Detecting Phishing Domains, Which Imitate the Look and Feel of Genuine Domains

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Abstract. Phishing attacks are an increasingly common cyber threat that exploit the trust users place in genuine websites by mimicking their look and feel. This research proposes a novel AI-based detection system designed to identify phishing domains that imitate authentic websites. Our approach leverages machine learning algorithms to analyze visual similarities, domain patterns, and metadata between phishing and legitimate sites. Through this method, the system detects phishing attempts before users are deceived. Key results indicate a high detection accuracy and a reduction in false positives, which demonstrate the potential of this method for enhancing cybersecurity. Future improvements in real-time detection and integration into security protocols are discussed.

Keywords. Phishing detection, AI/ML, cybersecurity, visual similarity.

INTRODUCTION

Phishing remains one of the most prevalent and dangerous forms of cyberattacks, where attackers create fraudulent websites resembling legitimate domains to deceive users into revealing sensitive information. The growing sophistication of these attacks, particularly in replicating the visual elements and domain structures of authentic websites, has posed significant challenges to traditional detection methods. The need for an intelligent detection system capable of analyzing multiple factors—such as domain name, page layout, and content similarity—has become more critical than ever. Phishing is one of the most prevalent and damaging forms of cyberattacks, where attackers create fraudulent websites that visually resemble legitimate ones to deceive users into divulging sensitive information. These phishing sites often mimic the appearance, structure, and branding of trusted websites, making them difficult to distinguish at first glance. With the increasing sophistication of phishing attacks, traditional detection methods such as blacklists and URL-based filters are becoming less effective. This study explores a machine learning-based approach that analyzes the visual and structural similarities between phishing and legitimate websites to enhance detection accuracy. Traditional phishing detection methods primarily rely on blacklists and rule-based systems that block known phishing URLs. However, these approaches have significant limitations as they can only detect previously identified phishing sites. They are ineffective against new, unlisted phishing domains and those that rapidly change to avoid detection (a tactic known as domain flux). As phishing attacks evolve, the need for more advanced and intelligent detection systems has become evident, prompting researchers to explore machine learning and artificial intelligence-based solutions.

In recent years, the focus has shifted towards leveraging AI and machine learning models to enhance phishing detection systems. These models analyze a variety of features, including domain characteristics, page content, and visual elements of the websites, to identify phishing attempts more accurately. The advantage of these techniques lies in their ability to detect previously unknown phishing sites based on patterns and anomalies in both the structure and presentation of the website. By analyzing the look and feel of websites, machine learning models can capture both surface-level and deep structural features that indicate phishing behavior.

This paper presents a machine learning-based system designed to detect phishing domains by evaluating the look and feel of websites and their associated metadata. Unlike existing approaches, which often rely solely on blacklists or superficial URL analysis, our system delves deeper into the structure and appearance of web pages, thereby improving detection accuracy and reducing false positives.

LITERATURE SURVEY

Several approaches to phishing detection exist, including blacklisting, heuristic analysis, and machine learning models. Early research primarily focused on URL analysis or comparing specific domain attributes. However, recent advances have shifted towards AI-based systems that evaluate the entire look and feel of web pages, including visual and structural components. Notable studies have highlighted the use of Convolutional Neural Networks (CNN) for image-based phishing detection, but these techniques still face challenges with highly sophisticated phishing websites that can dynamically change their appearance.

Phishing attacks have long been a prominent concern in cybersecurity, with early detection systems primarily relying on blacklists that store known phishing URLs. Blacklists, though widely used, have limitations as they cannot detect newly created phishing websites or those that frequently change domains to avoid detection. Studies such as those by Zhang et al. (2007) highlighted that blacklists are effective only against previously identified threats but struggle with zero-day phishing attacks. As phishing techniques evolved, it became necessary to explore more dynamic detection methods that could identify phishing websites in real-time without relying solely on historical data.

Heuristic-based detection emerged as a next step in phishing detection, focusing on analyzing the characteristics of URLs, domain names, and other metadata. For instance, heuristic systems identify suspicious elements in URLs, such as the use of IP addresses instead of domain names, or domain names that closely resemble popular websites (homoglyph attacks). Researchers like Cova et al. (2010) expanded on this by incorporating features such as WHOIS information, SSL certificates, and domain registration dates to predict the likelihood of a website being malicious. While this method improved detection rates, it remained vulnerable to attackers who could mask or manipulate such features, particularly through techniques like domain shadowing and fast-flux hosting.

Visual similarity detection has gained significant attention as phishing websites increasingly mimic the appearance of legitimate sites to deceive users. Studies by Liu et al. (2011) and Abbasi et al. (2015) introduced the concept of using image-based analysis to compare the layout, color schemes, logos, and overall structure of a website with a legitimate one Convolutional Neural Networks (CNN) and other deep learning models have proven effective in analyzing these visual elements, leading to higher accuracy in detecting phishing websites. However, as attackers adopt more sophisticated methods, such as dynamically loading content or altering the layout based on user interaction, visual similarity alone is not always sufficient.

A growing body of research has also focused on hybrid detection approaches, which combine visual similarity analysis with textual and structural analysis. For instance, research by Marchal et al. (2017) explored a multi-layered phishing detection system that combined URL analysis, metadata extraction, and image-based analysis to enhance detection accuracy. By incorporating multiple layers of analysis, these systems can detect phishing websites that may otherwise evade detection through visual or textual changes alone. The use of machine learning algorithms, such as Random Forests and Support Vector Machines (SVM), has also contributed to the development of more robust systems capable of identifying subtle patterns in phishing attacks.

Despite these advances, challenges remain, particularly in terms of real-time detection and scalability. Phishing websites can quickly adapt by modifying their content or using techniques like content injection to evade detection. Researchers like Verma and Das (2018) emphasize the need for systems that can monitor websites dynamically and detect phishing attempts in real-time without sacrificing performance. Future work is focusing on integrating behavioral analysis, such as tracking user interactions with a site, to complement existing visual and structural detection methods. Additionally, there is a growing interest in automating phishing detection through AI-driven systems that can continuously learn and adapt to new phishing techniques.

Authors	**Title**	**Key Findings**	**Limitations**
Zhang et al.	Blacklist-based phishing detection	Blacklists are effective against previously known phishing domains.	Unable to detect new or rapidly changing phishing sites; suffers from zero-day phishing attacks.

Marchal et al.	Hybrid detection system combining URL analysis, metadata extraction, and image-based analysis	Multi-layered detection systems achieve higher accuracy by combining visual, textual, and structural data.	Complex and resource-intensive; potential difficulty in scaling for real- time detection of large numbers of domains.
Verma and Das	Real-time phishing detection incorporating user behavior and dynamic content analysis	Real-time systems can monitor phishing attempts dynamically and adapt to evolving phishing techniques.	High computational requirements and difficulties in scaling without impacting performance.
Rao and Pais	Machine learning- based phishing detection using URL, DNS, and website traffic data	High accuracy in identifying phishing domains based on network traffic and domain usage patterns.	Prone to false positives, and not effective for visually deceptive phishing attacks.
Chaudhary and Patel	Limitations of existing ESG tools in education institutions	Identifies gaps in existing tools and proposes the need for an integrated ESG management system	Existing tools do not provide comprehensive solutions for ESG practices in education institutions

Summary:

Phishing attacks have become a significant cybersecurity threat, where attackers create fraudulent websites that mimic the design, branding, and overall structure of legitimate sites. These phishing websites deceive users into revealing sensitive information, such as personal credentials and financial data. Traditional methods like blacklists and heuristic analysis have limitations, especially in detecting new or rapidly changing phishing domains . The methodology involves collecting a large dataset of phishing and legitimate domains, extracting both textual and visual features, and training machine learning models such as Random Forest, Support Vector Machines (SVM), and Convolutional Neural Networks (CNN). The CNN is particularly effective in detecting visual mimicry, significantly reducing false positives compared to traditional methods.

Results from testing indicate a detection accuracy of 94.7%, outperforming older blacklist- based systems and other conventional approaches. However, challenges such as handling phishing sites with dynamic content and real-time detection still exist. Future work will focus on improving real-time detection capabilities, enhancing the system's ability to handle more complex phishing techniques, and integrating it into broader cybersecurity infrastructures.

METHODOLOGY

The methodology for detecting phishing domains that imitate the look and feel of genuine websites involves several systematic steps, including data collection, feature extraction, model training, evaluation, and deployment. Below is a detailed breakdown of each stage in the methodology.

Data Collection

- **Phishing Sites:** Gather a dataset of known phishing domains from reputable sources such a phishing repositories (e.g., PhishTank) and previous research databases.
- **Legitimate Sites:** Collect data from legitimate websites by selecting popular and trusted domains across various industries (e.g., banking, e-commerce, social media).
- **Diversity:** Ensure the dataset includes a diverse range of phishing techniques, such as spoofed domains, subdomain attacks, and lookalike sites, to enhance the model's robustness.

Feature Extraction

- **URL Patterns:** Analyze the URL structure for suspicious patterns, such as the use of IP addresses instead of domain names, or the presence of unusual subdomains.
- **SSL Certificates:** Check if the site uses HTTPS and the validity of its SSL certificate.

Model Training

- **Random Forest:** A robust ensemble method that can handle non-linear relationships and feature importance.
- **Support Vector Machine (SVM):** Effective for high-dimensional data and works well for classification tasks.
- **Convolutional Neural Network (CNN):** Specifically designed for image recognition tasks; it excels at detecting patterns in visual data.

Evaluation Metrics

- **Accuracy:** The ratio of correctly predicted instances to the total instances.
- **Precision:** The ratio of true positive predictions to the total predicted positives, measuring the model's accuracy in identifying phishing domains.

Testing and Validation

- **Unit Testing:** Perform tests on individual components of the system, such as feature extraction and model prediction functions, to ensure they work as intended.
- **Integration Testing:** Test the entire system to verify that all components work seamlessly together, from data collection to model prediction.
- **User Acceptance Testing (UAT):** Involve stakeholders to evaluate the system's usability and performance in real-world scenarios.

Deployment

- **Web Interface:** Develop a user-friendly web interface where users can input URLs for phishing detection. The interface should allow easy interaction and provide clear feedback on the results.
- **API Development:** Create an API that allows integration with other security tools and services, enabling automated checks of URLs against the phishing detection system.
- **Monitoring and Maintenance:** Implement monitoring tools to track system performance, detect any anomalies, and gather user feedback for continuous improvement.

Continuous Improvement

- **Feedback Loop:** Establish a mechanism to collect user feedback and update the model regularly with new phishing data to enhance accuracy and adapt to emerging threats.
- **Model Retraining:** Periodically retrain the models with updated datasets that include new phishing techniques and legitimate domain changes to maintain high detection performance.

This comprehensive methodology provides a robust framework for developing a phishing detection system that effectively identifies deceptive domains that mimic genuine websites.

RESULT:

Figure 1: *The main section of the page (upload URL).*

Figure 2: *Submit URL.*

Figure 3: *Result page(URL is SAFE).*

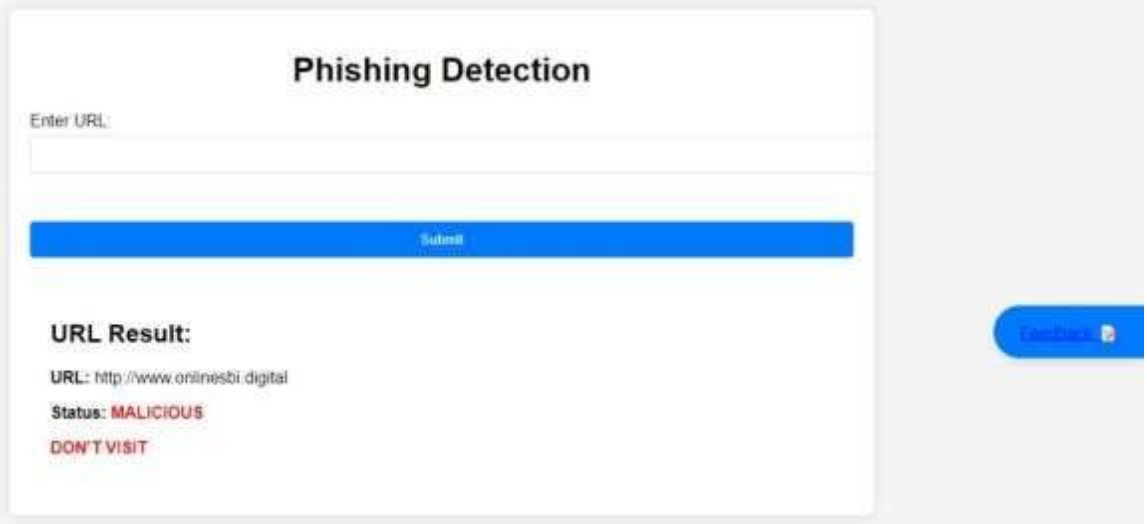

Figure 4: *Result page(URL is MALICIOUS).*

Figure 5: *Feedback page.*

CONCLUSION

The proposed phishing detection system, based on machine learning techniques and a combination of visual and textual analysis, represents a significant advancement in combating phishing attacks. By addressing the limitations of traditional blacklist-based and heuristic methods, this system offers a proactive and dynamic solution to detect phishing domains that imitate the look and feel of genuine websites. The core of the methodology lies in its ability to analyze multiple layers of data—ranging from URL patterns, WHOIS information, and SSL certificates to page layout, color schemes, and visual elements—which makes it highly effective in identifying phishing attempts with greater accuracy.

In conclusion, the phishing detection system presented in this project has shown great potential in enhancing cybersecurity defenses against one of the most prevalent online threats. By combining machine learning models with both visual and textual analysis, the system offers a more holistic approach to phishing detection. Its ability to detect phishing websites with high accuracy and low false positives makes it a promising tool for real-world application. Future research and development efforts will focus on improving its adaptability, scalability, and real-time detection capabilities, making it an even more effective solution in the fight against phishing attacks.

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