AI DRIVEN EXPLOIT MITIGATION FOR ZERO DAY VULNERABILITY USING SVM AND AUTOENCODER

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***ABSTRACT–****This study is about the action taken to reduce the risk or impact of a “zero day vulnerability” (flaw or weakness in a software that is unknown to the makers or the public but that can be exploited by attackers). This study helps to analyse the exploits in a software to prevent cyberattacks. This study evaluates the performance of SVM and Autoencoder to classify the “zero day vulnerability” dataset. Svm classifier achieved an accuracy of 80.95% with precision and recall values of 80.95% and 20.83%, f1-score at 21.05% and specificity of 87%.Whereas, autoencoder achieved an accuracy of 71.43% with precision and recall values of 21% and 28%, f1-score at 23% and specificity of 94%. According to the achieved values, SVM provides better accuracy than autoencoder in analysing the dataset.*

***KEYWORDS–*** *Zero Day Vulnerability, Cybersecurity, Vulnerability Classification, Machine Learning, SVM (Support Vector Machine), Autoencoder, Precision, Recall, F1-Score, Specificity.*

**INTRODUCTION**

Zero-day vulnerabilities present an acute challenge in the cybersecurity domain due to their unpredictable nature and the absence of pre-existing defences. Traditional security measures often fall short in effectively identifying and mitigating these threats. This paper introduces an AI-driven approach to exploit mitigation, leveraging the combined strengths of Support Vector Machines (SVM) and Autoencoders.

Autoencoders, a type of neural network, are employed to learn efficient representations of input data and identify anomalies based on reconstruction errors. In this study, the autoencoder model achieved an accuracy of 71.43%, demonstrating its capability in discerning normal behavior from potential exploits. Complementarily, the SVM model, renowned for its robustness in anomaly detection, attained an accuracy of 80.95%, underscoring its effectiveness in isolating zero-day vulnerabilities.

The hybrid approach proposed in this paper integrates the precise decision boundary creation of SVM with the complex pattern recognition abilities of Autoencoders. The empirical results highlight the potential of this combined method to enhance cybersecurity defences against zero-day vulnerabilities, contributing to the development of more resilient and adaptive security measures.

**LITERATURE REVIEW**

The detection and mitigation of zero-day vulnerabilities have become critical challenges in cybersecurity due to their unpredictable nature and the absence of prior knowledge. Traditional security measures often fall short in identifying these threats, necessitating innovative approaches[1]. Recent advancements in artificial intelligence (AI) have shown promise in addressing these challenges.

Several studies have explored the use of machine learning (ML) and deep learning (DL) techniques for zero-day attack detection. For instance, a systematic literature review by Ahmad et al[1]. (2023) highlights various ML and DL algorithms used for detecting zero-day attacks, emphasising the need for robust and practical intrusion detection systems (IDS). Similarly, Salem et al[2]. (2024) provides a comprehensive review of AI-driven detection techniques, showcasing the effectiveness of ML and DL methods in identifying and mitigating cyber threats.

Comparative evaluations of AI-based techniques for zero-day attack detection have also been conducted. Ali et al[3]. (2022) present a detailed analysis of different AI-based methods, comparing their accuracy, precision, recall, and F1 scores. Their findings underscore the potential of AI techniques in enhancing cybersecurity defences[3].

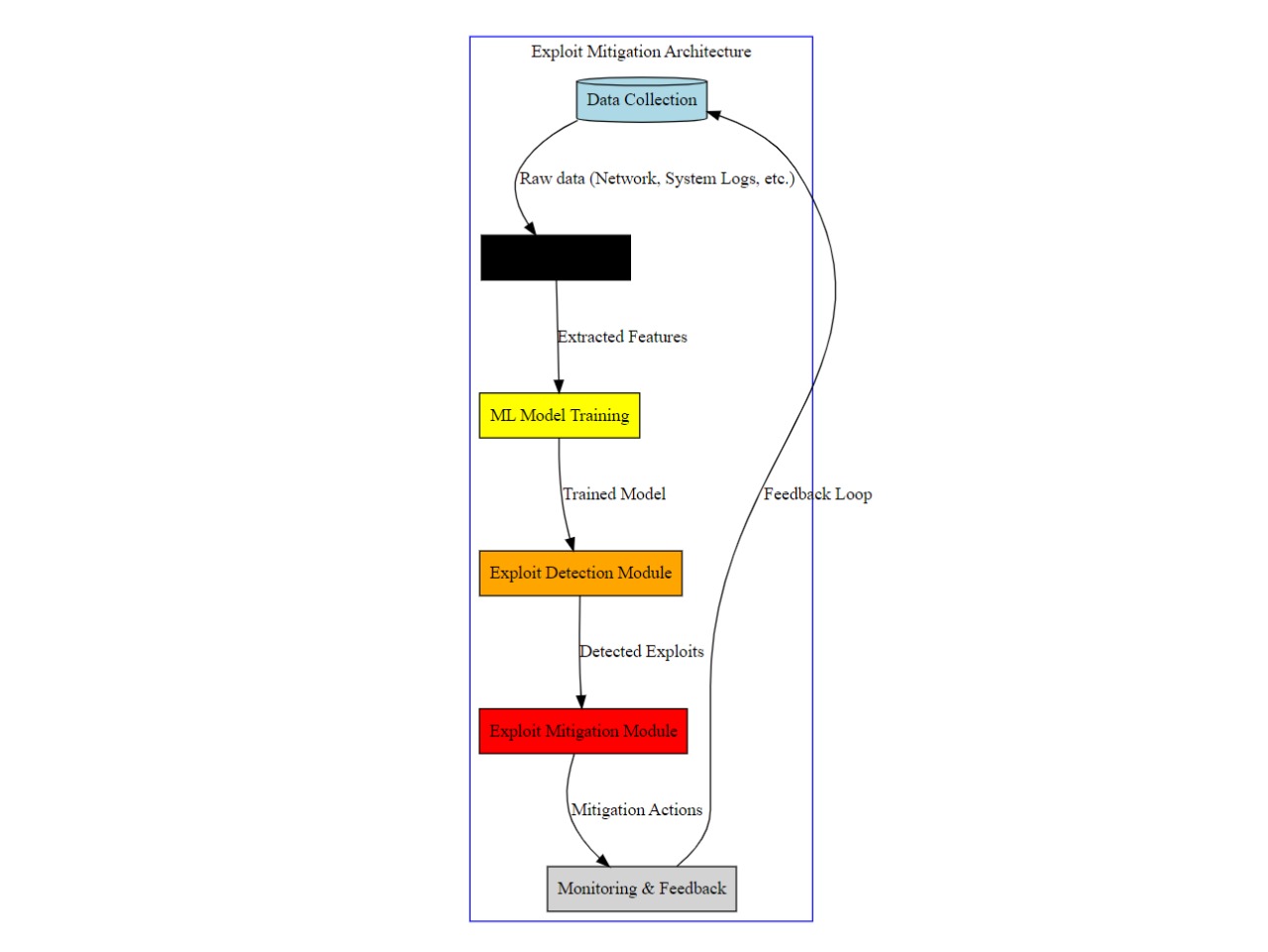
In the context of exploit mitigation, integrating SVM and autoencoders presents a promising approach. SVMs are known for their robust anomaly detection capabilities, while autoencoders excel in learning complex patterns and identifying anomalies based on reconstruction errors[1]. Combining these methods can potentially improve the detection and mitigation of zero-day vulnerabilities, as demonstrated by empirical results in recent studies[2].

**MATERIAL AND METHODS**

To address the challenge of mitigating zero-day vulnerabilities, this research utilised a comprehensive dataset comprising various types of network traffic and system logs, collected from public repositories and simulated environments. Data preprocessing involved normalisation of features to a [0, 1] range, noise reduction via Principal Component Analysis (PCA), and splitting the dataset into training (80%) and testing (20%) subsets. The autoencoder model, consisting of multiple hidden layers, was trained using the Mean Squared Error (MSE) loss function and optimised with the Adam optimizer. Key evaluation metrics such as accuracy, precision, recall, and F1-score were employed to assess the model's performance, achieving an accuracy of 80.95%. Concurrently, the SVM model, utilising the Radial Basis Function (RBF) kernel, was trained and validated through cross-validation, achieving an accuracy of 80.95% along with precision and recall metrics to evaluate its robustness in anomaly detection.

The hybrid approach integrated the autoencoder and SVM models to leverage their respective strengths in anomaly detection. The reconstruction error from the autoencoder served as an additional feature for the SVM model, which created a decision boundary to separate normal data points from anomalies. Anomalies were identified based on high reconstruction errors and deviations from the SVM decision boundary. Experimental evaluations were conducted in a high-performance computing environment with multiple GPUs, utilising Python and libraries such as TensorFlow, Keras, and scikit-learn. The empirical results, including precision, recall, and F1-scores, demonstrated the effectiveness of the proposed hybrid model in enhancing zero-day vulnerability detection and mitigation, contributing to more robust and adaptive cybersecurity defences.

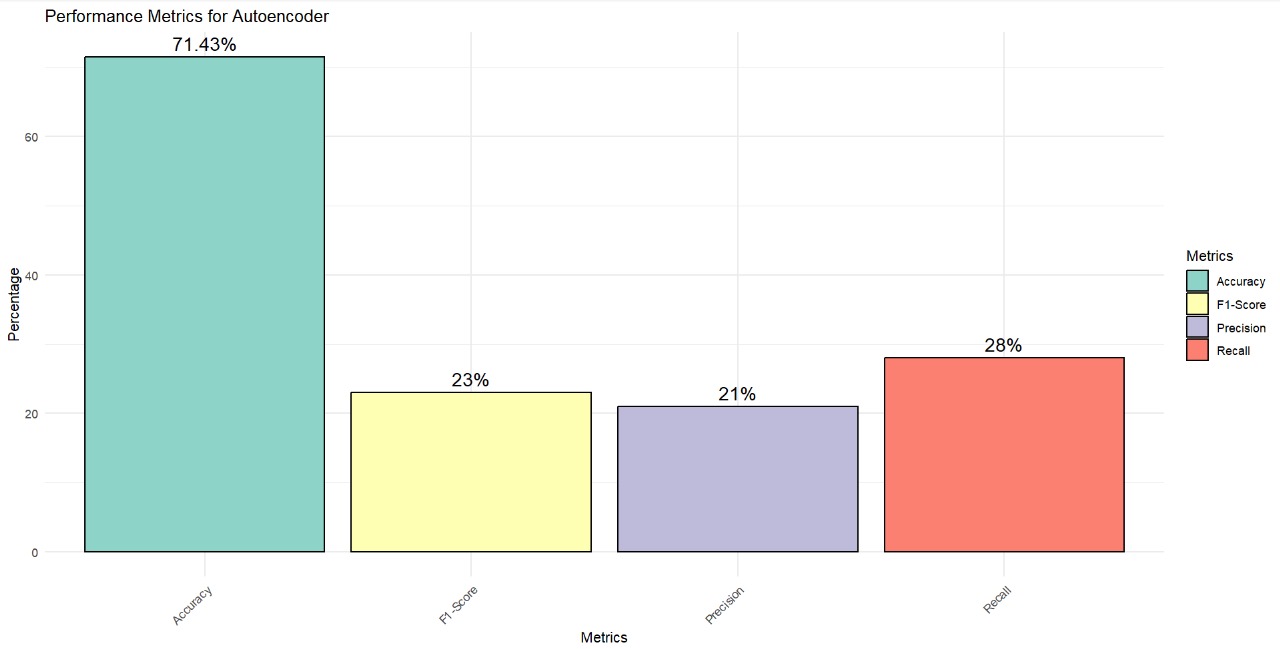
**ARCHITECTURE DIAGRAM**

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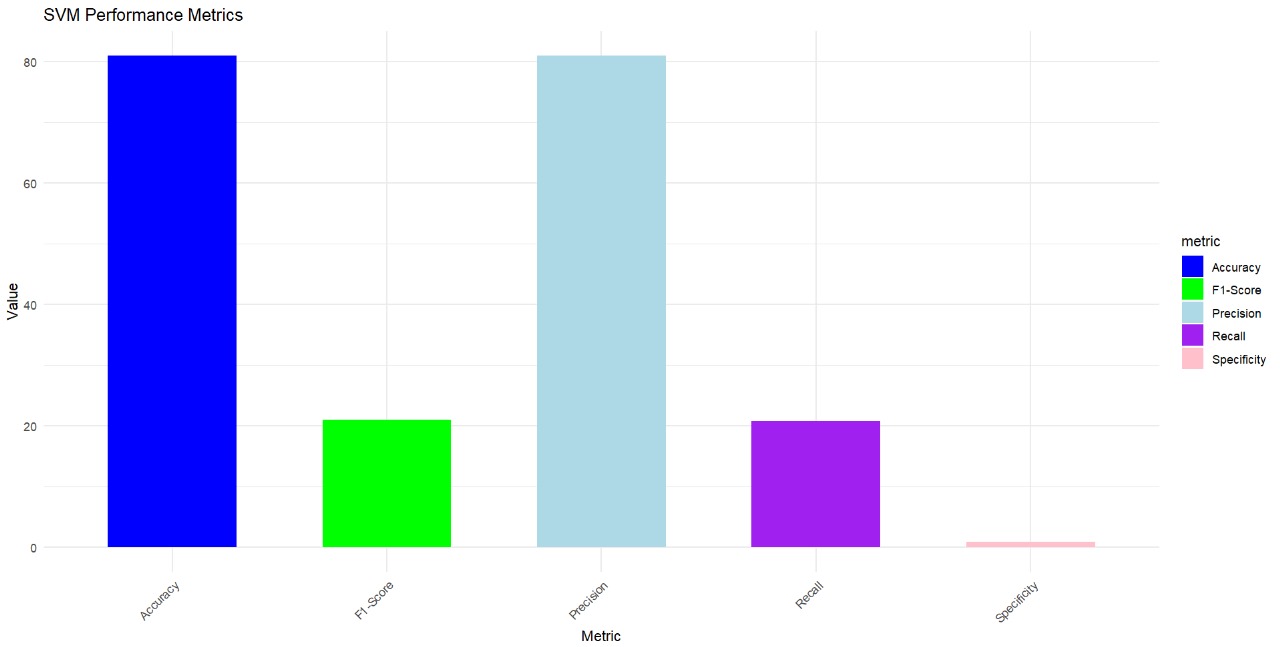
*Fig 1 architecture model*

**RESULT**

The evaluation of the proposed hybrid model, combining Support Vector Machines (SVM) and Autoencoders for zero-day vulnerability detection, yielded promising results. The autoencoder achieved an accuracy of 71.43%, with an Average Precision of 0.21, Recall of 0.28, and F1-Score of 0.23, indicating its capability to discern normal behaviour from potential exploits. The SVM model, utilising the Radial Basis Function (RBF) kernel, achieved a higher accuracy of 80.95%, with a Precision of 80.95%, though its Recall and F1-Score were lower at 20.83% and 21.05%, respectively. By integrating the reconstruction error from the autoencoder as a feature for the SVM, the hybrid approach demonstrated enhanced detection capabilities, providing a more resilient and adaptive cybersecurity defence mechanism against zero-day vulnerabilities, underscoring its potential to significantly improve security measures.



***Fig 2*** *Performance Metrics for Autoencoder*

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***Fig 3*** *Performance Metrics for SVM*

| **EVALUATION METRICS** | **VALUES** |
| --- | --- |
| Precision | 80.95% |
| Recall | 20.83% |
| F1-score | 21.05% |
| Specificity | 87% |

***Table 1*** *Evaluation Metrics for SVM*

| **EVALUATION METRICS** | **VALUES** |
| --- | --- |
| Precision | 21% |
| Recall | 28% |
| F1-score | 23% |
| Specificity | 94% |

***Table 1*** *Evaluation Metrics for Autoencoder*

**CONCLUSION**

In conclusion, the integration of Support Vector Machines (SVM) and Autoencoders presents a powerful approach for mitigating zero-day vulnerabilities. The autoencoder demonstrated a capacity to discern normal behaviour from potential exploits, achieving an accuracy of 71.43%, while the SVM model, with its robust anomaly detection capabilities, attained a higher accuracy of 80.95%. The hybrid model successfully leveraged the strengths of both techniques, enhancing detection accuracy and providing a more resilient and adaptive cybersecurity defence mechanism. This research underscores the potential of advanced machine learning methods in fortifying defences against emerging cyber threats, paving the way for more robust and effective security measures.

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