Enhancing Malware Analysis and Detection Using Adversarial Machine Learning Techniques

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Introduction

- Machine learning-driven malware detection systems have demonstrated potential in identifying zero-day malware.
- Existing approaches lack robustness and needs more testing on different types of malware.
- AML attacks can help to determine effectiveness and robustness of a detection system.

Challenges:

- Obfuscated malware can be difficult to catch. Memory forensics is the solution. (VolMemLyzer)
- CIC-MalMem-2022 dataset only covers Spyware, Ransomware, and Trojan Horses.
- ML based malware detection systems have been tested on Windows, but further research is needed on Linux and MacOs to create unification between the systems.

Approach

Phase 1:
Develop and train machine learning based Malware Detection Model:

- Take memory snapshot and extract features.
- Data balancing using SMOTE.
- Split data and input into detection system.
- Binary output (malicious or benign).

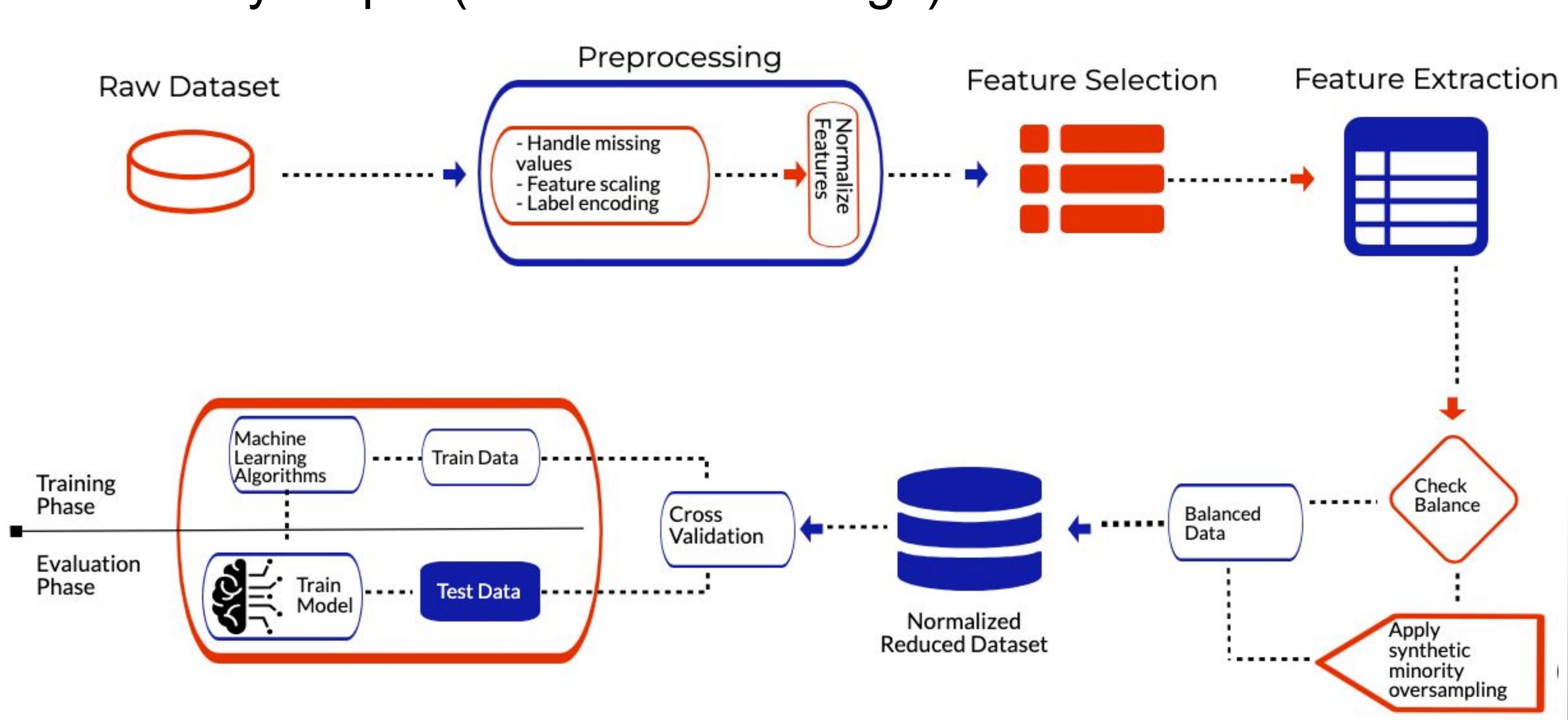


Figure 1: Basic ML based Detection System Workflow

Phase 2:
Attack the detection model using JSMA

- Collect malware binaries to execute on a VM and take memory snapshot.
- VolMemLyzer to extract features to CSV file (new dataset).
- Feed CSV files into the detection model.
- Record performance for analysis in phase 3.

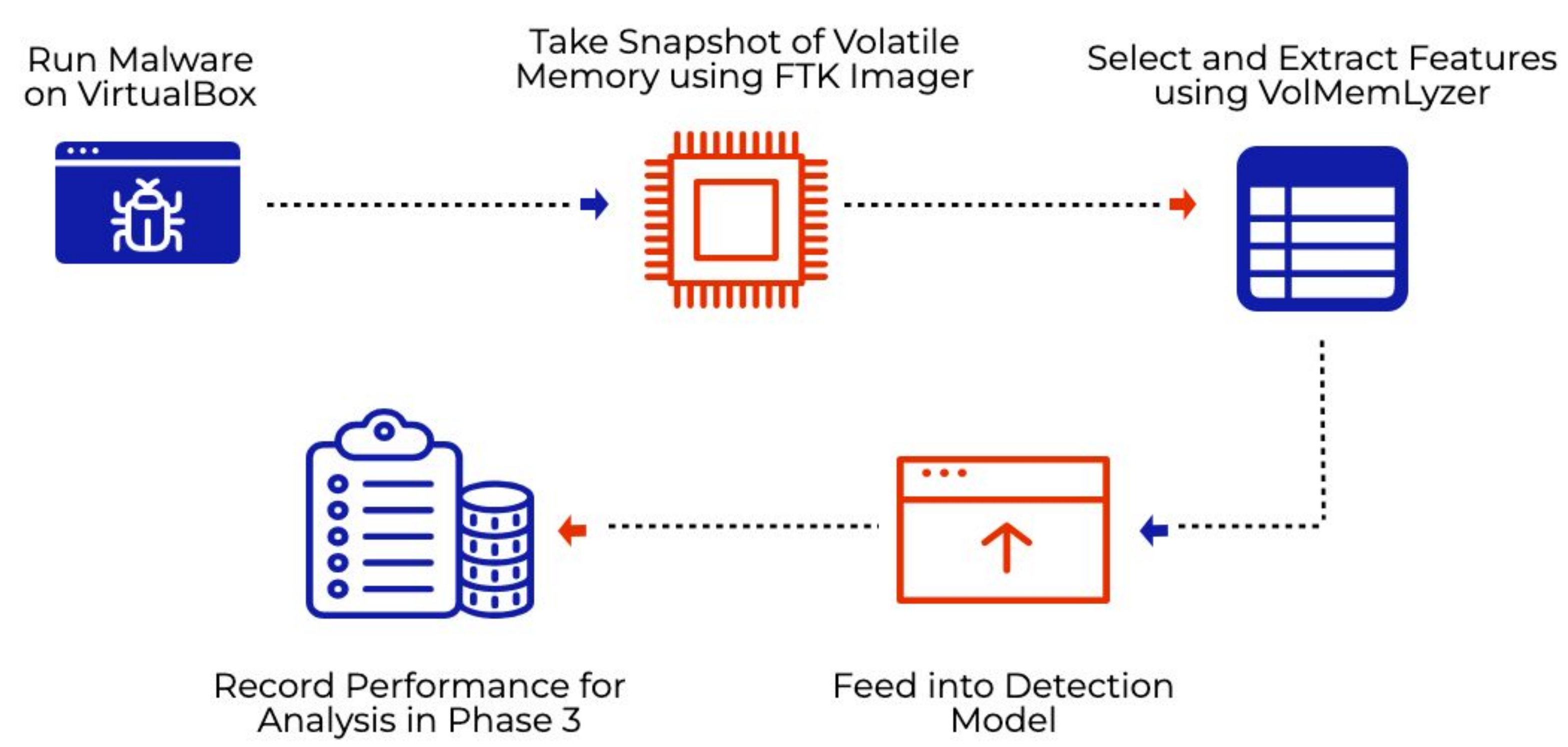


Figure 2: AML Model Workflow

Phase 3: (Future Work)
Analyze model performance and Adversarial Example Transferability

- Robustifying Techniques
  - Defensive Distillation
  - Adversarial Training
- AE Transferability
  - Provides insight into ML models

Tools

python

Volatility

VirtualBox

scikit learn

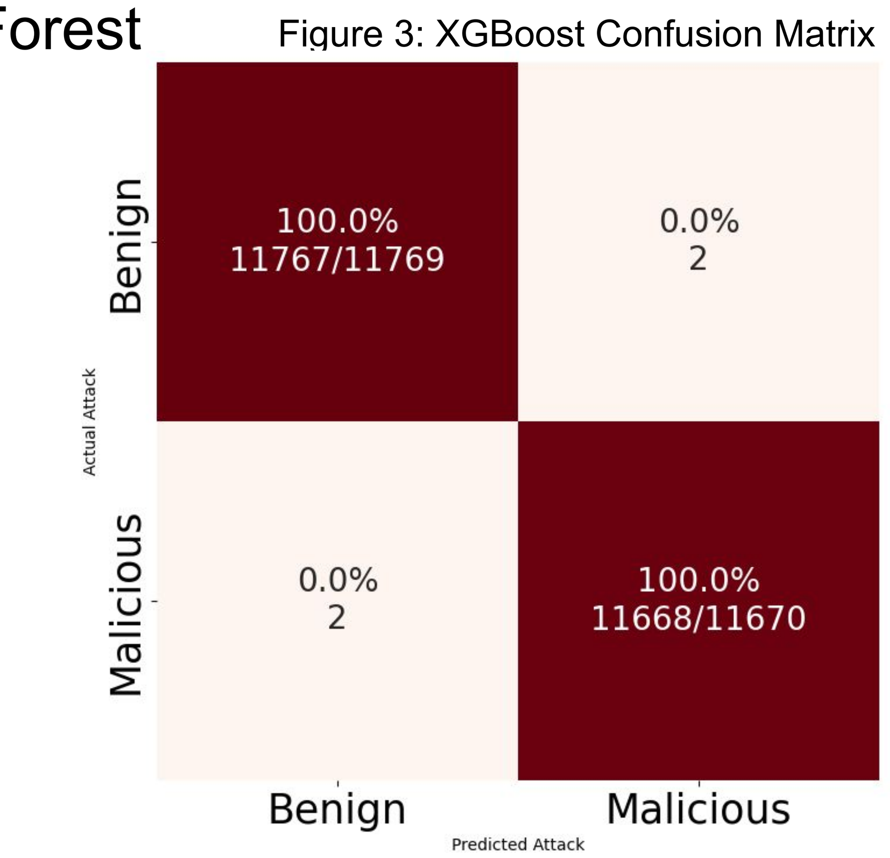
jupyter

exterro FTK® Imager

Results

- Algorithms Tested in Detection Model
  - Decision Trees, Random Forest, LGBM, XGBoost
- Top Performers
  - XGBoost, Random Forest
- Metrics used:
  - 10-fold cross validation
  - accuracy
  - F1 Score
  - FPR
  - sensitivity
  - PPV
  - Cohen kappa
  - specificity
  - MCC

Figure 3: XGBoost Confusion Matrix



Authors	Algorithm	Accuracy (in %)
[1]	RF, DT	92.01, 99.00
[2]	LR	99.97
[3]	KNN w/ Stacked Ensemble	97.00
This study	XGBoost, RF	99.98, 99.98

Table 1: Performance comparison of related works.

Conclusions

- ML based Detection systems are a viable solution to combat zero-day malware, but needs more research.
- The new dataset from Phase 2 will help researchers to robustify their models against many forms of malware.

Future work:

- Defensive Distillation, Adversarial Training
- AE Transferability Problem
- Test model on MacOS and Linux

References
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3. Carrier et al, Detecting obfuscated malware using memory feature engineering. ICISSP, SciTePress (2022), pp. 177-188

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