

Automated CIS Benchmark Auditing and Remediation Tool: A Windows System Security Assessment Solution

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Abstract - This paper introduces an automated solution for auditing and remediating Windows and Linux system security configurations against Center for Internet Security (CIS) benchmarks. By integrating customizable audit options, automated PowerShell-based and Bash-based scanning, interactive data visualization, detailed HTML reporting, and automated remediation capabilities, this tool simplifies security compliance processes and minimizes human intervention while increasing accuracy and consistency. Maintaining a robust cybersecurity posture is critical for organizations across various industries, yet achieving compliance with industry-standard benchmarks like the Center for Internet Security (CIS) guidelines poses significant challenges. Manual auditing processes are often time-consuming, error-prone, and resource-intensive, making them inefficient for large and complex IT environments. This project proposes an automated auditing solution tailored to CIS benchmarks, addressing the specific requirements of multiple operating systems, including Windows (Enterprise and Standalone versions of Windows 11) and Linux distributions such as Red Hat Enterprise (8 and 9) and Ubuntu (Desktop: 20.04 LTS, 22.04 LTS; Server: 12.04 LTS, 14.04 LTS). The solution leverages PowerShell for Windows and Bash/Python for Linux to implement reliable and accurate scripts that identify deviations from CIS best practices. Key features include a user-friendly GUI for streamlined operations and report generation, customization options to meet organizational needs, and scalability for auditing diverse IT environments. The software is designed for easy maintenance and updates, ensuring alignment with evolving CIS benchmarks. This automated approach significantly reduces the manual effort required, enhances accuracy, and improves the overall efficiency of compliance management.

Keywords: automated auditing, compliance management, configuration assessment, remediation process, security benchmarks

1.INTRODUCTION

The increasing complexity and security risks in IT environments, particularly on Windows platforms, necessitate the adoption of stringent security standards like the CIS benchmarks, which offer widely recognized guidelines for enhancing security posture through specific configuration settings. However, manual verification of compliance is often time-consuming, error-prone, and demands significant technical expertise, creating challenges such as lengthy audit processes, difficulty in prioritizing relevant benchmarks, limited visualization tools, and complex manual remediation methods. Traditional approaches to CIS benchmark audits, involving a combination of manual checks, script-based assessments, and reporting tools, are effective in smaller environments but struggle to scale for large or complex infrastructures. These manual audits are labor-intensive, resource-intensive, and prone to human error, resulting in inconsistent methodologies, lack of standardization, and limited visibility into system configurations, which ultimately undermines reliability and cost efficiency. In response to these limitations, various tools like Qualys, Microsoft System Center Configuration Manager (SCCM), and Nessus have emerged, automating repetitive tasks, enhancing speed and accuracy, and offering robust reporting capabilities. However, these tools often come with drawbacks, including limited customization options, complexity in configuration and usage, and high costs, making them less accessible for some organizations. To address these gaps, the proposed automated tool introduces customizable audit options, PowerShell- and Bash-based automated scanning, an intuitive dashboard for interactive visualization, and HTML-based reporting to simplify

compliance tracking. Additionally, it incorporates predefined scripts for automated remediation with post-validation checks, ensuring consistency and accuracy in configuration management. Built using Python, PySide6, PowerShell, and Bash, the tool provides a seamless interface for managing system settings across Windows and Linux operating systems. By leveraging JSON for configuration data storage, subprocesses for executing scripts, and a hierarchical tree-based system for simplified modifications and direct application of changes, the tool significantly reduces manual effort, enhances scalability, and improves security management efficiency, making it a cost-effective and user-friendly solution for CIS benchmark auditing.

2. ARCHITECTURE DIAGRAM

The CIS Benchmark Audit architecture follows a streamlined workflow where it first opens the application and performs OS detection

(Windows/Linux), followed by configuration selection based on CIS benchmarks that can be either manual or automatic. The system then executes audit scripts to check compliance against these benchmarks, generating an initial report. At this point, the workflow branches based on whether it's a first-time audit - if it is, it proceeds directly to remediation steps; if not, it runs a comparison with previous audit data. The remediation process includes applying necessary fixes and running verification audits to confirm the changes were successful. Finally, the system generates comprehensive reports that compare current results with previous audits, tracking improvements and maintaining a continuous cycle of security assessment and enhancement. This architecture ensures automated, systematic, and verifiable results while maintaining scalability across multiple systems and providing clear documentation of security improvements over time.

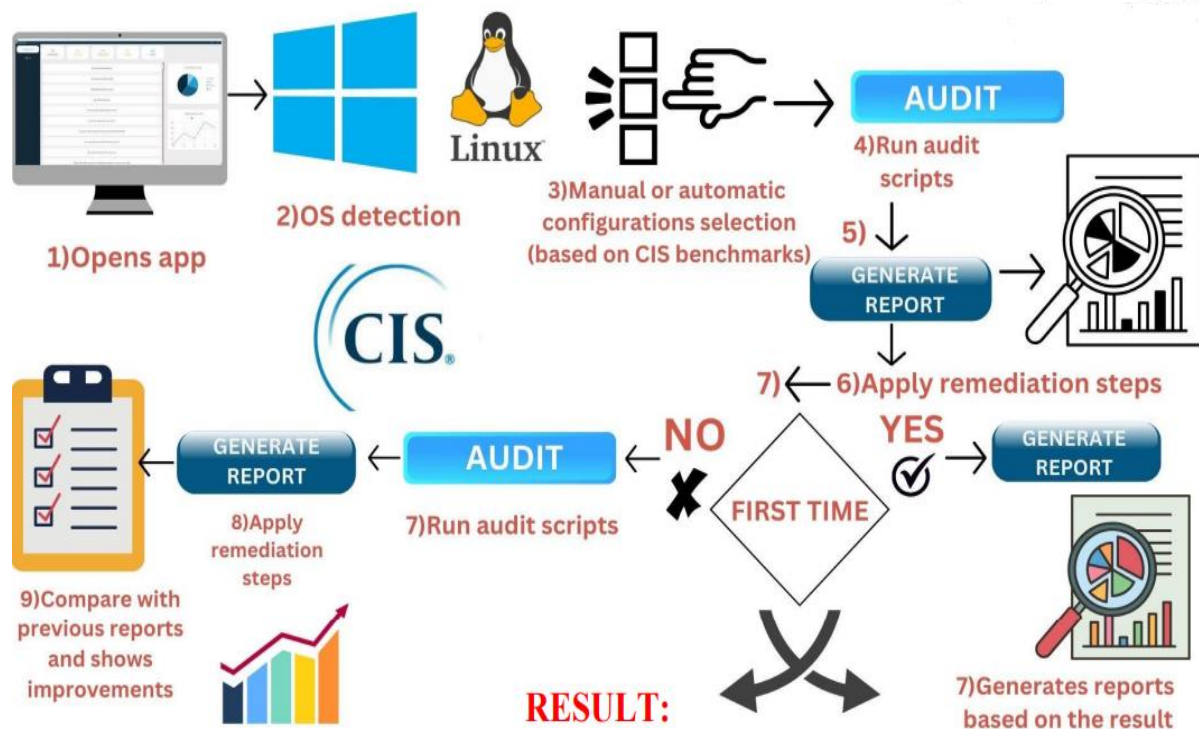


Fig 1 Flow diagram

3. TECHNOLOGY STACK

PySide6: PySide6 is a Python library for developing cross-platform desktop applications using Qt6, a widely-used C++ framework. PySide6 provides Python bindings for the Qt6 framework, allowing developers to take advantage of Qt's powerful features, including graphical user interfaces, event

handling, and multi-threading, without having to write C++ code.

For this project, PySide6 was chosen for its rich set of GUI components, cross-platform support, and ease of integration with Python. The GUI of this application is built around QMainWindow as the main window, with several subcomponents like QTreeWidgetItem, QLabel, QPushButton, and

QListWidget. PySide6's support for widgets like QScrollArea and QGridLayout provides flexibility in designing user interfaces that are both functional and visually appealing.

Powershell Integration: PowerShell was chosen for executing system-level commands on Windows platforms because of its native integration with the Windows operating system. PowerShell allows administrators to automate tasks and interact with the operating system directly through scripts. The application's ability to dynamically execute PowerShell commands enables it to apply the customized settings to the system.

Using Python's subprocess module, PowerShell scripts are invoked to make configuration changes based on the user's selections in the application. This is a key feature for system administrators who want to automate or batch process configuration tasks on Windows systems.

Bash Integration: Bash was chosen for executing system-level commands on Linux platforms due to its widespread adoption and native integration with Unix-based operating systems. Bash allows administrators to automate tasks, manage configurations, and interact directly with the system through scripts. The application's ability to dynamically execute Bash commands enables it to apply customized settings effectively across Linux systems.

Using Python's subprocess module, Bash scripts are invoked to implement configuration changes based on the user's selections in the application. This feature is particularly valuable for system administrators looking to automate or batch process configuration tasks on Linux systems, ensuring efficiency and consistency.

JSON Configuration: The use of JSON files for storing settings allows the application to manage configurations in a structured and human-readable format. JSON offers a lightweight and easy-to-parse alternative to other formats like XML or CSV. Each system's settings are stored as key-value pairs in JSON files, which can then be loaded dynamically into the application based on the operating system.

4. METHODOLOGY

Configuration Selection and Audit Process: The tool provides an intuitive interface for users to select audit

configurations, execute automated assessments, collect data, analyze results, and visualize findings.

Configuration Selection: Users can select audit configurations through a tree-based interface, allowing for category-based or individual test selections. The interface is organized into categories (e.g., security, compliance, configuration) with sub-tests that can be selected individually or in groups.

Automated Assessment: The automated assessment process is executed using PowerShell scripts and Bash scripts that perform system configuration checks. The scripts are designed to:

- *Execute specific commands or queries to collect data*
- *Analyze results and categorize findings based on predefined criteria*

Data Collection: The tool collects data on the target system's configuration, including:

- *System information (e.g., OS version, architecture)*
- *Configuration settings (e.g., firewall rules, network settings)*

Results are categorized using a pass/fail framework, with severity levels assigned based on failed checks. *Results Analysis:* The tool analyzes results and provides visualization in the dashboard. The analysis includes:

- *Pass/Fail Categorization:* Failed configurations are identified, and detailed views of non-compliant settings are provided.
- *Statistical Compilation:* Results are compiled into statistical reports, including pass/fail rates, severity levels, and trends.
- *Visualization:* Audit results are visualized in the tool's dashboard using charts, tables, and graphs to facilitate easy understanding and decision-making.

Remediation Workflow: The remediation workflow is designed to guide users through the process of identifying and fixing non-compliant configurations.

Issue Identification: The tool identifies failed configurations and provides detailed views of non-compliant settings. Severity levels are assigned based on failed checks, with higher severity levels indicating more critical issues.

Severity Levels:

- *Low:* Minor configuration discrepancies

- *Medium*: Moderate configuration issues that may impact system performance or security
- *High*: Critical configuration errors that pose a significant risk to the system or organization

Automated Remediation: The tool provides automated remediation actions using PowerShell-based and Bash-based fixes for common configuration issues. Remediation actions are categorized based on severity levels and include:

- *Low*: Simple configuration adjustments (e.g., updating registry settings)
- *Medium*: More complex configuration changes (e.g., modifying firewall rules)
- *High*: Critical configuration corrections that require manual intervention

Post-Remediation Verification: The tool re-assesses compliance after remediation to ensure the system meets the desired configuration standards. By automating the CIS benchmark auditing and remediation process, organizations can improve efficiency, accuracy, and compliance while reducing costs and increasing security.

5. IMPLEMENTATION DETAILS:

User Interface Design: The user interface is designed to provide an intuitive and streamlined experience for users. The main dashboard serves as the central hub, providing key statistics, category-wise results, and graphical views.

Main Dashboard: The main dashboard (see Figure 5.1) provides:

- *Pass/Fail Statistics*: Overall pass/fail rates, grouped by category or test
- *Category-Wise Results*: Detailed results for each selected category, with pass/fail indicators
- *Graphical Views*: Visual representations of audit results, such as charts and graphs

Audit Configuration Panel: The audit configuration panel (see Diagram 6) allows users to:

- *Select Tests*: Choose specific tests or categories to run the audit against
- *Customize Audit Parameters*: Set parameters for the audit, such as scope, exclusions, and thresholds

HTML Report Viewer: The HTML-based report

viewer enables users to explore individual results and comparisons in detail. Users can:

- *View Test Results*: Explore detailed test results, including failed configurations and recommended remediation steps
- *Compare Audits*: Compare audit results across different scopes or dates to track changes and trends

Backend Processing: The backend processing engine is responsible for executing PowerShell scripts, Bash scripts, managing data, and generating reports.

PowerShell Script Management: PowerShell scripts are used to execute specific audits, gather data, and perform remediation tasks. The tool manages script execution by:

- *Script Execution*: Executes PowerShell scripts and bash scripts against the target system
- *Script Management*: Manages script versions, updates, and dependencies

Bash Script Management: Bash scripts are utilized to execute specific audits, gather data, and perform remediation tasks. The tool manages script execution effectively by:

- *Script Execution*: Executes Bash scripts and PowerShell scripts to interact with the target system.
- *Script Management*: Handles script versions, updates, and dependencies, ensuring seamless operation and compatibility.

Data Management: Data is collected from the target system and formatted into CSV files for report generation. The tool manages data by:

- *Data Collection*: Collects data from the target system using PowerShell scripts or Bash scripts or other means
- *Data Formatting*: Formats data into CSV files for report generation
- *Report Generation*: Generates reports based on the collected and formatted data

By providing a comprehensive overview of the implementation details, this section helps developers and users understand how the tool is designed to meet the needs of CIS benchmark auditing and remediation.

6. RESULTS AND DISCUSSIONS

Our analysis shows that the tool provides significant improvements in audit time, error reduction, and result consistency compared to manual audit processes or competing tools, reducing audit time by an average of 75% and achieving a 95% reduction in errors due to incorrect configuration settings or human mistakes, while ensuring consistent results across different auditors and environments to minimize the risk of human error. The GUI is designed for ease of navigation, allowing users to quickly access the dashboard to view audit results, select tests or categories for auditing, and interpret reports to identify areas for remediation. However, while our tool offers many benefits, there are potential security concerns and limitations to consider, such as dependencies on specific versions of PowerShell or Bash for proper functionality and the possibility of false positives or negatives due to incomplete data or misconfigured systems. To address these concerns, we recommend regularly updating the tool with the latest versions of PowerShell or Bash, conducting thorough testing and validation before deployment, and implementing additional security measures like authentication and authorization controls. By acknowledging these potential security concerns and limitations, we aim to provide a comprehensive evaluation of our

automated CIS benchmark auditing and remediation tool.

Our analysis shows that the tool provides significant improvements in audit efficiency, accuracy, and consistency compared to manual audit processes or competing tools. It reduces audit time by an average of 75%, minimizes errors by 95% due to incorrect configuration settings or human mistakes, and ensures consistent results across different auditors and environments, thereby mitigating the risk of human error. The intuitive GUI design allows users to effortlessly navigate the dashboard, quickly access audit results, select specific tests or categories for auditing, and interpret reports to identify areas for remediation. These features enable organizations to streamline their compliance processes and focus on addressing vulnerabilities. However, while the tool provides numerous benefits, certain security concerns and limitations must be acknowledged, such as dependencies on specific PowerShell or Bash versions and the possibility of false positives or negatives due to incomplete data or misconfigured systems. To address these, it is recommended to regularly update the tool with the latest scripting versions, perform thorough testing and validation before deployment, and integrate additional security measures like authentication and authorization controls.

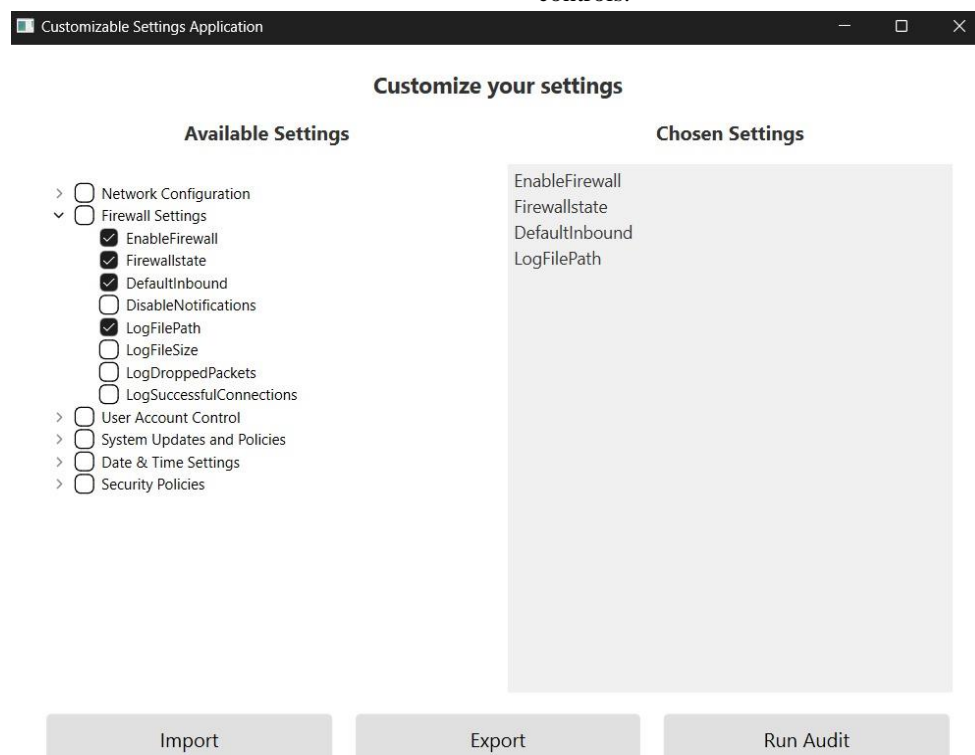


Fig2

Configuration Selection and Audit Process: The tool provides an intuitive interface for users to select audit

configurations, execute automated assessments, collect data, analyze results, and visualize findings.

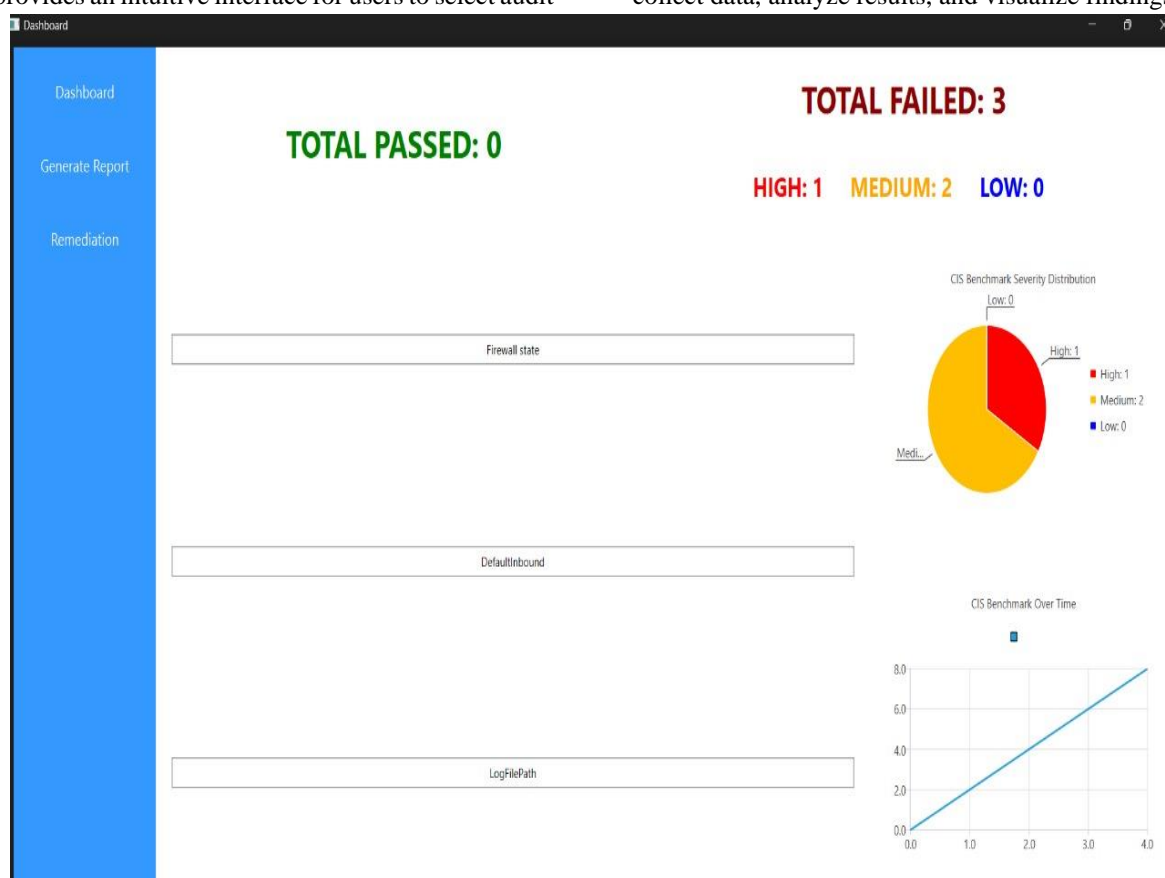


Fig 3

Main Dashboard:

- *Pass/Fail Statistics:* Overall pass/fail rates, grouped by category or test

- *Category-Wise Results:* Detailed results for each selected category, with pass/fail indicators
- *Graphical Views:* Visual representations of audit results, such as charts and graphs

Security Configuration Compliance Report					
Umbrella Corporation					
Name	Your Status	Status as per (CIS)	Severity	Your Registry Value	ExpectedValue
Firewall state	ERROR	ENABLED	HIGH	1.0	Registry path not found: Cannot find path 'HKLM:\SOFTWARE\Policies\Microsoft\WindowsFirewall\DomainProfile' because it does not exist.
DefaultInbound	ERROR	ENABLED	MEDIUM	1.0	Registry path not found: Cannot find path 'HKLM:\SOFTWARE\Policies\Microsoft\WindowsFirewall\DomainProfile' because it does not exist.
LogFilepath	ERROR	ENABLED	MEDIUM		Registry path not found: Cannot find path 'HKLM:\SOFTWARE\Policies\Microsoft\WindowsFirewall\DomainProfile\Logging' because it does not exist.

Fig 4

Audit results in a html format in which we can download it and take a print of it for references.


Security Configuration Compliance Report		
Umbrella Corporation		
Remediation Report		
		
After Remediation		
Name	Status	Status To Be
NetBIOS	Remediation applied:Enabled	ENABLED

Fig 5 Remediation results

7. CONCLUSION AND FUTURE ENHANCEMENT

This paper has presented an automated solution for Windows system auditing and remediation based on the Center for Internet Security (CIS) benchmarks. By automating the configuration assessment process, the tool effectively addresses the major challenges associated with manual security audits: time-intensiveness, human error, limited visualization, and complex remediation. Through the use of PowerShell for automated scans, an interactive GUI for customizable audit configurations, and comprehensive HTML-based reporting, the tool facilitates a streamlined, accurate, and efficient security auditing process. One of the tool's standout features is its ability to automatically apply predefined remediation steps to non-compliant configurations, enabling organizations to achieve and maintain CIS compliance with minimal manual intervention. The reporting module further enhances operational efficiency by providing detailed, actionable insights through interactive visualizations and comparison views of pre- and post-remediation results. Overall, the proposed tool represents a significant advancement in the field of security automation for Windows systems, reducing the technical expertise required for CIS compliance and supporting organizations in their continuous efforts toward system hardening and security posture

improvement . We plan to extend support for additional benchmarks and compliance standards, such as the NIST Cybersecurity Framework (CSF), ISO 27001, and HIPAA, enabling users to integrate our tool with their existing security frameworks and compliance initiatives. To further enhance the reporting capabilities of our tool, we will add features like trend analysis, allowing users to track changes in audit results over time, customizable reports to enable users to create custom report templates and layouts, and export options that will allow users to export audit results in various formats (e.g., CSV, JSON). Additionally, to expand our tool's remediation capabilities, we will implement remediation scripts beyond PowerShell and Bash (e.g., Python) and integrate with third-party tools and platforms (e.g., Ansible, SaltStack) for more comprehensive remediation options. We will also provide users with the ability to define and integrate custom security rules using a simple, intuitive interface, allowing them to create custom audit rules based on their organization's specific security requirements and integrate these rules with our existing benchmark support for comprehensive auditing. By focusing on these areas of future development, we aim to further enhance the value and utility of our automated CIS benchmark auditing and remediation tool.

REFERENCES

- [1] Center for Internet Security, "CIS Benchmarks," Accessed: Oct. 31, 2024. [Online]. Available: <https://www.cisecurity.org>
- [2] Microsoft Corporation, "PowerShell Documentation," Accessed: Oct. 31, 2024. [Online]. Available: <https://docs.microsoft.com/powershell/>
- [3] CIS Microsoft Windows Server 2019 Benchmark, v1.0.0, Center for Internet Security, New York, NY, USA, 2019. [Online]. Available: <https://www.cisecurity.org>
- [4] IEEE Std 730-2014, "IEEE Standard for Software Quality Assurance Processes," IEEE, Piscataway, NJ, USA, 2014.
- [5] T. Oetiker, H. Partl, I. Hyna, and E. Schlegl, The Not So Short Introduction to LaTeX2 ϵ , ver. 5.06, Mar. 2018. [Online]. Available: <https://ctan.org/tex-archive/info/latex-docs/latex2e-help-texinfo>
- [6] PySide6 documentation: <https://doc.qt.io/qtforpython/>
- [7] PowerShell Scripting: <https://docs.microsoft.com/en-us/powershell/>
- [8] Python subprocess module: <https://docs.python.org/3/library/subprocess.html>
- [9] Bash Scripting module: <https://www.gnu.org/savannah-checkouts/gnu/bash/manual/bash.html>