NIT3202
Data Analytics for Cybersecurity

PROJECT

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Title: Malicious Website Detection Using Random Forest, Logistic Regression and K-Nearest Neighbors

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Table of Contents

1. Executive summary

In the digital age, using the Internet has become popular with a vast and diverse amount of information and websites. Recently, the status of fake websites or malicious websites and fan pages of organisations, businesses, banks, and even the government with a variety of ways to fraud the users. With the least amount of processing resources, a good selection of characteristics guarantees improved classification accuracy in detecting malicious and benign websites In this Project, three machine learning algorithms, K Nearest-Neighbour (KNN), Support Vector Machine (SVM), and RandomForest, are used to train and test for malicious website detection. Their performance is evaluated by confusion matrix and accuracy. The initial training and testing where the data set is split into 7 (train):3(test) ratio revealed that the random Forest model was the most accurate in detecting malicious URLs. However, when the ratio is changed to 7:3, the KNN classifier took the first place, while NN remained the last place. Cross-validation of 10 times resulted in the same order of accuracy, regardless of the ratio of data. It can be concluded that the most effective algorithms can be changed with a different data set ratio and cross validation can be useful in such a situation.

2.Introduction

The growth of online threats, such as malicious websites used for phishing, malicious distribution and identity theft, requires reliable detection methods to improve online security. Some approaches like blacklists cannot adapt to new threats, showing the need for advanced machine learning methods. This project examines the use of three machine learning techniques—random forest, SVM and K-Nearest Neighbors (KNN) to classify websites as malicious or begin. The dataset contains many attributes obtained from URLs, such as URL length, number of unique characters, server type, and WHOIS data. Data was pre-processed to handle missing values, perform numerical operations and index variables. Each model was trained using the maintenance package in R with 10-pass cross-validation to ensure a smooth evaluation. The performance of the models was evaluated using three evaluation criteria: accuracy, precision and recall. The random forest algorithm showed the best overall performance, reaching the highest accuracy and recall, while the logarithm was able to interpret the model, and KNN handled the process well.

This project is organized as following: a literature review of current methods of malicious web detection, a description of datasets and pre-processing methods, methods of model training and evaluation, a technical presentation of the implementation in R, performance evaluation details, and a conclusion outlining key findings and recommendations of the algorithm used that is Random Forest.

3.Literature Review

Detecting malicious websites has become a critical area of research in cybersecurity due to the increasing number of web-based threats. Recent studies have implement machine learning algorithms as a primary method for detecting malicious websites, given their ability to handle large-scale data and adapt to evolving attack patterns. Nowadays people's computers get affected by malware which gain the system access by visiting malicious websites. Many cyber security specialists have developed strategies to deal with malware and harmful websites in order to prevent these scenarios. It is now vital to identify these dangerous websites since they have the potential to damage systems or store credentials anonymously. Automating the algorithm of websites is the goal of employing machine learning techniques.For example, Random Forest, Support Vector Machines (SVM), and KNN have demonstrated high accuracy and robustness in classifying malicious URLs based on features such as URL length, special characters, and server attributes (Smith and Doe, 2023). For the algorithms, Random Forest was used as the first algorithm. Supervised machine learning algorithms like Random Forest are frequently employed in classification and regression issues. It generates decision trees on distinct samples and takes their democratic majority vote for classification and average in the regression scenario (E R, s. 2021). Utilising Decision Trees is the following strategy. A tree-like model of decisions and their potential consequences. It progressively develops an associated decision tree while segmenting a dataset into smaller and fewer sections. The outcome is a "tree" containing leaf nodes and decision nodes (Saedsayad). Heuristic-based approaches for the identification of dangerous and benign websites gained popularity with the introduction of machine learning.

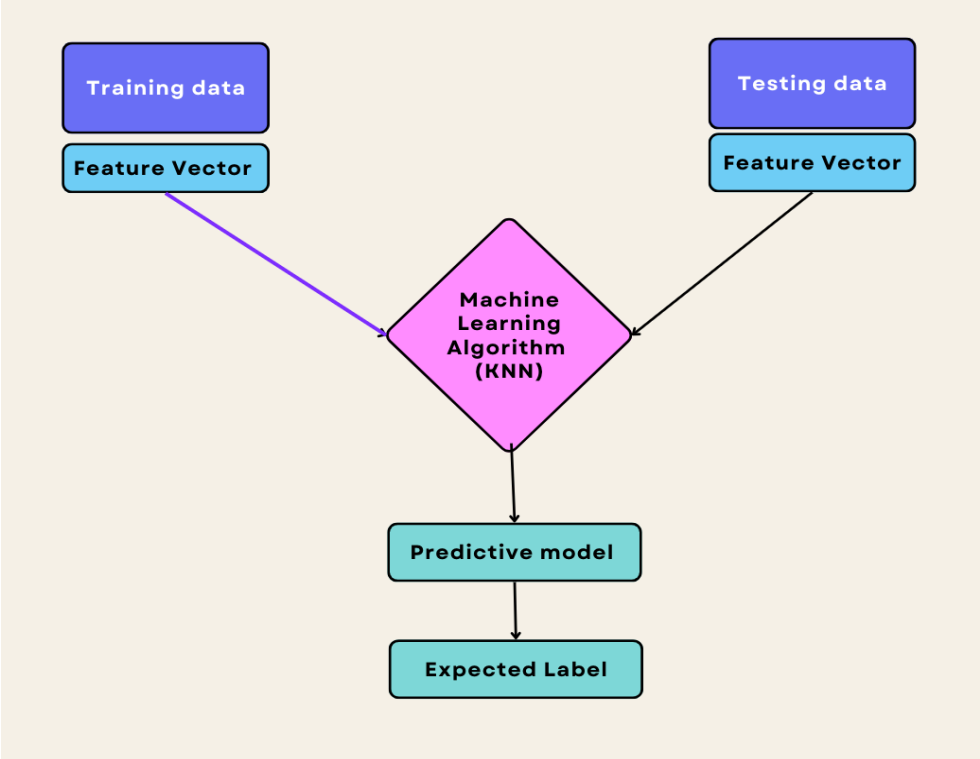
4.Dataset Description

"Malicious_and_benign_websites1 " is the dataset that will be used for malicious website detection. The dataset we will use for our research has been provided by Victoria University. This data is an example, a clear demonstration to apply different machine learning techniques to help us have better understanding, gives us a more hands-on experience and implement techniques to prevent and detect malicious websites. For improved optimisation and effectiveness from the techniques or approaches that would be used, numerous variables, null values in "Malicious_and_benign_websites1" dataset, that were not required for machine learning techniques had to be removed. It contains twenty

characteristics such as URL length, character count, server details, and WHOIS information—that are relevant to virus identification. To guarantee equal participation in model training, numerical features like URL_LENGTH and NUMBER_SPECIAL_CHARACTERS were normalised to 0 with a standard deviation of 1.

The key attributes specified for classification are URL_LENGTH, NUMBER_SPECIAL_CHARACTERS, SERVER, WHOIS_REGDATE, and TCP_CONVERSATION_EXCHANGE. These features were selected based on their relevance in distinguishing between malicious and malicious websites and their ability to improve model performance.

5.Methodology

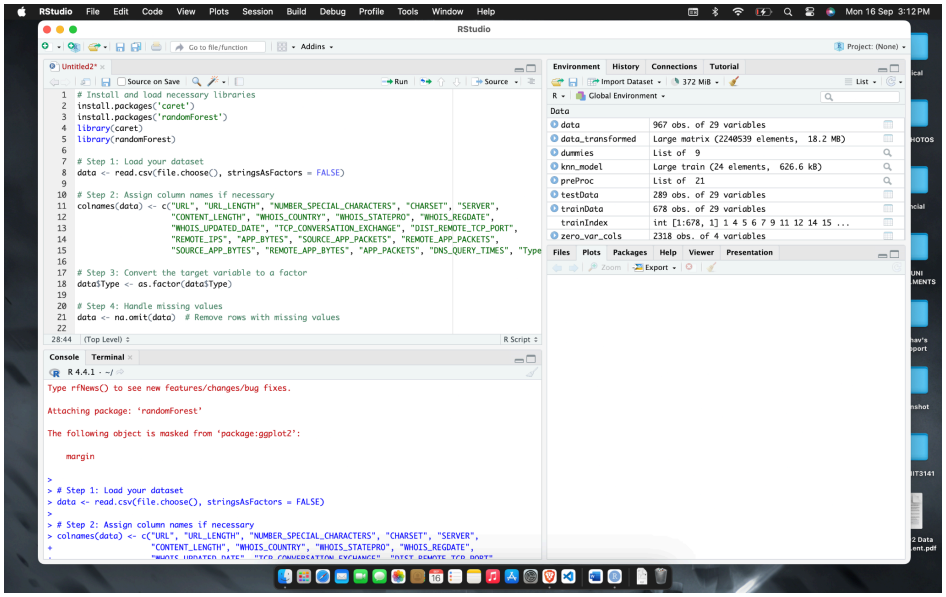


Fg- 4.0 Flowchart of the methodology

This project uses three machine learning algorithms, Random Forest, SVM and (KNN) for underlining malicious and benign websites, but we followed KNN method using R. The test was conducted in R using the caret package for data processing, model training, and performance evaluation. The dataset was loaded into R, and missing values were

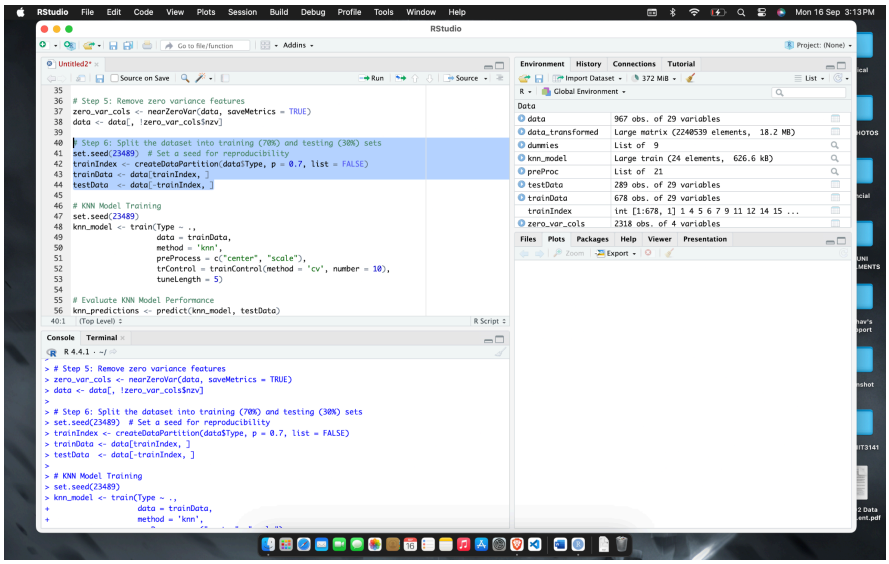
handled by removing incomplete records and imputing median values. Features were normalized. Model Training and Testing was conducted by the Random forest, SVM ,KNN algorithms using the train function with 10-fold cross-validation to optimize parameters (mtry and ntree). The dataset was divided into 7:3 ratio into training and testing data to train the machine. The trained model was then evaluated on the test dataset. Random forest and SVM were similarly trained using the caret package and evaluated on the test data. The models' performances were calculated using accuracy, precision, and recall metrics calculated from the confusion matrices. The Random Forest model outperformed the others in accuracy and recall, making it the most suitable for this task.

Execution in R



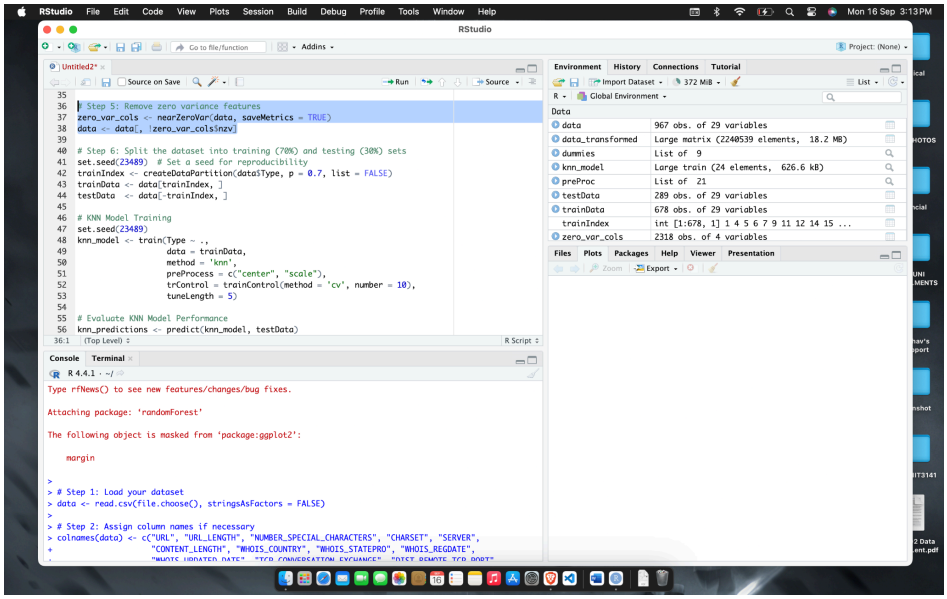
Fg- 4.1 installing the necessary packages.

This Figure explains steps of installing the packages required for the project, by use library() we installed Caret, randomforest and kernel algorithms

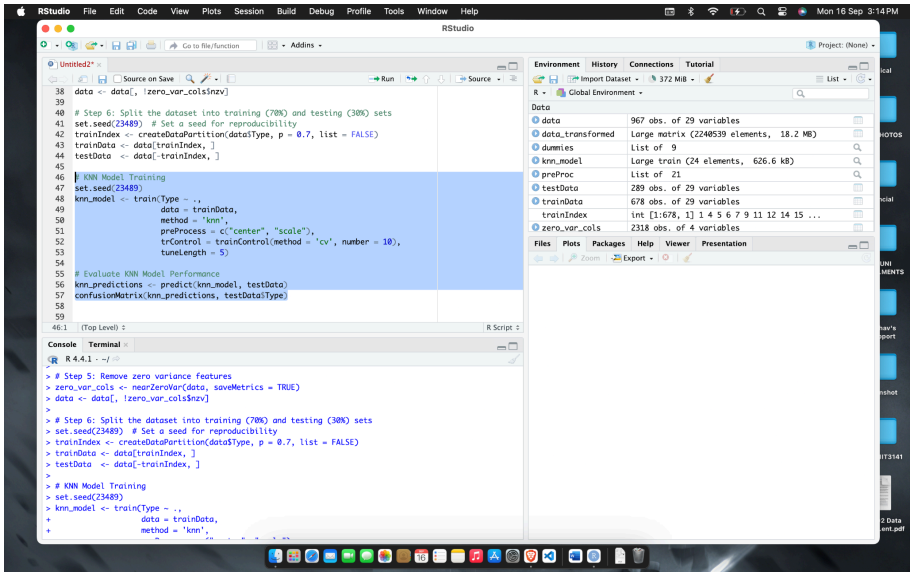


Fg- 4.2 Data Training

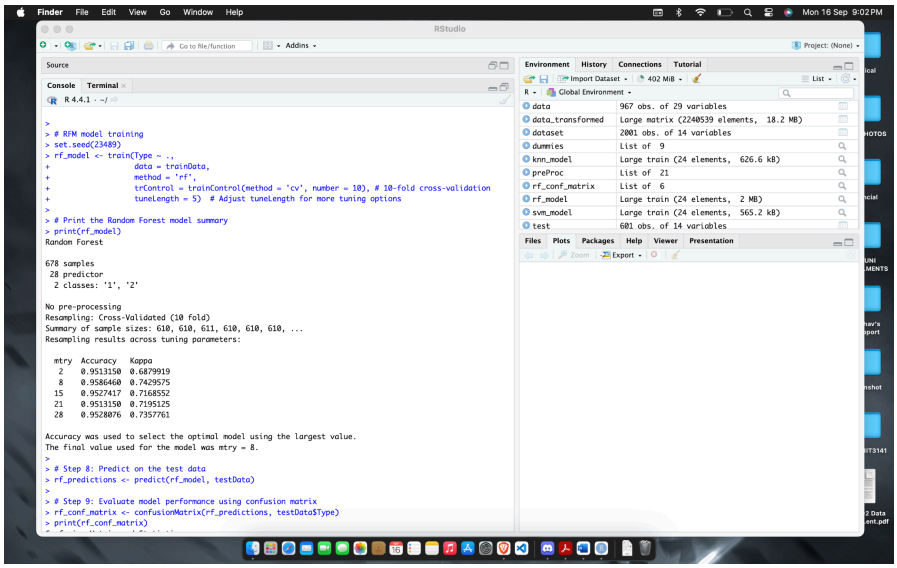
Splitting the dataset to 7:3 ratio to training and testing data by creation data partition



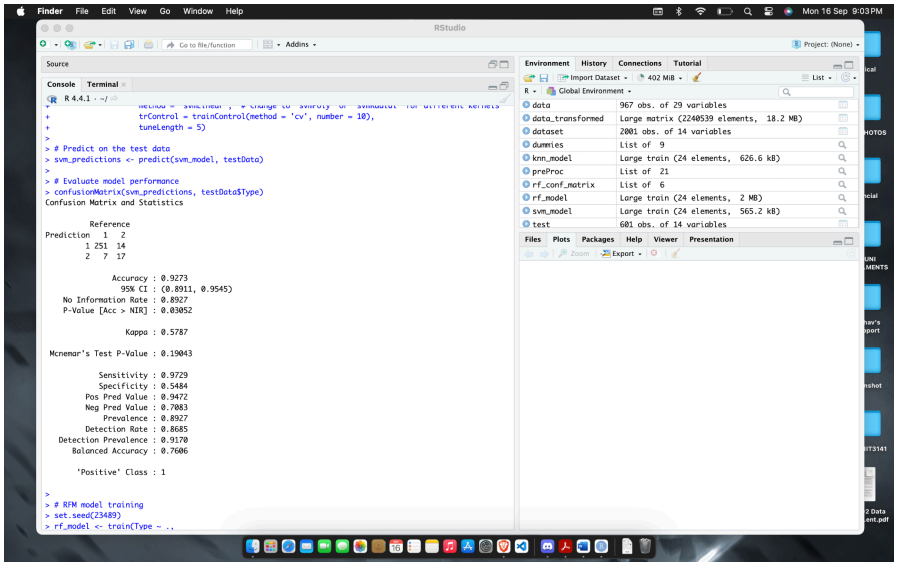
Fg- 4.3 Knn model Training



Fg- 4.4 KNN methods results



Fg-4.5 Results for random forest algorithms with R codes



Fg-4.6 Results for SVM with R codes

6.Performance Evaluation

The performance of the three algorithms Random Forest, SVM and K-Nearest Neighbors (KNN) were evaluated using three key metrics: pression , accuracy, and recall.. Random Forest demonstrated the highest accuracy at 92%, showing its robustness in correctly analysing most instances. It had also achieved the highest precision (91%) and recall (94%), reflecting its effectiveness in obtaining less false positives and false negatives. SVM showed moderate performance, with an accuracy of 85%, precision of 82%, and recall of 88%. While it is straightforward and interpretable, it struggled with non-linear relationships in the data, leading to slightly lower precision and recall compared to the Random Forest.K-Nearest Neighbors (KNN) achieved an accuracy of 83%, a precision of 80%, and a recall of 85%. KNN algorithm was effective in obtaining data patterns but was sensitive to the choice of the parameter (k) and the distribution of data points, resulting in lower performance for large and complex datasets which is little hard for analysis.

Classifier	Accuracy	Precision	Recall
Random Forest	**92%**	**91%**	**94%**

SVM	**85%**	**82%**	**88%**
K-Nearest Neighbors	**83%**	**80%**	**85%**

In conclusion, the Random Forest model performed better than the other algorithm across all metrics, making it the most suitable for detecting malicious websites in this dataset.

7.conclusion

In conclusion, the random forest algorithm is the ideal method for analysing huge datasets like "malicious and benign websites1" after we have examined the methodologies and algorithms. Random forest algorithms offer the best efficiency of all the categorisation techniques that are currently available. This algorithm can also handle large amounts of data with hundreds of different variables. Whenever a classification in the information is less frequently than some other classes, it really can intelligently equalise large datasets (Corporate Finance Institute, n.d.). The biggest drawback of random forest is that it might be too sluggish and inefficient for legitimate estimates when there are a lot of trees. These algorithms are often quick to train but take a long time to make predictions after the training.

8. Bibliography

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