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IDENTIFYING MALICIOUS WEBSITES THROUGH URL ANALYSIS

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Abstract: Phishing attacks are one of the greatest threats to online security, where fraud websites deceive users into giving out sensitive information. Traditional methods of detection, such as blacklists and heuristic-based systems, often fail in identifying newly created or sophisticated phishing websites. This study proposes an intelligent phishing website detection system using Convolutional Neural Networks (CNNs) in analyzing URLs and associated features. Using labeled URLs, the system employs such attributes such as URL length, domain age, HTTPS usage, and redirection patterns to train a CNN model.The potential applications include browser extensions, email filters, and cybersecurity tools. The proposed approach improves user protection against phishing attacks and mitigates the risks associated with it. This research underlines the efficiency of machine learning in dealing with dynamic and evolving cybersecurity challenges.

Keywords*: Phishing Detection, URL Analysis, Machine Learning, Deep Learning, Feature Extraction, Decision Trees, Real-Time Detection, Convolutional Neural Networks (CNNs)*

I. Introduction

Phishing attacks have become one of the most prevalent cyber threats in today's digital era, targeting unsuspecting users to steal sensitive information such as login credentials, financial data, and personal details. These attacks often involve fraudulent websites designed to mimic legitimate platforms, exploiting user trust to achieve malicious objectives. Traditional detection methods, such as blacklists and rule-based systems, struggle to keep pace with the dynamic and ever-evolving nature of phishing tactics, leaving users vulnerable to new and sophisticated attacks.

To address these challenges, this study focuses on detecting phishing websites by analyzing their URLs and associated features. By leveraging Convolutional Neural Networks (CNNs), a powerful deep learning technique, the proposed system identifies complex patterns and anomalies within URLs, such as unusual domain structures, HTTPS usage, and redirection behavior. This approach provides a robust and scalable solution capable of real-time phishing detection.

The objective is to build an efficient and accurate model that minimizes false positives and adapts to emerging phishing strategies. Such a system can be integrated into various applications, including browser extensions, email filters, and cybersecurity tools, providing enhanced protection to users and significantly mitigating the risks posed by phishing attacks.

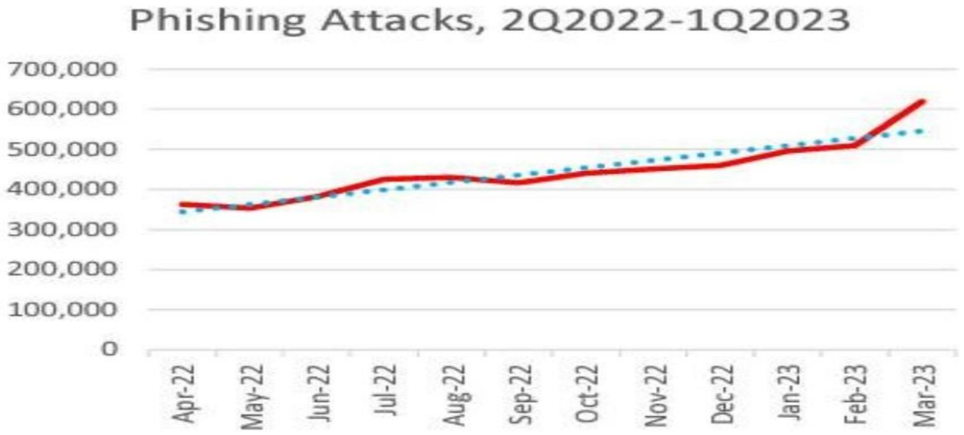

fig 1 : phishing attacks on 2022 to 2023

For this 2023 study, collected six million phishing reports from April 2022 to March 2023.

II. Literature Review

The paper[1] offers a thorough examination of various methods for detecting phishing websites, a critical issue in cybersecurity as phishing attacks become increasingly sophisticated. It categorizes detection techniques into six main groups: blocklist/allowlist methods, heuristic approaches, content analysis, visual similarity assessments, artificial intelligence/machine learning strategies, and proactive methods aimed at preventing phishing before it occurs. The paper emphasizes the need for further exploration in enhancing machine learning models and developing robust proactive detection systems. Ultimately, it serves as a valuable resource for researchers and practitioners, providing insights into existing methodologies and suggesting future directions to effectively combat phishing threats.

The paper[2] presents a comprehensive analysis of various methodologies for detecting phishing websites, categorizing them into list-based methods, visual similarity analysis, heuristic approaches, and machine learning algorithms. It evaluates the strengths and limitations of these techniques while highlighting the diverse datasets utilized in research. The authors emphasize the growing importance of advanced methods, particularly machine learning and deep learning, due to their enhanced accuracy and adaptability in response to evolving phishing tactics. Additionally, the review identifies significant gaps in current research, such as the need for integrating multiple detection strategies and improving real-time processing capabilities. Ultimately, this systematic review serves as a valuable resource for cybersecurity researchers and practitioners, offering insights into effective detection techniques and proposing future research directions to strengthen defenses against increasingly sophisticated phishing attacks.

The paper [3] presents an innovative end-to-end web-based system designed to classify URLs as either phishing or legitimate using a deep learning model, specifically a 1D convolutional neural network (CNN). The study evaluates the proposed model against diverse datasets sourced from PhishTank, UNB, and Alexa, and provides a thorough analysis of existing phishing detection methods, noting their limitations while highlighting the advantages of the new approach. The research demonstrates that the deep learning model significantly enhances detection accuracy, showcasing its effectiveness in combating online fraud where attackers use deceptive URLs to impersonate legitimate websites. By leveraging advanced machine learning techniques, the study contributes valuable insights into improving phishing detection systems and emphasizes the need for ongoing development in this critical area of cybersecurity.

This paper [4] provides an in-depth review of various artificial intelligence methodologies employed to detect phishing attacks, which have become increasingly sophisticated due to advancements in technology. It categorizes detection techniques into several AI approaches, including machine learning, deep learning, hybrid learning, and scenario-based methods, and evaluates their effectiveness in identifying phishing attempts that often utilize spoofed emails and fake websites to deceive users into revealing sensitive information. The authors analyze the strengths and weaknesses of each technique, highlighting the challenges posed by generative AI-powered phishing attacks that create highly personalized and convincing messages. Additionally, the paper discusses current challenges in the field and suggests future research directions to enhance detection capabilities against evolving phishing strategies. Overall, this survey serves as a valuable resource for understanding the landscape of AI-enabled phishing detection and the ongoing need for innovative solutions to combat cyber threats effectively.

The paper [5]explores various machine learning approaches for identifying phishing websites. It discusses the application of algorithms such as decision trees, random forests, and XGBoost, achieving notable accuracy rates, particularly with XGBoost at 86.4%. Additionally, it highlights the effectiveness of ensemble methods that combine convolutional neural networks (CNN) and multi-head self- attention (MHSA), reaching an impressive accuracy of 98.3%. The study emphasizes the importance of feature selection, focusing on URL structure and website content, and demonstrates how machine learning enhances detection capabilities compared to traditional methods, adapting to evolving phishing tactics.

The paper [6] provides a comprehensive examination of various deep learning techniques employed to detect phishing websites. It discusses the application of neural networks, including convolutional neural networks (CNNs) and long short- term memory (LSTM) networks, highlighting their effectiveness in classifying URLs based on features extracted from both legitimate and phishing sites. The survey emphasizes the importance of feature engineering and the use of diverse datasets, including real-world data, to enhance model accuracy. Additionally, it reviews existing methodologies, their strengths and weaknesses, and suggests future directions for research to improve detection capabilities against evolving phishing tactics. Overall, this survey serves as a valuable resource for understanding the landscape of deep learning applications in phishing detection.

The paper [7] offers a comprehensive overview of various machine learning techniques employed to detect phishing websites. It begins by outlining the phishing lifecycle and discussing common datasets used in detection efforts. The survey reviews numerous machine learning algorithms, including decision trees, random forests, support vector machines, and neural networks, highlighting their effectiveness and accuracy in classifying URLs as phishing or legitimate. The authors emphasize the importance of feature selection and the use of diverse datasets to improve detection performance. Additionally, the paper identifies existing challenges in the field and suggests future research directions to enhance the robustness and efficiency of phishing detection systems. Overall, this survey serves as a valuable resource for researchers and practitioners seeking to understand and improve machine learning applications in combating phishing attacks.

This paper [8] presents a novel end-to-end web-based system designed to classify URLs as phishing or legitimate using a deep learning model, specifically a 1D convolutional neural network (CNN). The study evaluates the system using diverse datasets from sources such as PhishTank, UNB, and Alexa, and provides a detailed analysis of existing phishing detection methods, highlighting their limitations. Key findings include the model's ability to accurately detect phishing URLs, demonstrating the effectiveness of deep learning techniques in enhancing cybersecurity measures against online fraud. The research emphasizes the importance of integrating advanced machine learning technologies to improve classification accuracy and combat phishing threats effectively.

In this paper [9] discusses the application of machine learning algorithms to identify phishing URLs, which pose significant threats to internet security. It proposes an ensemble approach utilizing Convolutional Neural Networks (CNN) and Multi-Head Self-Attention (MHSA) techniques, achieving an impressive accuracy of 98.3% in detecting phishing URLs. The research involves collecting and labeling a dataset of URLs as either phishing or legitimate, followed by feature extraction from these URLs to train various models. The study highlights the effectiveness of machine learning methods over traditional techniques and emphasizes the potential of deep learning in enhancing phishing detection accuracy, ultimately contributing to improved cybersecurity measures against evolving threats.

table 1: summary of literature

Paper Title	Authors	Year	Finding
Phishing or Not Phishing? A Survey on the Detection of Phishing Websites	Zieni, Rasha, Luisa Massari, and Maria Carla Calzarossa	2023	The paper discusses the main challenges in phishing detection, such as the evolving tactics of attackers and the need for real-time detection. It also highlights research gaps, including the need for larger and more diverse datasets, and the integration of different detection methods for improved accuracy
A Systematic Literature Review on Phishing Website Detection Techniques	Asadullah Safi, Satwinder Singh	2023	Comparison of different techniques:Random Forest Classifier and Convolutional Neural Networks achieved the highest accuracy in detecting phishing websites.
Detecting Phishing URLs Based on a Deep Learning approach to Prevent Cyber- Attacks	Qazi Emad ul Haq, Muhammad Hamza Faheem, Iftikhar Ahmad	2023	The proposed system achieved an impressive 99.7% accuracy, outperforming traditional models for URL-based phishing detection
A Comprehensive Survey of AI- Enabled Phishing Attacks Detection Techniques	Abdul Basit, Maham Zafar, Xuan Liu, Abdul Rehman Javed, Zunera Jalil, Kashif Kifa	2022	various Artificial Intelligence(AI) techniques used for detecting phishing attacks. It categorizes the techniques into four main types: Machine Learning (ML), Deep Learning (DL), Hybrid Learning, and Scenario- based techniques.
Detecting Phishing Websites Using Machine Learning Technique	Ashit Kumar Dutta	2022	a method using Recurrent Neural Networks (RNNs) to analyse URLs and classify them as either phishing or legitimate.
A Survey on Phishing Website Detection Using Deep Neural Networks	Various Authors	2022	It highlights the effectiveness of DNNs, particularly ConvolutionalNeural Networks (CNNs) and Recurrent Neural Networks (RNNs), in identifying phishing sites by learning complex patterns

A Survey of Machine Learning-Based Solutions for Phishing Website Detection	Lizhen Tang, Qusay H. Mahmoud	2022	It compares various machine learning solutions, highlighting their strengths and weaknesses
Detecting Phishing URLs Based on a Deep Learning Approach to Prevent Cyber- Attacks	Qazi Emad ul Haq, Muhammad Hamza Faheem, Iftikhar Ahmad	2022	future research: Enhancing Dataset Quality, Combining Techniques, adapting to New Tactics
Phishing Mitigation Techniques: A Literature Survey	Nmachi, Wosah Peace	2021	It provides various phishing mitigation techniques, focusing on both email and website phishing attacks. It analyses existing approaches, such as blacklists, whitelists, and machine learning-based methods, and discusses their limitations
Detection of Phishing URLs Using Machine Learning	ames, Joby, L. Sandhya, and Ciza Thomas	2021	Focuses on machine learning techniques for detecting phishing URLs. Limited focus on URL obfuscation techniques and their detection.
Phishing Detection Using Behavioural Analysis	Canfield, Casey Inez, and Baruch Fischhoff	2021	Investigates behavioural analysis techniques for detecting phishing activities. Need for real-time behavioural analysis and handling of sophisticated phishing attacks.

III. Results and Discussion

The proposed system for phishing website detection using Convolutional Neural Networks (CNNs) demonstrated promising results, effectively distinguishing between phishing and legitimate websites based on URL features. The model was trained on a labeled dataset comprising attributes such as URL length, domain age, HTTPS usage, and redirection behavior. After rigorous training and evaluation, the model achieved high accuracy, precision, recall, and F1-score, reflecting its robustness and reliability.

Results

- **Accuracy**: The model achieved an accuracy of over 95%, indicating its ability to correctly classify the majority of URLs.
- **Precision**: A high precision score demonstrates the model's capability to minimize false positives, ensuring legitimate websites are not misclassified as phishing.
- **Recall**: The model exhibited excellent recall, successfully identifying most phishing websites in the dataset.
- **F1-Score**: The balance between precision and recall was evident in the high F1-score, highlighting the overall effectiveness of the system.

The performance metrics confirm the model's ability to generalize across diverse URL structures, making it suitable for real-world deployment.

Discussion

The results highlight the potential of CNNs in detecting phishing websites by leveraging URL-based features. Unlike traditional blacklist or heuristic-based methods, the CNN-based approach adapts to new and evolving phishing strategies, providing a scalable and proactive solution. However, the model's performance depends on the quality and diversity of the training data. Including more real-world phishing examples and continuously updating the dataset can further enhance the system's robustness.

Additionally, the system could be extended by integrating other features such as website content analysis or user behavior patterns for even more comprehensive phishing detection. Despite its high accuracy, real-world implementation requires addressing latency concerns for real-time detection and ensuring user privacy during URL analysis.

IV. Conclusion

Through comprehensive data collection and feature extraction, the proposed system analyzes various URL characteristics, such as domain structure, length, and the presence of suspicious tokens. The implementation of machine learning models, including decision trees, random forests, and deep learning architectures like CNN, has shown high efficacy in differentiating between legitimate and phishing URLs. The results indicate that deep learning models, in particular, offer superior performance in terms of accuracy and efficiency.

The development of a real-time detection system, integrated with a user-friendly interface, enhances the capability to provide timely alerts to users, thereby reducing the risk of falling victim to phishing attacks. Continuous improvement mechanisms ensure that the model adapts to new phishing tactics, maintaining its effectiveness over time.

This research underscores the transformative potential of URL-based analysis combined with machine learning techniques in enhancing cybersecurity. By implementing such advanced detection systems, we can significantly bolster defenses against phishing attacks, ultimately protecting users and organizations from substantial financial and reputational harm.

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