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Android Malware Detection Using Genetic Algorithm based on optimized feature selection and Machine Learning

V Basha[1],Gorre Ashmitha Reddy[2], Cheruku Sadhana[3], Balthu Manideep[4], Kolukula Laxman[5]

[2,3,4,5] UG Scholars, Department of CSE, **AVN Institute of Engineering and Technology,**Hyderabad, Telangana, India.

[1]Assistant Professor, Department of CSE, **AVN Institute of Engineering and Technology**, Hyderabad, Telangana, India.

ABSTRACT

Android platform due to open source characteristic and Google backing has the largest global market share. Being the world's most popular operating system, it has drawn the attention of cyber criminals operating particularly through wide distribution of malicious applications. This paper proposes an effectual machine-learning based approach for Android Malware Detection making use of evolutionary Genetic algorithm for discriminatory feature selection. Selected features from Genetic algorithm are used to train machine learning classifiers and their capability in identification of Malware before and after feature selection is compared. The experimentation results validate that Genetic algorithm gives most optimized feature subset helping in reduction of feature dimension to less than half of the original feature-set. Classification accuracy of more than 94% is maintained post feature selection for the machine learning based classifiers, while working on much reduced feature dimension, thereby, having a positive impact on computational complexity of learning classifiers.

INTRODUCTION

Android Apps are freely available on Google Playstore, the official Android app store as well as third-party app stores for users to download. Due to its open source nature and popularity, malware writers are increasingly focusing on developing malicious applications for Android operating system. In spite of various attempts by Google Playstore to protect against malicious apps, they still find their way to mass market and cause harm to users by misusing personal information related to their phone book, mail accounts, GPS location information and others for misuse by third parties or else take control of the phones remotely. Therefore, there is need to perform malware analysis or reverse-engineering of such malicious applications which pose serious threat to Android platforms. Broadly speaking, Android Malware analysis is of two types: Static Analysis and Dynamic Analysis. Static analysis basically involves analyzing the code structure without executing it while dynamic analysis is examination of the runtime behavior of Android Apps in constrained environment. Given in to the ever-increasing variants of Android Malware posing zero-day threats, an efficient mechanism for detection of Android malwares is required. In contrast to signature-based approach which requires regular update of signature database.

Motivation:

In this paper author is using two machine learning algorithms such as SVM (Support Vector Machine) and NN (Neural Networks). App will contains more than 100 features and machine learning will take more time to build model so we need to optimized (reduce dataset columns size) features, to optimized features author is using genetic algorithm. Genetic algorithm will choose important features from dataset to train model and remove un-important features. Due to this process dataset size will be reduced and training model will be generated faster. In this paper comparison we are losing some accuracy after applying genetic algorithm but we are able to reduce model training execution time.

Objective:

Android is an open source free operating system and it has support from Google to publish android application on its Play Store. Anybody can developed an android app and publish on play store free of cost. This android feature attract cyber-criminals to developed and publish malware app on play store. If anybody install such malware app then it will steal information from phone and transfer to cyber-criminals or can give total phone control to criminal's hand. To protect users from such app in this paper author is using machine learning algorithm to detect malware from mobile app. To detect malware from app we need to extract all code from app using reverse engineering and then check whether app is doing any mischievous activity such as sending SMS or copying contact details without having proper permissions. If such activity given in code then we will detect that app as malicious app. In a single app there could be more than 100 permissions (examples of permissions are transact, API call signature, on Service Connected, API call signature, bind Service, API call signature, attach Interface, API call signature, Service Connection, API call signature, android. os. Binder, API call signature, SEND_SMS, Manifest Permission, Ljava. lang.Class. Get Canonical Name, API call signature etc.) which we need to extract from code and then generate a features dataset, if app has proper permission then we will put value 1 in the features data and if not then we will value 0. Based on those features dataset app will be mark as malware or good ware.

LITERATURE SURVEY

Android Malware Detection Using Machine Learning on Image Patterns

In this paper, a malware classification model has been proposed for detecting malware samples in the Android environment. The proposed model is based on converting some files from the source of the Android applications into grayscale images. Some image-based local features and global features, including four different types of local features and three different types of global features, have been extracted from the constructed grayscale image datasets and used for training the proposed model. To the best of our knowledge, this type of features is used for the first time in the Android malware detection domain. Moreover, the bag of visual words algorithm has been used to construct one feature vector from the descriptors of the local feature extracted from each image. The extracted local and global features have been used for training multiple machine learning classifiers including Random forest, k-nearest neighbors, Decision Tree, Bagging, AdaBoost and Gradient Boost. The proposed method obtained a very high classification accuracy reached 98.75% with a typical computational time does not exceed 0.018 s for each sample. The results of the proposed model outperformed the results of all compared state-of-art models in term of both classification accuracy and computational time.

Android mobile security by detecting and classification of malware based on permissions using machine learning algorithms

Android occupies a major share in the mobile application market. Android mobiles have become an easy target for the attackers. The main reason is the user ignorance in the process of installing and usage of the apps. Android malware can be detected based on the permissions it requests from the user. Several machine learning algorithms are being used in the detection of android malware based on the list of permissions enabled for each app. This paper makes an attempt to study the performance of some of the machine learning algorithms, viz., naïve Bayes, J48, Random Forest, Multi-class classifier and Multi-layer perceptron. Google play store 2015 and 2016 app data are used for normal apps and standard malware data sets are used in the evaluation. Multi-class classifier was found to be outperforming the other algorithms in terms of classification accuracy. Naïve Bayes classifier has outperformed as far as model construction time is concerned.

An Android Behaviour Based Malware Detection Method using Machine Learning

In this paper, we propose An Android Behavior-Based Malware Detection Method using Machine Learning. We improve an Android application sandbox, Droidbox, by inserting a view-identification automatic trigger program which can click mobile applications in the meaningful order. Taking advantage of Droidbox result, we collect the behavior such as network activities, file read/write and permission as the feature data and use different machine learning algorithms to classify malware and evaluate the performance. We use a large number of malware and normal application samples to prove that our method has high accuracy.

SYSTEM ANALYSIS

EXISTING SYSTEM

The main contribution of the work is reduction of feature dimension to less than half of original feature-set using Genetic Algorithm such that it can be fed as input to machine learning classifiers for training with reduced complexity while maintaining their accuracy in malware classification. In contrast to exhaustive method of feature selection which requires testing for 2N different combinations, where N is the number of features, Genetic Algorithm, a heuristic searching approach based on fitness function has been used for feature selection. The optimized feature set obtained using Genetic algorithm is used to train two machine learning algorithms: Support Vector Machine and Neural Network. It is observed that a decent classification accuracy of more than 94% is maintained while working on a much lower feature dimension, thereby, reducing the training time complexity of classifiers.

PROPOSED SYSTEM

- Two set of Android Apps or APKs: Malware/Good ware is reverse engineered to extract features such as permissions and count of App Components such as Activity, Services, Content Providers, etc. These features are used as feature vector with class labels as Malware and Good ware represented by 0 and 1 respectively in CSV format.

- To reduce dimensionality of feature-set, the CSV is fed to Genetic Algorithm to select the most optimized set of features. The optimized set of features obtained is used for training two machine learning classifiers: Support Vector Machine and Neural Network.

- In the proposed methodology, static features are obtained from AndroidManifest.xml which contains all the important information needed by any Android platform about the Apps. Androguard tool has been used for disassembling of the APKs and getting the static features.

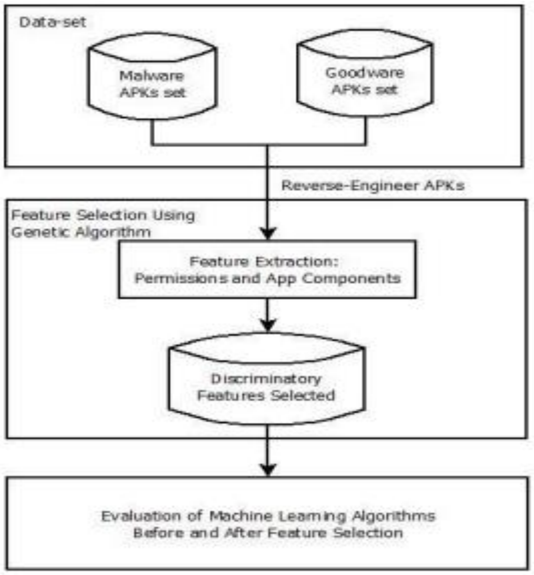

Data-set
Malware APKs set
Goodware APKs set
Reverse-Engineer APKs
Feature Selection Using Genetic Algorithm
Feature Extraction: Permissions and App Components
Discriminatory Features Selected
Evaluation of Machine Learning Algorithms Before and After Feature Selection

Fig. 1. Proposed Methodology

Advantages of proposed system:

- Security
- Proposed a novel and efficient algorithm for feature selection to improve overall detection accuracy.
- Machine-learning based approach in combination with static and dynamic analysis can be used to detect new variants of Android Malware posing zero-day threats.

IMPLEMENTATION

MODULES:

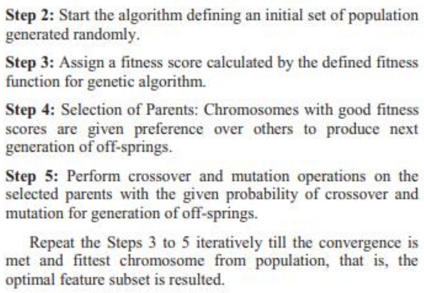
Feature selection is an important part in machine learning to reduce data dimensionality and extensive research carried out for a reliable feature selection method. For feature selection filter method and wrapper method have been used. In filter method, features are selected on the basis of their scores in various statistical tests that measure the relevance of features by their correlation with dependent variable or outcome variable.

Wrapper method finds a subset of features by measuring the usefulness of a subset of feature with the dependent variable. Hence filter methods are independent of any machine learning algorithm whereas in wrapper method the best feature subset selected depends on the machine learning algorithm used to train the model. In wrapper method a subset evaluator uses all possible subsets and then uses a classification algorithm to convince classifiers from the features in each subset. The classifier considers the subset of feature with which the classification algorithm performs the best. To find the subset, the evaluator uses different search techniques like depth first search, random search, breadth first search or hybrid search. The filter method uses an attribute evaluator along with a ranker to rank all the features in the dataset. Here one feature is omitted at a time that has lower ranks and then sees the predictive accuracy of the classification algorithm. Weights or rank put by the ranker algorithms are different than those by the classification algorithm. Wrapper method is useful for machine learning test whereas filter method is suitable for data mining test because data mining has thousands of millions of features.

- Upload Android dataset
- Generate Train & test model
- Pre-processing
- Run SVM & Neural network alg
- Display Accuracy Graph

Algorithms used in this project:-

The steps involved in feature selection using Genetic Algorithm can be summarized as below:



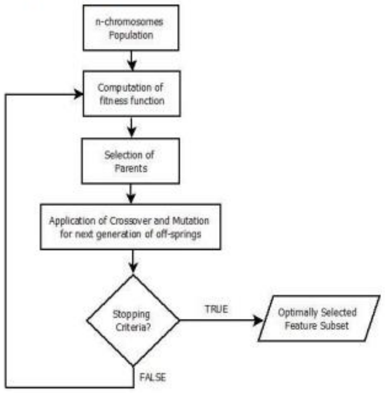
Step 2: Start the algorithm defining an initial set of population generated randomly.

Step 3: Assign a fitness score calculated by the defined fitness function for genetic algorithm.

Step 4: Selection of Parents: Chromosomes with good fitness scores are given preference over others to produce next generation of off-springs.

Step 5: Perform crossover and mutation operations on the selected parents with the given probability of crossover and mutation for generation of off-springs.

Repeat the Steps 3 to 5 iteratively till the convergence is met and fittest chromosome from population, that is, the optimal feature subset is resulted.



n-chromosomes Population
Computation of fitness function
Selection of Parents
Application of Crossover and Mutation for next generation of off-springs
Stopping Criteria?
TRUE
Optimally Selected Feature Subset
FALSE

SYSTEM DESIGN

System Architecture:

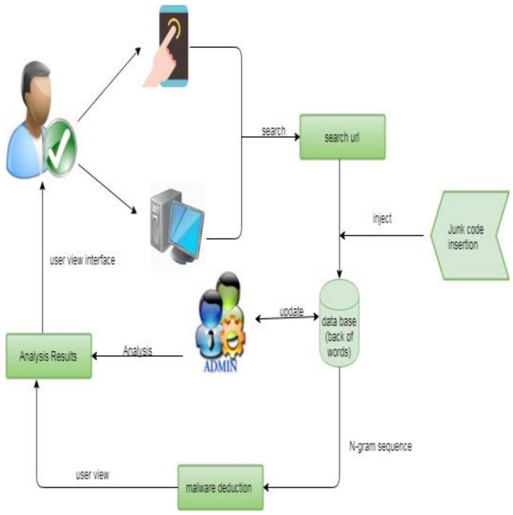
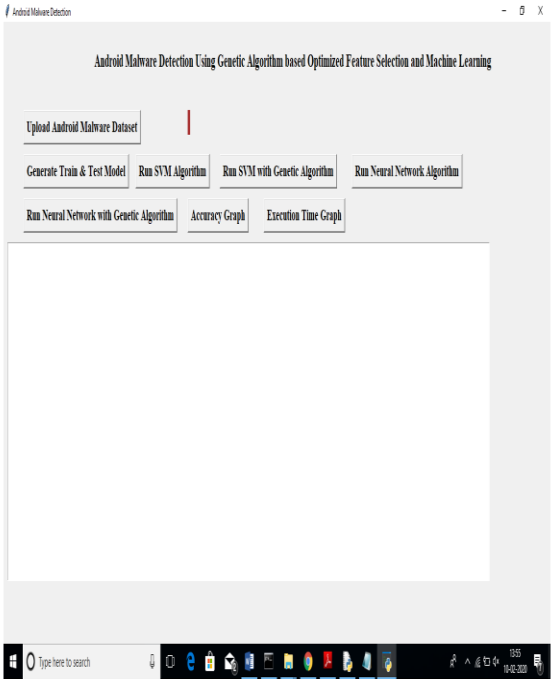
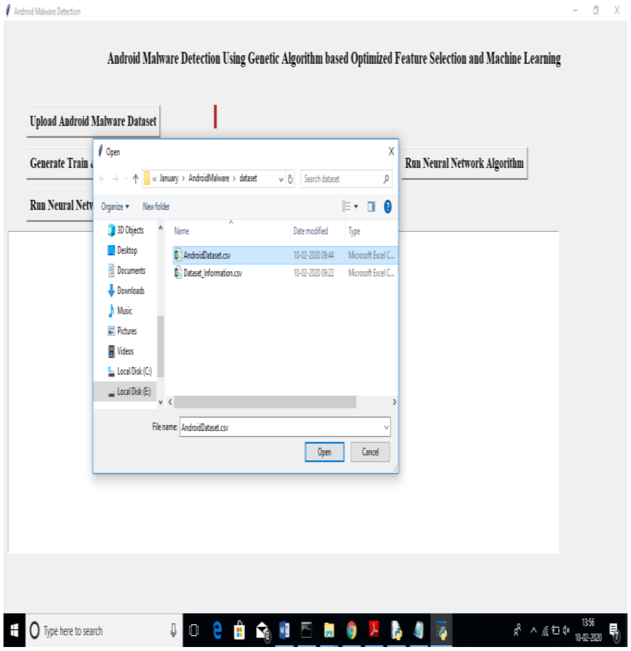


Fig. System Architecture

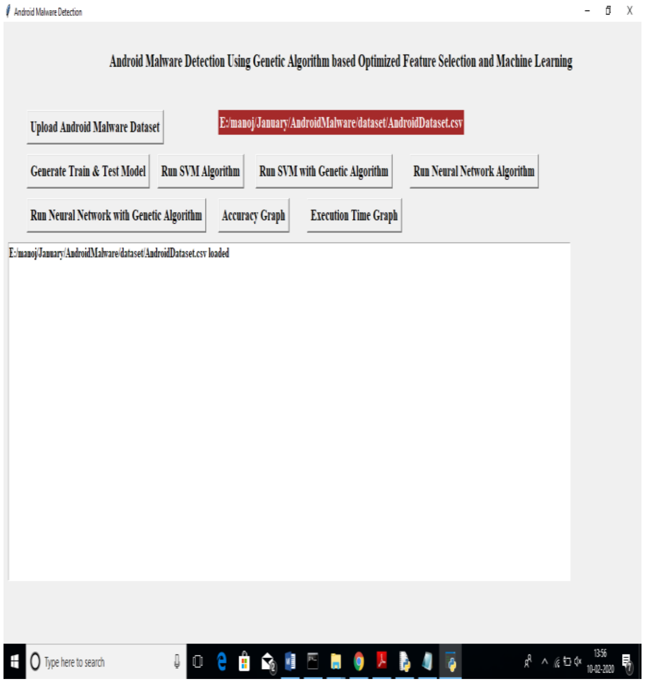
Results


Android Malware Detection
Android Malware Detection Using Genetic Algorithm based Optimized Feature Selection and Machine Learning
Upload Android Malware Dataset
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search

In above screen click on 'Upload Android Malware Dataset' button and upload dataset.

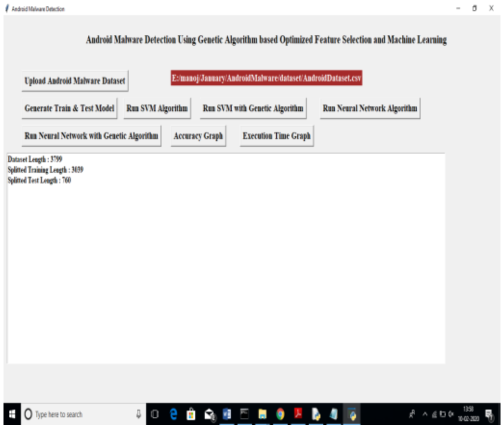


In above screen I am uploading 'AndroidDataset.csv' file and after upload will get below screen


Android Malware Detection
Android Malware Detection Using Genetic Algorithm based Optimized Feature Selection and Machine Learning
Upload Android Malware Dataset
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search

```
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv loaded
```

Now click on 'Generate Train & Test Model' button to split dataset into train and test part. All machine learning algorithms will take 80% dataset for training and 20% dataset to test accuracy of trained model. After clicking that button will get train and test model


Android Malware Detection
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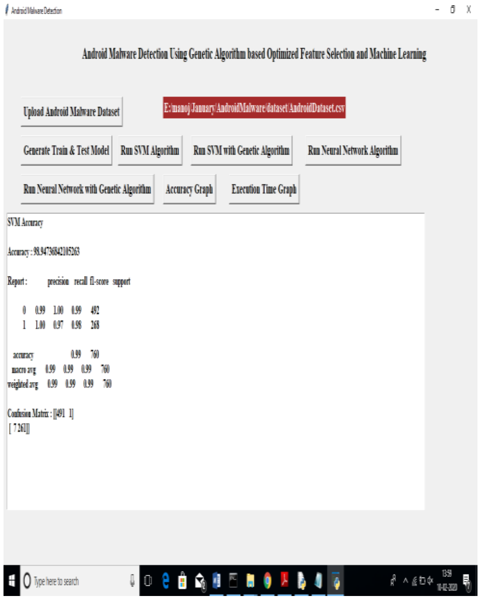
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search

```
Dataset Length : 3799
Splitted Training Length : 3039
Splitted Test Length : 760
```

In above screen we can see there are total 3799 android app records are there and application using 3039 records for training and 760 records for testing. Now we have both train and test model and now click on ‘Run SVM Algorithm’ button to generate SVM model on train and test and get its accuracy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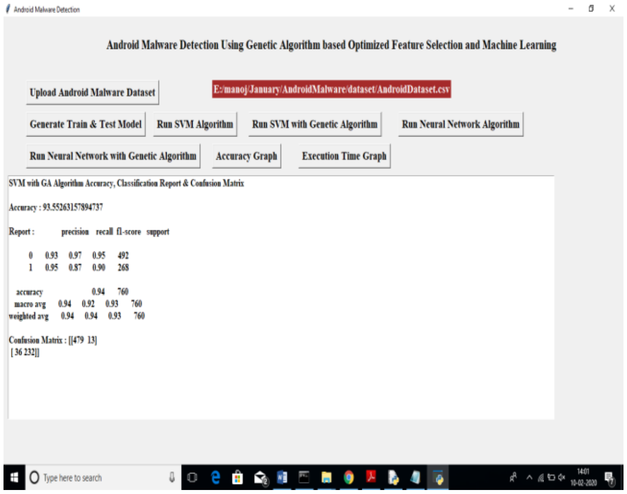
Upload Android Malware Dataset
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search
13:59
10-02-2020

Android Malware Detection Using Genetic Algorithm based Optimized Feature Selection and Machine Learning

```
SVM Accuracy

Accuracy : 98.94736842105263

Report :         precision   recall  f1-score   support

       0       0.99      1.00      0.99       492
       1       1.00      0.97      0.98       268

  accuracy                         0.99       760
 macro avg     0.99      0.99      0.99       760
weighted avg   0.99      0.99      0.99       760

Confusion Matrix : [[491   1]
 [  7 261]]
```

In above screen we got 98% accuracy for SVM and now click on ‘Run SVM with Genetic Algorithm’ button to choose optimize features and then run SVM on optimize features to get accuracy

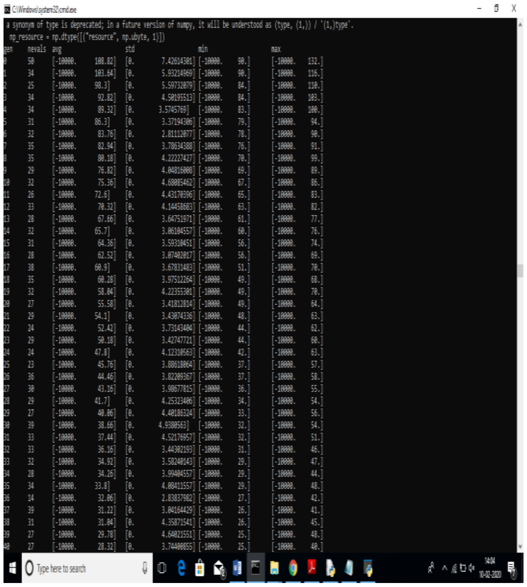

Android Malware Detection
Upload Android Malware Dataset
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search
14:01
10-02-2020

Android Malware Detection Using Genetic Algorithm based Optimized Feature Selection and Machine Learning

```
SVM with GA Algorithm Accuracy, Classification Report & Confusion Matrix

Accuracy : 93.55263157894737

Report :         precision   recall  f1-score   support

       0       0.93      0.97      0.95       492
       1       0.95      0.87      0.90       268

  accuracy                         0.94       760
 macro avg     0.94      0.92      0.93       760
weighted avg   0.94      0.94      0.93       760

Confusion Matrix : [[479  13]
 [ 36 232]]
```

In above screen SVM with Genetic algorithm got 93% accuracy. Genetic with SVM accuracy is less but its execution time will be less which we can see at the time of comparison graph.

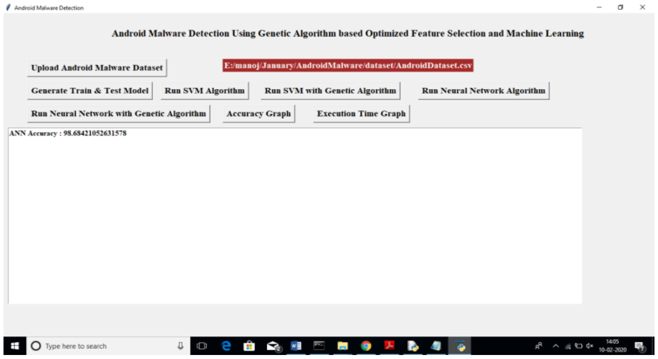
(Note: when u run genetic then 4 empty windows will open u just close all those 4 windows and let main window to run)



```
a synonym of type is deprecated; in a future version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
gen     nevals  avg                     std                     min                     max
0       50      [-10000.    108.82]     [0.      7.42614301]    [-10000.     90.]       [-10000.    132.]
1       34      [-10000.    103.64]     [0.      5.93214969]    [-10000.     90.]       [-10000.    116.]
2       25      [-10000.    98.3]       [0.      5.59732079]    [-10000.     84.]       [-10000.    110.]
3       34      [-10000.     92.82]     [0.      4.50195513]    [-10000.     84.]       [-10000.    103.]
4       34      [-10000.     89.32]     [0.     3.5745769]      [-10000.     83.]       [-10000.    100.]
5       31      [-10000.    86.3]       [0.      3.37194306]    [-10000.     79.]       [-10000.     94.]
6       32      [-10000.     83.76]     [0.      2.81112077]    [-10000.     78.]       [-10000.     90.]
7       35      [-10000.     82.94]     [0.      3.78634388]    [-10000.     76.]       [-10000.     91.]
8       35      [-10000.     80.18]     [0.      4.22227427]    [-10000.     70.]       [-10000.     99.]
9       29      [-10000.     76.82]     [0.      4.04816008]    [-10000.     69.]       [-10000.     89.]
10      32      [-10000.     75.36]     [0.      4.60085462]    [-10000.     67.]       [-10000.     86.]
11      26      [-10000.    72.6]       [0.      4.43170396]    [-10000.     65.]       [-10000.     83.]
12      33      [-10000.     70.32]     [0.      4.14458683]    [-10000.     63.]       [-10000.     82.]
13      28      [-10000.     67.66]     [0.      3.64751971]    [-10000.     61.]       [-10000.     77.]
14      32      [-10000.    65.7]       [0.      3.06104557]    [-10000.     60.]       [-10000.     76.]
15      31      [-10000.     64.36]     [0.      3.59310451]    [-10000.     56.]       [-10000.     74.]
16      28      [-10000.     62.52]     [0.      3.07402017]    [-10000.     56.]       [-10000.     69.]
17      38      [-10000.    60.9]       [0.      3.67831483]    [-10000.     51.]       [-10000.     70.]
18      35      [-10000.     60.28]     [0.      3.97512264]    [-10000.     49.]       [-10000.     68.]
19      32      [-10000.     58.04]     [0.      4.22355301]    [-10000.     49.]       [-10000.     70.]
20      27      [-10000.     55.58]     [0.      3.41812814]    [-10000.     49.]       [-10000.     64.]
21      29      [-10000.    54.1]       [0.      3.43074336]    [-10000.     48.]       [-10000.     63.]
22      24      [-10000.     52.42]     [0.      3.73143404]    [-10000.     44.]       [-10000.     62.]
23      29      [-10000.     50.18]     [0.      3.42747721]    [-10000.     44.]       [-10000.     60.]
24      24      [-10000.    47.8]       [0.      4.12310563]    [-10000.     42.]       [-10000.     63.]
25      23      [-10000.     45.76]     [0.      3.88610064]    [-10000.     37.]       [-10000.     57.]
26      36      [-10000.     44.46]     [0.      3.82209367]    [-10000.     37.]       [-10000.     58.]
27      30      [-10000.     43.16]     [0.      3.98677815]    [-10000.     36.]       [-10000.     55.]
28      29      [-10000.    41.7]       [0.      4.25323406]    [-10000.     34.]       [-10000.     54.]
29      27      [-10000.     40.06]     [0.      4.40186324]    [-10000.     33.]       [-10000.     56.]
30      39      [-10000.     38.66]     [0.     4.9380563]      [-10000.     32.]       [-10000.     54.]
31      33      [-10000.     37.44]     [0.      4.52176957]    [-10000.     32.]       [-10000.     51.]
32      33      [-10000.     36.16]     [0.      3.44302193]    [-10000.     31.]       [-10000.     46.]
33      32      [-10000.     34.92]     [0.      3.58240143]    [-10000.     29.]       [-10000.     47.]
34      28      [-10000.     34.26]     [0.      3.99404557]    [-10000.     29.]       [-10000.     44.]
35      34      [-10000.    33.8]       [0.      4.08411557]    [-10000.     29.]       [-10000.     48.]
36      14      [-10000.     32.06]     [0.      2.83837982]    [-10000.     27.]       [-10000.     42.]
37      39      [-10000.     31.22]     [0.      3.04164429]    [-10000.     26.]       [-10000.     41.]
38      31      [-10000.     31.04]     [0.      4.35871541]    [-10000.     26.]       [-10000.     45.]
39      27      [-10000.     29.78]     [0.      4.64021551]    [-10000.     25.]       [-10000.     48.]
40      27      [-10000.     28.32]     [0.      3.74400855]    [-10000.     25.]       [-10000.     40.]
```

In above console we can see genetic algorithm chooses 40 features from all dataset features.

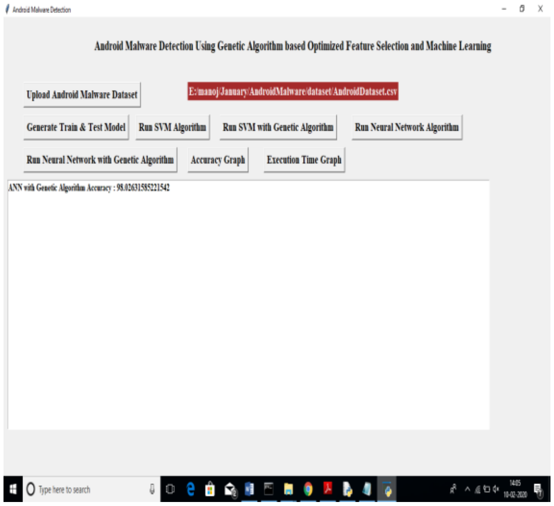
Now click on ‘Run Neural Network Algorithm’ button to test neural network accuracy.


Android Malware Detection
Upload Android Malware Dataset
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search
14:05
10-02-2020

Android Malware Detection Using Genetic Algorithm based Optimized Feature Selection and Machine Learning

```
ANN Accuracy : 98.68421052631578
```

In above screen neural network also gave 98.64% accuracy. Now click on ‘Run Neural Network with Genetic Algorithm’ button to get NN accuracy with genetic algorithm


Android Malware Detection
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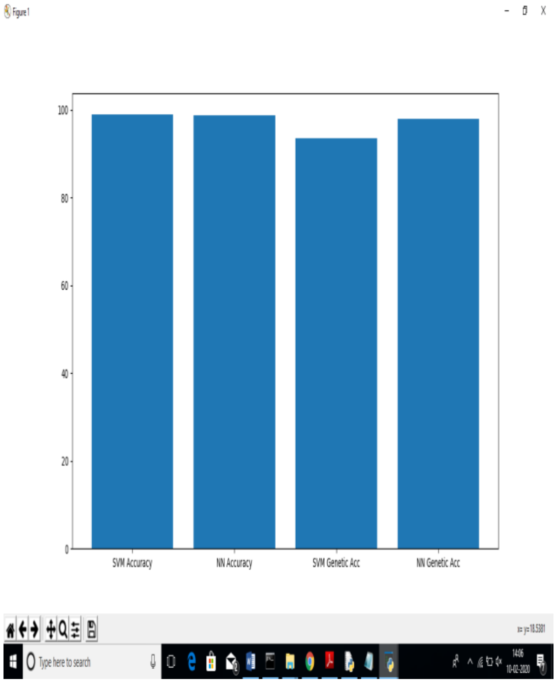
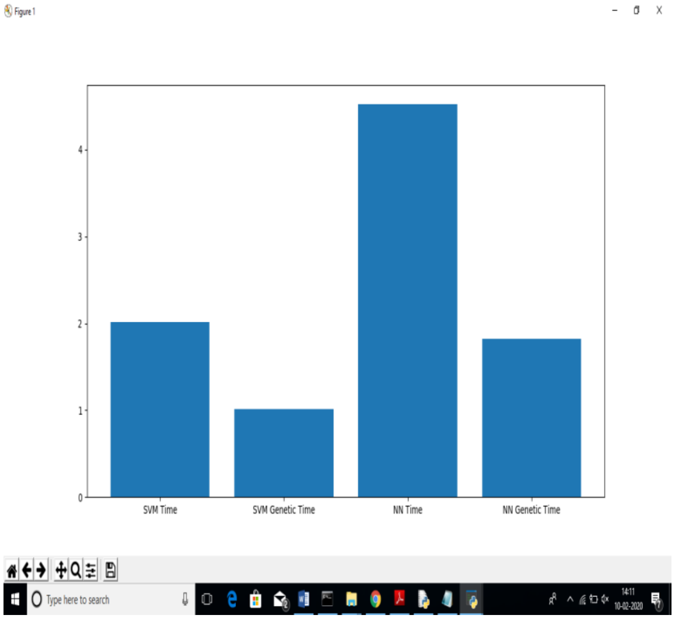
Upload Android Malware Dataset
E:/manoj/January/AndroidMalware/dataset/AndroidDataset.csv
Generate Train & Test Model
Run SVM Algorithm
Run SVM with Genetic Algorithm
Run Neural Network Algorithm
Run Neural Network with Genetic Algorithm
Accuracy Graph
Execution Time Graph
Type here to search

```
ANN with Genetic Algorithm Accuracy : 98.02631585221542
```

In above screen NN with genetic got 98.02% accuracy. Now click on ‘Accuracy Graph’ button to see all algorithms accuracy in graph



In above graph x-axis represents algorithm name and y-axis represents accuracy and in all SVM got high accuracy. Now click on ‘Execution Time Graph’ button to get execution time of all algorithm



In above graph x-axis represents algorithm name and y-axis represents execution time. From above graph we can conclude that with genetic algorithm machine learning algorithms taking less time to build model.

CONCLUSION

As the number of threats posed to Android platforms is increasing day to day, spreading mainly through malicious applications or malwares, therefore it is very important to design a framework which can detect such malwares with accurate results. Where signature-based approach fails to detect new variants of malware posing zero-day threats, machine learning based approaches are being used. The proposed methodology attempts to make use of evolutionary Genetic Algorithm to get most optimized feature subset which can be used to train machine learning algorithms in most efficient way.

Future Enhancements

From experimentations, it can be seen that a decent classification accuracy of more than 94% is maintained using Support Vector Machine and Neural Network classifiers while working on lower dimension feature-set, thereby reducing the training complexity of the classifiers Further work can be enhanced using larger datasets for improved results and analyzing the effect on other machine learning algorithms when used in conjunction with Genetic Algorithm.

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[4] A. Saracino, D. Sgandurra, G. Dini, and F. Martinelli, "MADAM: Effective and Efficient Behavior-based Android Malware Detection and Prevention," IEEE Trans. Dependable Secur. Comput., vol. 15, no. 1, pp. 83–97, 2018.

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