusual behaviour (phishing). This form of detection of phishing is beneficial from the point of view of the use of the models of ML in order to use "historical data". Also, when the "log data" is monitored continuously, it results in the adaptation of new methods of phishing and on the basis of that alerts are given.

III. METHODS

3.1 Data collection & processing

Data is the resource on which the effectiveness of the ML models for the detection of phishing is dependent. The better the quality of input data the better results are obtained. This data in mainly important for the "training" & "evaluation".

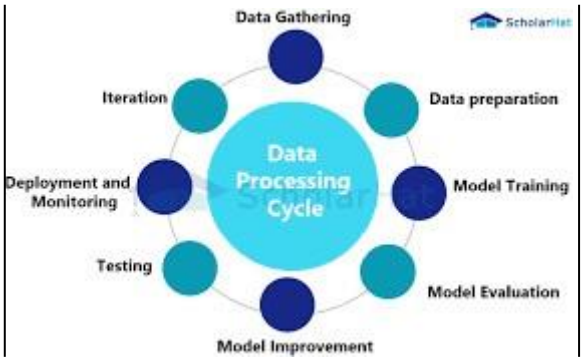

Figure 2: Data Processing
(Source: data:image/png;base64)

The data contains a set of URLs that contains both good and phishing URLs. The main sources for the collection of data are datasets of public, "phishing database", and " crawlers (web)". In order to achieve better results it is wise to collect data on phishing that contains the different techniques of phishing. Also, it should collect data from good websites for making comparisons. After the collection of data, it is processed before the analysis of it (Salahdine *et al*. 2021). This method of pre-processing data includes the below.

Normalization

At this stage, the data are prepared so that it can be fit to become a good input for ML.

3.2 Design of Machine Learning models

There are models that can be helpful for the detection of phishing activities. ML models are developed in different stages for this purpose. This stage includes the selection of essential algorithms, and changing them in such a way that can result in achieving good results. This starts with the selection of ML techniques (Deval *et al*. 2021). These techniques should possess the "classical algorithms" and method of "deep learning". The details of the stages are provided below.

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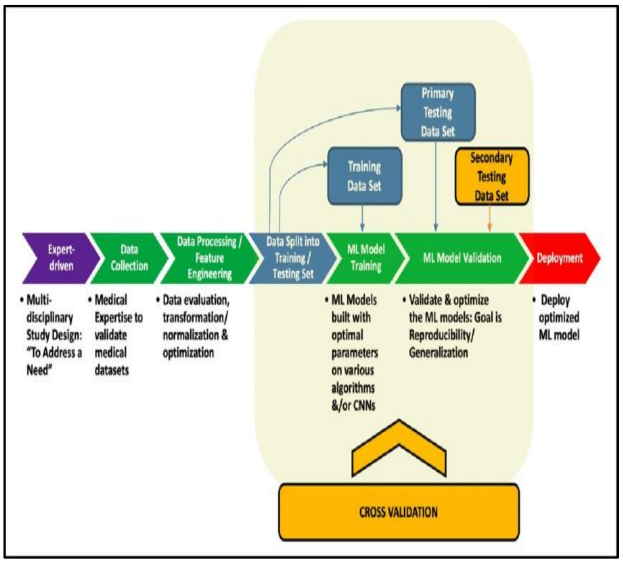

Figure 3: Supervised ML model
(Source: https://www.researchgate.net)

Selection of algorithm-

There are some algorithms that are mostly used for the detection of phishing. These are SVM, "decision tree", and "neural network". Among these, the algorithms are decided on the basis of system requirements.

Training of models-

After the completion of the pre-processing, the data is divided into two halves. The first one is called "training set" The use of this is to build models. Another one is the "validation set" (Somesha *et al*. 2020). It is used for the evaluation of the performance of the prepared models.

Feature Engineering-

This is a process that is used for the betterment of the prediction of the models. This consists of the selection of features that provide good information and reduction of dimensionality for the increase of capability of computation.

3.2 Deployment & Implementation

This is the next process after the completion of training the models. The steps that are included in this are given below.

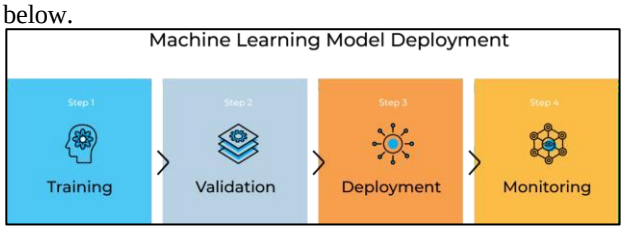

Figure 4: Deployment of ML model
(Source: https://framerusercontent.com)

Integration-

These modes can be used with the integration of emails & browsers. With this use of this, it will be possible to analyses the URLs and the contents present in the emails (Gandotra & Gupta, 2021). As a result of this, it protects the users against phishing.

Scalability-

In this stage, it is ensured that the system is capable of attaining a large "traffic volume". Hence, features like the efficiency of the system and speed are analyzed.

Monitoring-

This involves checking the system on a continuous basis in order to increase the performance of the models.

IV. RESULT

4.1 Accuracy Improvement

The models based on ML have some significantly good results in terms of the detection of phishing cases. This is possible because of the use of algorithms such as "random forest", "decision tree", and SVM.

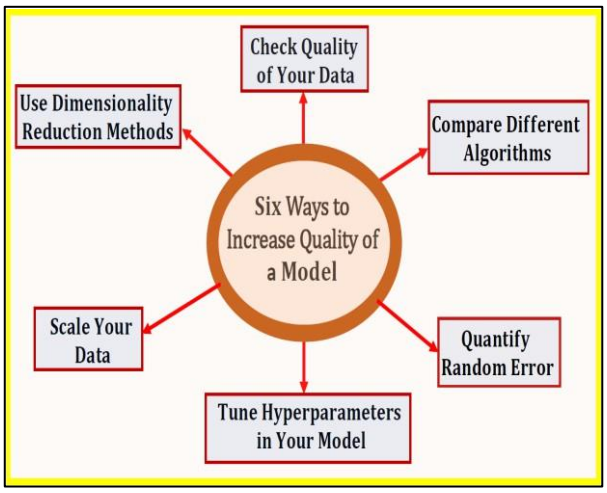

Figure 5: Accuracy of ML models
(Source: https://encrypted-tbn0.gstatic.com)

In many cases, the level of accuracy has crossed 95%. There are different forms of features that are integrated together such as lexical, on the basis of content, and on the basis of behavior (Odeh *et al*. 2021). All of these results in finding out the phishing websites from the good websites.

4.2 Enhancement of adaptability

Adaptability is a feature that is very much essential for the improvement of the effectiveness of the ML models. This involves making improvements on a continuous basis. The system of learning in real-time makes it easy to know about the new patterns of phishing. Also, it helps in maintaining a good accuracy of detection of phishing (Aljofey *et al*. 2020). It can be noticed that when hybrid methods are used different models of ML are integrated together. In this way, the system becomes more adaptable.

4.3 Detection in real-time

There are many good results that can be observed when these n\models are combined with the

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emails & browsers. Also, another good result of this is that the gateway of security gets enhanced for the detection of phishing.

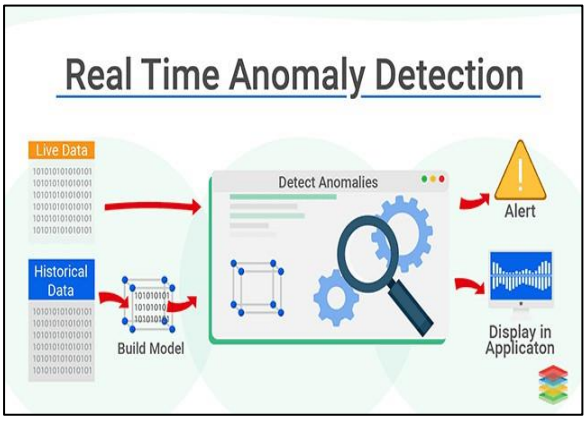

Figure 6: Real-Time threat detection
(Source: https://miro.medium.com)

In this way, the URLs are analyzed fast and give the users fast alerts. In the process where lexical data is involved, it results in a fast filtration of data. Hence, it is possible to analyse the content in depth. Hence, more security can be provided.

V. CONCLUSION

When ML is used in the system for the detection of phishing, good results can be observed. The main algorithms that are used by ML for this purpose are SVM, "decision trees", & "nural networks". This system has gained an accuracy of 95%. When the models are updated in a continuous manner then it results in having new data that highlights new methods of phishing. As a result of this more secure system can be made. In the present day, the scenario of phishing is increasing. Hence, it has become essential to use ML for the detection of this. Moreover, the use of AI is likely to increase the performance of these models.

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