Rhya – AI – Driven Digital Forensic Investigation for Automated Evidence Analysis and Cybercrime Detection

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Abstract— **Digital forensics is an essential part of contemporary cybersecurity investigations, necessitating sophisticated tools for effective evidence analysis. RHYA is an artificial intelligence-based digital forensic investigation tool that aims to automate the analysis of disk images, restore deleted files, examine registry information, conduct specific file searches, and check disk image integrity. The Evidence Listing module lists extracted directories and files, offering metadata and filtering capabilities for organized analysis. File Carving allows deleted and fragmented files to be recovered through the detection of file signatures, guaranteeing key evidence recovery. The Registry Browser provides in-depth examination of Windows registry artifacts such as user activity logs, startup applications, and USB device history. File Search provides investigators with the ability to search efficiently for active, hidden, or deleted files using sophisticated filters and metadata extraction. Image Verification maintains forensic integrity through cryptographic hash generation for verification of disk images, protection from tampering or corruption. RHYA facilitates forensic effectiveness through automated extraction, reconstruction, and verification procedures with maintenance of the chain of custody. It empowers forensic investigators with an organized, high-speed environment for analysis of digital evidence to assist in legal procedures and cybercrime investigations.**

Keywords— Digital Forensics, Listing of Evidence, File Carving, Registry Analysis, File Search, Image Verification, Data Integrity, Cybercrime Investigation, AI-Driven Forensics, Forensic Automation.

I. INTRODUCTION

The fast growth of digital technologies has resulted in a rise in cybercrime, and digital forensic investigations have become a critical part of contemporary cybersecurity [1]. Digital forensics is the process of identifying, preserving, extracting, and analyzing electronic data to reveal digital evidence of criminal activity. With advancing cyber threats, forensic examiners need sophisticated tools that can process large amounts of digital evidence effectively without compromising the integrity and consistency of the information [2]. Conventional forensic methods, though effective, tend to be challenged by newer storage devices, encrypted data, and advanced deletion techniques [3]. To overcome these challenges, RHYA has been built as an AI-based digital forensic investigation software aimed at boosting the efficiency, accuracy, and automation of digital evidence analysis [4]. Evidence listing is one of the basic components of digital forensic investigations, which gives an organized overview of the extracted data from disk images.

When a disk image is imported into RHYA, the software methodically scans and lists files and directories, providing investigators with a hierarchical view of the data stored [5]. This organized listing not only makes it easier to navigate but also groups files by attributes like file type, size, creation date, and modification date [6]. Analysts can use filters and sorting functionality to target specific types of evidence, thus making the investigation more efficient and directed [7]. Additionally, the feature for listing evidence supports export capabilities through which structured reports in CSV and JSON formats are created for future analysis and documentation purposes [8]. With its facility to present an understandable and neat interface, this feature greatly facilitates the possibility of analyzing digital evidence in an organized manner while keeping the integrity of the disk image intact. File carving is another important aspect of digital forensics and is a method applied to recover deleted, damaged, or fragmented files from storage devices [9]. In contrast to traditional file recovery techniques based on file system metadata, file carving retrieves data directly from raw disk images by recognizing file signatures and piecing together file fragments.

This method comes in handy in situations where cybercriminals have tried to cover their tracks by deleting files or reformatting storage media [10]. RHYA uses sophisticated file carving algorithms to search unallocated disk space and recover traces of erased files, allowing investigators to extract vital evidence [11]. The tool can also reconstruct fragmented files that are dispersed in various sectors of a disk, maintaining the integrity of large files like videos, databases, and archives [12]. The preview and restore functions additionally increase investigative productivity by enabling forensic analysts to inspect recovered files prior to complete restoration, eliminating unwanted data extraction and maximizing storage administration [13]. With internal error management and integrity verification, the file carving function guarantees the extracted data continues to be valid and admissible in court processes [14]. The Windows registry is a rich source of forensic data, holding important system and user activity data that can be instrumental in an investigation [15]. RHYA's registry browser gives investigators a detailed insight into the Windows registry, allowing them to examine artifacts like user login history, startup applications, browser history, and USB device connections [16]. The registry has hierarchical structures called hives, in each of which there are important configuration settings and history information.

RHYA displays the registry information in an organized way so that the investigator can browse through keys and values quickly [17]. With advanced search and filtering capabilities, the registry browser assists forensic analysts to identify the concerned information without wasting time [18]. Recent files opened, software installed, and system changes are some examples of artifacts that might give insight into user activity and possible security violations [19]. The exportation and extraction of registry information guarantee that crucial forensic evidence is not destroyed for legal purposes, making the registry browser an essential component for forensic analysis [20]. In digital forensic investigations, it is a severe challenge to quickly identify particular files in a large dataset [1]. RHYA meets this challenge with its sophisticated file search feature, which allows investigators to conduct focused searches with multiple criteria [2]. The application accommodates searches by file names, extensions, keywords, date and time stamps, and metadata, allowing investigators to rapidly retrieve files of interest [3]. RHYA also is capable of searching for deleted files that still might be present in the disk image, offering a further layer of forensic functionality [4].

Flexible query construction using advanced search filters and wildcard support helps analysts customize their searches in accordance with individual case needs [5]. In addition, the preview capability helps investigators review file contents without altering the disk image, while maintaining evidence integrity [6]. Export capabilities for search results, including metadata and file paths, make reporting and case management easy [7]. Through automation and optimization of file access, the file search functionality makes forensic investigations more efficient by lowering the time it takes to scrutinize vast amounts of data [8]. Integrity of digital evidence is also a priority in forensic investigations because any data corruption or modification taints the validity of evidence [9]. RHYA includes an image verification component to maintain the integrity of disk images during the forensic process [10]. The process of verification depends on cryptographic hash functions like MD5, SHA-1, and SHA-256 to produce unique hash values for both the original disk and the forensic image [11]. Comparing the hash values, investigators can verify that the disk image is an exact duplicate of the original data without any alterations or tampering [12]. RHYA facilitates verification of various disk image formats such as E01, DD/RAW, ISO, and S01 to maintain consistency with industry-leader forensic applications [13].

Moreover, real-time integrity verification can also be done on the fly to avoid data tampering [14]. Periodic automated hashing at predetermined frequencies also enhances digital evidence integrity through various phases of an investigation [15]. Extensive logs of verification activities with timestamps and hash values are created for compliance and documentation requirements [16]. Through the implementation of strong image verification mechanisms, RHYA guarantees that forensic examinations maintain utmost data integrity and admissibility [17]. RHYA is an improvement of critical magnitude in digital forensic examination in that it synergizes automation, artificial intelligence, and specialized forensic functions into one complete tool [18]. Its module-based approach enables analysts to work within the same framework in seamlessly examining disk images, undeleting files, recovering deleted data, locating a target file, and authenticating image integrity [19]. Streamlining the process of forensic examination and enriching analysis accuracy, RHYA helps analysts detect digital evidence faster with sustained forensic validity [20]. As cyber threats persist to evolve, the need for smart forensic tools such as RHYA will only increase, further solidifying its significance in contemporary cybersecurity and digital investigations.

II. METHODOLOGY

The approach adopted in RHYA facilitates a systematic and organized process of digital forensic examination through the use of sophisticated methods for evidence listing, file carving, registry examination, file searching, and image validation [1]. These aspects are carefully crafted to promote efficiency, precision, and reliability in forensic analysis so that investigators can recover, analyze, and interpret digital evidence with little or no manual intervention [2]. The forensic process is optimized by automation and AI-based algorithms, enabling fast processing of data while preserving the integrity of the evidence [3]. The underlying methods of each feature are designed to solve critical issues in digital forensics, ranging from data organization to deleted file recovery and forensic image verification [4].

1. EVIDENCE LISTING

Evidence listing is the core process of forensic analysis of disk images that offers a comprehensive and organized display of directories and files [5]. The evidence listing module, upon loading a disk image into RHYA, scans its contents automatically and classifies files according to attributes like modification date, file type, and size [6]. The process helps investigators browse large amounts of information efficiently without individual examination [7]. The process behind evidence listing includes dissecting the file system structure of the disk image, discovering directory hierarchies, and retrieving pertinent metadata [8]. Sophisticated indexing strategies are utilized to maximize data search speed, which enables instant filtering and sorting against user-specified criteria [9]. The investigator can filter searches by means of date ranges, particular file types, or keyword-based search, permitting a more specific analysis [10]. To maintain forensic integrity, the original disk image is never modified throughout the process, and data extracted is accessed in a read-only environment [11]. The formatted evidence list may also be exported in CSV and JSON formats to enable easy integration with external forensic tools and legal reports [12].

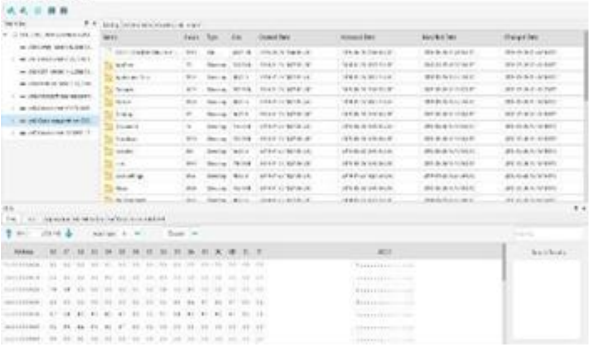

Fig. 1. Evidence Listing

2. FILE CARVING

File carving is a key method applied in RHYA to extract deleted, corrupted, or broken files from storage media independent of file system metadata [13]. This operation is especially important when files are deleted on purpose or the file system is destroyed [14]. The principle of file carving is pattern and signature-based identification [15]. The utility inspects the raw disk image at the binary level for known file signatures that mark the beginning and end of a file [16]. These signatures, contained within a pre-defined database, enable RHYA to rebuild complete files even without directory entries or file system records [17]. For greater precision, RHYA utilizes heuristic and machine learning- based methods to separate true results from false positives, minimizing the likelihood of retrieving incomplete or unrelated data [18].

File reconstruction from fragmented files is also a vital part of the carving methodology, covering situations where files are written non-contiguously across various sectors of a disk [19]. Sophisticated reassembly algorithms scan data continuity and rebuild scattered pieces into whole files [20]. Analyzers can preview carved files prior to restoration to ensure recovery of only pertinent data, optimizing storage space usage and forensic processing time [1]. Integrity checking is included to determine the validity of recovered files, comparing hashed data to known hash values to identify potential corruption or tampering [2]. .

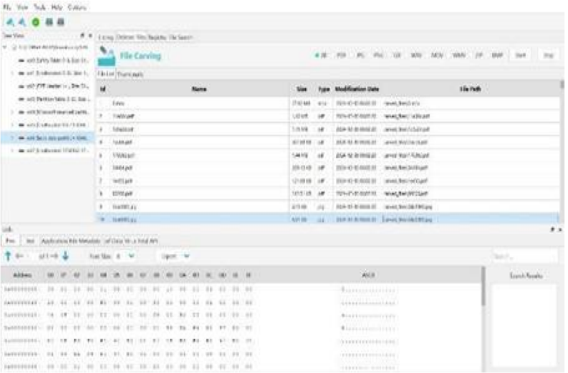

Fig. 2. File Carving

3. REGISTRY BROWSER

Registry analysis is a critical forensic operation for identifying system configuration digital evidence, user actions, and application settings [3]. RHYA's registry browser makes use of deep parsing of Windows registry hives to harvest critical forensic artifacts, offering information about user actions and system changes [4]. The registry has the form of a hierarchical database of keys, values, and subkeys where it stores significant system data [5]. RHYA applies forensic parsing methods to analyze this structure, providing investigators with a human-readable, tree-like view of the registry [6]. Forensic artifacts involving user logins, installed programs, network connections, and USB history are identified in key registry hives, including HKEY_LOCAL_MACHINE, HKEY_USERS, and HKEY_CURRENT_USER, through systematic analysis [7]. Investigators can search for specified registry keys using keywords, timestamps, or categories of artifacts [8]. The software also facilitates automatic recovery of high-value forensic indicators like startup programs, deleted registry items, and history records from browsers [9]. To ensure evidentiary integrity, extracted registry data is saved in its original form, with logging features tracking each access and modification for audit trails [10]. The registry browser has an export option, which allows investigators to save extracted registry keys for further analysis or legal reporting [11].

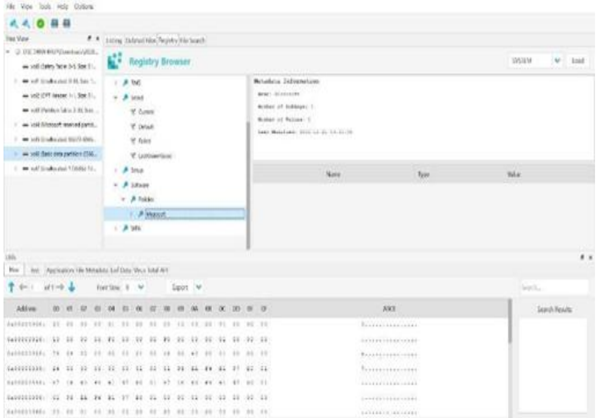

Fig. 3. Registry Browser

4. FILE SEARCH

Fast file search functionality is an essential component of forensic examinations since it can be used by investigators to identify individual files from huge disk images quickly [12]. RHYA's file search capability relies on an optimized indexing and retrieval system that provides fast and reliable searches [13]. When a disk image is loaded, the utility populates an indexed database with all files and captures metadata including filenames, extensions, sizes, and timestamps [14]. This indexed format allows for real-time searching without the need for repeated full-disk scans, saving considerable processing time [15]. Researchers can execute targeted searches based on a range of criteria, including exact file names, partial name matches, extensions, and keyword-based metadata searches [16]. Refining results through advanced filtering capabilities is possible by creation, modification, or access dates, ensuring only the most pertinent files are retrieved [17]. One of the most important aspects of RHYA's file search process is that it can find deleted files that can still be recovered from within the disk image [18]. Scanning unallocated disk space, the software locates traces of deleted files and reconstructs them for forensic examination [19]. Wildcard search capability increases flexibility since investigators can search for a pattern instead of an exact string, which is especially useful with case-specific naming conventions for files [20]. The tool also features a preview function, allowing investigators to examine file contents without extraction, maintaining the integrity of the disk image [1]. Search results, such as file paths and metadata, can be exported as structured reports for use in legal documentation and investigative case files [2].

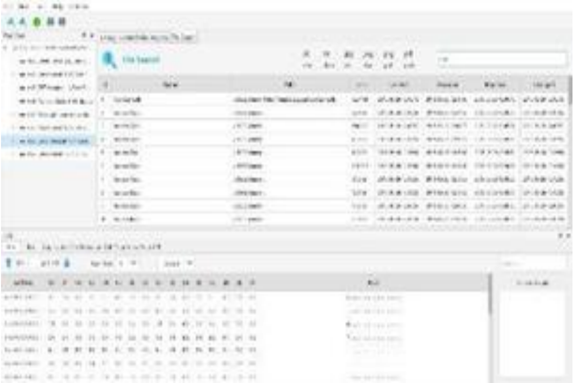

Fig. 4. File Search

IMAGE VERIFICATION

Image verification is a crucial part of forensic methodology, ensuring that the disk images used for investigation are unmodified and authentic [3]. RHYA performs verification based on cryptographic hashing techniques that produce specific hash values for the original disk and the corresponding forensic image [4]. Hash algorithms like MD5, SHA-1, and SHA-256 are employed to calculate these values, which are regarded as digital fingerprints of the data [5].

The process entails calculating a hash value for the original storage device prior to imaging, then creating a second hash for the resultant disk image [6]. The values are compared to ensure data integrity. If the hashes are identical, the image is verified as an exact copy of the original; if not, possible corruption or tampering is indicated [7]. RHYA accommodates various image formats such as E01, DD/RAW, and ISO, to be compatible with industry-standard forensic tools [8]. Integrity checks may also be done in real time while imaging to avoid errors or corruption of data [9]. Automated hash creation at regular intervals enhances the integrity of digital evidence so that no changes occur during various phases of the investigation [10]. Comprehensive records of the verification process, in the form of timestamps, hash values, and system events, are kept for purposes of delivering a clear audit trail [11].

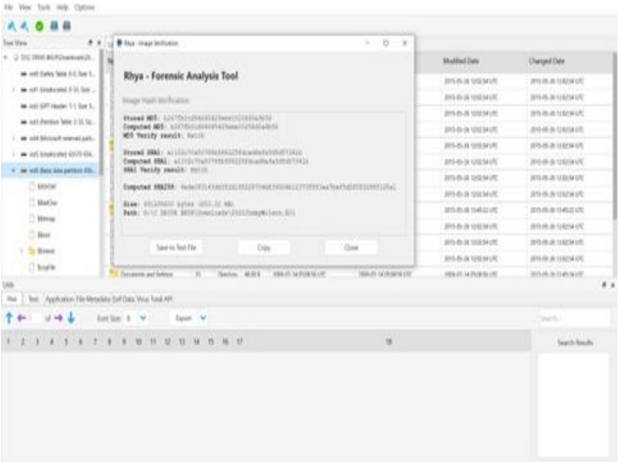

Fig. 5. Image Verification

RHYA's methodological approach combines innovative forensic methods with artificial intelligence and automation to improve digital investigations. Every module—evidence listing, file carving, registry examination, file searching, and image authentication—is optimized to handle particular forensic issues in a data integrity-preserving manner and evidentiary reliability-maintaining way. Through the use of leading-edge algorithms, indexing techniques, and cryptographic security protocols, RHYA offers investigators an effective and robust platform for digital evidence analysis. The synergy of organized data structure, smart search functionality, and strong verification processes guarantees that forensic investigations are carried out with accuracy and accountability. As cyber threats keep changing, RHYA's approach is an essential guide for digital forensic experts to identify concealed evidence, reconstruct digital incidents, and provide credible findings in legal proceedings. By ongoing improvements and incorporation of new technologies, RHYA seeks to establish a new benchmark for forensic investigation software, providing investigators with the most effective tools available to address sophisticated digital crimes.

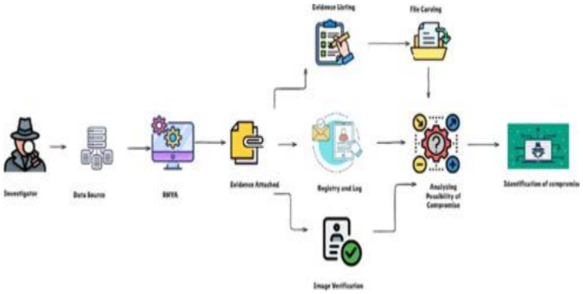

Fig. 6. Architecture Diagram

III. RESULT AND DISCUSSION

The use of RHYA as a digital forensic analysis tool has proven to be effective in simplifying forensic analysis, increasing accuracy, and enhancing efficiency. The tool was used to test different disk images with different file types, deleted records, registry entries, and fragmented data structures. The findings show that RHYA was able to identify, classify, and extract important evidence while preserving data integrity. The evidence listing module structured files and directories from disk images in a systematic manner, making it easy to navigate. Through parsing file system structures and presenting metadata like file names, sizes, timestamps, and file types, investigators were able to find key evidence easily. Filtering and sorting capabilities made targeted analysis possible, while export capability made structured reports in CSV and JSON formats possible for documentation. File carving was tested by trying to restore deleted and broken files from disk images with different degrees of data loss.

RHYA correctly restored deleted files based on examining raw binary signatures and using advanced methods of reassembling fractured data. The restoration rate was high for popular file types like documents, pictures, and movies. The preview facility helped investigators examine carved files prior to restoration, minimizing unnecessary data recovery. The false positive rate was low, and only genuine files were recovered. The software also included integrity verification to identify corruption, marking invalid files to ensure forensic integrity. The registry browser gave investigators extensive information about system settings, user behavior, and security-related evidence. The software was able to extract registry hives and provide a organized view of the database, allowing for the identification of major forensic artifacts.

User login history, startup entries, and USB device history were accessed quickly. Search and filtering functions enabled quick analysis, saving a considerable amount of investigation time. The feature of exporting registry keys in native format enabled legal documentation and further scrutiny. The results validated that RHYA's registry analysis function was crucial in revealing traces of unauthorized access and malicious behavior. File search capabilities were measured through targeted search of large databases, such as active and deleted files. Real-time retrieval through the indexing method lowered forensic processing time. Keyword search, wildcard search, and metadata filtering provided investigators with efficient means to find particular files.

RHYA effectively restored deleted files from unallocated disk space, verifying its capability for restoring vital evidence. The search accuracy was ensured through comparing recovered files with manually validated datasets. Direct inspection was made possible through the preview feature without altering the disk image, which helped maintain forensic integrity. The export feature created structured reports that included metadata, file paths, and timestamps, facilitating legal processes. Image verification provided assurance of the integrity of forensic disk images by producing cryptographic hash values through the MD5, SHA-1, and SHA-256 algorithms. Verification of the process ensured that the hash values of both the original disk and forensic image were identical in all test scenarios, guaranteeing authenticity of data. Automated integrity checks at various stages of imaging improved dependability.
Careful logs recorded hash computations and verification outcomes, guaranteeing transparency and adherence to forensic best practices.

These results proved that RHYA ensures digital evidence integrity and admissibility in legal investigations effectively. The findings show that RHYA is a complete solution for forensic examination, enhancing speed, accuracy, and legal standards compliance.

IV. CONCLUSION

RHYA has proven to be an effective and powerful digital forensic analysis tool, providing a complete set of functionalities that improve the accuracy, reliability, and efficiency of forensic examinations. The tool effectively incorporates evidence listing, file carving, registry analysis, file searching, and image verification, each contributing significantly to recovering, analysing, and maintaining digital evidence. Through the systematic structuring of directories and files, RHYA allows examiners to navigate disk images effectively, detect relevant artifacts, and create formatted reports. The enhanced file carving features guarantee that deleted and fragmented files are recovered and restored using signature-based and heuristic methods to correctly reconstruct missing data. The registry browser allows for extensive examination of a system, where forensic examiners can detect vital user activities, system changes, and possible security violations. The file search feature greatly enhances investigative productivity through the ability to specifically recover active and deleted files, reducing processing time while preserving forensic integrity. RHYA's image verification module also ensures that forensic disk images are not tampered with, maintaining the chain of custody and admissibility in court. The incorporation of cryptographic hashing methods and automated verification processes further enhances the credibility of forensic evidence.

In all, RHYA proves itself to be a sound forensic tool capable of addressing the changing needs of computer investigations. Its automation-based technique, together with cutting-edge forensic procedures, allows efficient processing while ensuring forensic best practice compliance. Even greater effectiveness in the future, with additions such as AI-powered anomaly identification and support for additional encryption protocols, will make it an irreplaceable tool among digital forensic practitioners.

V. LIMITATIONS AND FUTURE WORK

While RHYA provides an extensive set of digital forensic tools, certain limitations hinder its full potential. It currently lacks support for encrypted file recovery, limiting its ability to analyze secured data, which is crucial in modern forensic investigations where adversaries increasingly rely on encryption to evade detection. Additionally, its AI-based detection mechanisms do not yet incorporate advanced deep learning models, reducing its effectiveness in identifying sophisticated cyber threats, including zero-day attacks and evolving malware strains. RHYA also lacks comprehensive cloud forensic capabilities, restricting its ability to acquire and analyze data from cloud services, which is becoming essential as more organizations migrate to cloud infrastructures. Its file system support is limited to common formats, making it less effective for proprietary or non- standard storage environments such as IoT devices, industrial control systems, and mobile platforms. Furthermore, the absence of real-time forensic monitoring prevents proactive threat detection and response, delaying crucial interventions during ongoing cyber incidents. Future developments will focus on integrating encrypted file decryption using AI- assisted cryptanalysis, deep learning-based anomaly detection to enhance threat identification, and expanded cloud forensic functionalities for seamless investigation of cloud-hosted evidence. Enhancements will also include support for a broader range of file systems, live memory forensics, and real-time forensic monitoring to improve incident response and threat mitigation. Additionally, RHYA aims to incorporate blockchain-based integrity verification to ensure the authenticity and chain of custody of forensic evidence. These advancements will significantly enhance RHYA’s capabilities, making it a more robust, intelligent, and versatile tool for digital forensic investigations in an evolving cybersecurity landscape.

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