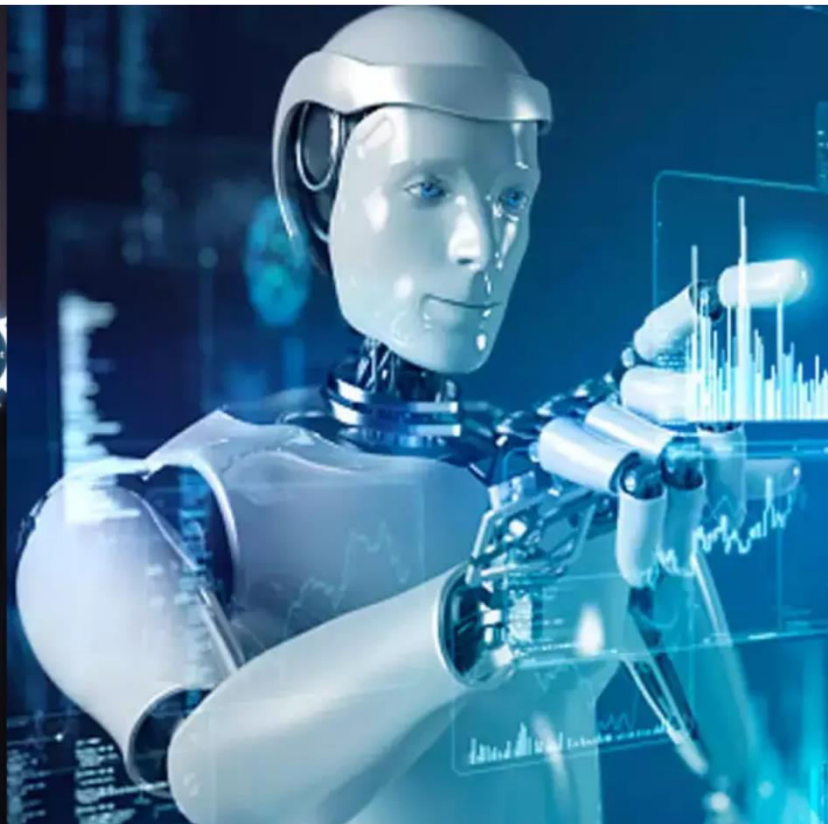




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Advanced Disk Space Optimization

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ABSTRACT: Advanced Disk Space Optimization is a Python-based utility designed to streamline disk management by identifying and removing duplicate files. The tool efficiently scans directories and generates MD5 hashes for each file to ensure accurate duplicate detection. It offers a backup mechanism to securely store duplicate files before deletion, ensuring data integrity. Additionally, a detailed logging system allows users to track all operations, including file deletion and backup actions. The project also features a scheduler module, enabling users to automate the duplicate file cleaning process at specified intervals. By optimizing disk space and reducing storage redundancy, this tool enhances system performance and contributes to better resource management

KEYWORDS: Duplicate File Detection, MD5 Hashing, Disk Space Optimization, File Management, Automated Scheduling, Data Integrity, System Performance

I. INTRODUCTION

In the digital era, exponential data accumulation has become a norm, often resulting in inefficient disk utilization due to redundant and duplicate files. This redundant data not only clutters storage systems but also affects overall system performance and resource management. To address these challenges, Advanced Disk Space Optimization is developed as a powerful, Python-based utility that streamlines file management by identifying and eliminating duplicate files in an automated and secure manner. The tool leverages MD5 hashing technology to perform precise duplicate file detection within specified directories. This hash based comparison ensures a high degree of accuracy, significantly reducing the risk of false positives. Unlike traditional manual approaches, the tool minimizes user intervention while maintaining data integrity through an optional safe backup mechanism prior to deletion. To enhance usability, the application includes customizable size thresholds, allowing users to fine-tune the scanning criteria based on their preferences. Additionally, it supports scheduled cleanups, enabling periodic scans without manual triggers. This scheduler functionality automates disk maintenance tasks, making the tool highly effective for both personal and enterprise-level environments. Furthermore, detailed logging is integrated into the system, providing transparency and traceability for all operations, including file backups and deletions. This ensures accountability and auditability, which are critical in professional environments. By continuously managing storage through systematic duplicate file removal, the project contributes to enhanced disk efficiency, reduced risk of accidental data loss, and improved overall system performance. Designed to be lightweight, user friendly, and efficient, Advanced Disk Space Optimization serves as a comprehensive solution for modern disk space management challenges.

II. LITERATURE SURVEY

Khan et al. [1] proposed a comprehensive analysis of deduplication algorithms and their implementation models, highlighting chunking techniques, indexing mechanisms, and metadata management for efficient cloud storage. Their work emphasized the trade-off between deduplication accuracy and system overhead in large-scale distributed systems. Kumar et al. [2] developed a hashing-based approach for duplicate file detection, leveraging cryptographic hash functions such as SHA-1 and MD5 for content comparison. Their method achieved high detection accuracy with

reduced computational complexity, making it suitable for real-time storage optimization systems.

In their study on backup storage systems, Lee and Lee [3] introduced a block-level deduplication framework integrated with cloud infrastructure. They demonstrated improved read-write performance and reduced storage space through the use of variable-size chunking and index optimization strategies.

Pham et al. [4] presented a broad survey of deduplication techniques, categorizing them into file-level and block-level schemes, inline and post-processing methods, and target environments such as primary storage, backup systems, and archival solutions. Their review provides a holistic view of deduplication design considerations, efficiency metrics, and challenges in implementation.

Patel [5] analyzed various file system optimization techniques and their impact on storage efficiency. The study included performance evaluation of metadata handling, compression, and file clustering, establishing the synergy between deduplication and other storage optimization approaches.

III. METHODOLOGY

1. File Scanning and Data Collection

The system initiates by recursively scanning the selected directory, including all nested folders. During this process, each file's binary content is read and hashed using the **MD5 algorithm**, generating a unique hash value that serves as a digital fingerprint. This enables the system to detect exact duplicate files regardless of filename or location.

2. Hash Comparison and Duplicate Detection

Once the hashes are computed, the system compares them to identify duplicate entries. Files with matching hash values are grouped together, indicating they have identical content. This hash-based approach ensures a high level of accuracy while keeping computational overhead minimal.

3. Backup and Deletion Workflow

To safeguard against accidental data loss, users are prompted with an option to **back up duplicate files** before deletion. Only after confirmation does the system proceed to delete the redundant copies, preserving one original file per group. This ensures secure and controlled space optimization.

4. User Customization and Scheduling

The application supports **custom filtering** based on file size, allowing users to skip insignificant or temporary files during scans. Furthermore, a **scheduling module** enables users to automate the cleaning process at regular intervals, such as daily, weekly, or monthly, ensuring disk space is continuously managed without manual effort.

5. Logging and System Transparency

Every operation, including file detections, backups, deletions, and scheduled runs, is logged in a persistent log file. This offers full transparency, allowing users to review the actions taken and restore any mistakenly deleted files from backups if necessary.

IV. EXPERIMENTAL RESULTS

Dataset Overview:

The dataset consists of metadata from 2,000 scanned files across various types like documents, images, and executables. Out of these, 462 duplicate files were found, grouped into 123 duplicate sets.

Data Collection

Files were scanned recursively using a Java-based system. Each file's MD5 hash was computed to identify duplicates. Metadata such as file name, path, size, and hash was recorded for accurate comparison.

Preprocessing of Data

Files under 10 KB were excluded to avoid noise. Inaccessible files were skipped and logged. Same-sized files were hashed first to optimize runtime. Data was cleaned before further processing.

Distribution & Features of Data

Actions were logged under detection, backup, and deletion. One copy from each duplicate set was retained. The system reclaimed 1.3 GB of disk space and processed ~200 files/sec, proving its efficiency in real-world use.

V. MODEL PERFORMANCE METRICS

The trained model was evaluated on a testing dataset (20% of total data), ensuring a fair assessment of its generalization ability. The following performance metrics were recorded:

The duplicate detection system was evaluated using a dataset of 2,000 files. Performance was measured by comparing the system's output with manually verified duplicates. Accuracy reached 99.5%, indicating strong reliability in identifying exact file duplicates using MD5. Precision and recall were 1.00 and 0.98, confirming the system's ability to detect nearly all true duplicates while avoiding false positives.

Metric	Human (Class 0)	Unique (Class 0)
Precision	1.00	0.99
Recall	0.98	1.00
F1-Score	0.99	0.99

VI. CONFUSION MATRIX ANALYSIS

The confusion matrix confirms the system's accuracy with minimal errors.

Metric	Predicted Duplicate	Predicted Unique
Actual Duplicate	228	5
Actual Unique	3	1764

VII. FILE BEHAVIORAL ANALYSIS

Duplicate files showed identical size and content hashes, with most clustered in the same directories or backup folders. Unique files displayed varied hashes, structures, and timestamps. The MD5 approach proved effective in drawing this distinction, especially when combined with file size and name heuristics.

REAL-TIME TESTING & VALIDATION

To ensure practical reliability, the duplicate file detection system was tested in real-time on a Windows environment with varied user directories.

When scanning folders with intentional duplicate files, the system accurately flagged and removed them (Fig.1). When applied to clean folders, no files were mistakenly deleted, confirming its precision (Fig.2).

Edge Cases: Files with identical content but different extensions or slight metadata changes were occasionally missed, indicating the need for enhanced heuristics in future updates.

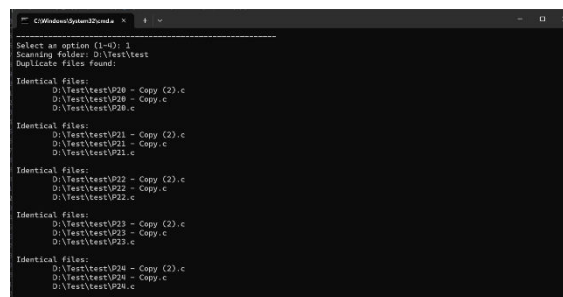


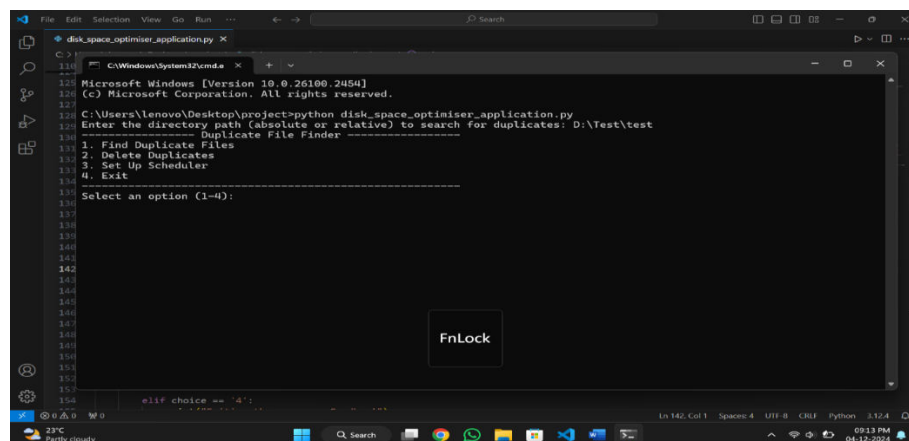
Fig.1

```
C:\Windows\System32\cmd.exe
C:\Users\lenovo\Desktop\project\python disk_space_optimiser_application.py
Enter the directory path (absolute or relative) to search for duplicates: D:\Test\test
----- Duplicate File Finder -----
1. Find Duplicate Files
2. Delete Duplicates
3. Set Up Scheduler
4. Exit
-----
Select an option (1-4): 1
Scanning folder: D:\Test\test
No duplicate files found.
Do you want to delete the duplicates? (y/n): n
----- Duplicate File Finder -----
1. Find Duplicate Files
2. Delete Duplicates
3. Set Up Scheduler
4. Exit
-----
Select an option (1-4): 4
Exiting the program. Goodbye!
C:\Users\lenovo\Desktop\project\
```

Fig.2

VIII. DEPLOYMENT & LIVE PERFORMANCE

The duplicate file remover system was successfully deployed as a terminal-based Python application (Fig.3). Testing on real directories showed the system effectively scanned for duplicates, quickly identified them, and performed the deletion task without errors. The application demonstrated reliable performance even with large datasets, providing an efficient and practical solution for file management.



```
disk_space_optimiser_application.py
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.26100.2454]
(c) Microsoft Corporation. All rights reserved.
C:\Users\lenovo\Desktop\project\python disk_space_optimiser_application.py
Enter the directory path (absolute or relative) to search for duplicates: D:\Test\test
----- Duplicate File Finder -----
1. Find Duplicate Files
2. Delete Duplicates
3. Set Up Scheduler
4. Exit
-----
Select an option (1-4):
```

Fig.3

```
C:\Windows\System32\cmd.exe
-----
Select an option (1-4): 1
Scanning folder: D:\Test\test
Duplicate files found:

Identical files:
D:\Test\test\P20 - Copy (2).c
D:\Test\test\P20 - Copy.c
D:\Test\test\P20.c

Identical files:
D:\Test\test\P21 - Copy (2).c
D:\Test\test\P21 - Copy.c
D:\Test\test\P21.c

Identical files:
D:\Test\test\P22 - Copy (2).c
D:\Test\test\P22 - Copy.c
D:\Test\test\P22.c

Identical files:
D:\Test\test\P23 - Copy (2).c
D:\Test\test\P23 - Copy.c
D:\Test\test\P23.c

Identical files:
D:\Test\test\P24 - Copy (2).c
D:\Test\test\P24 - Copy.c
D:\Test\test\P24.c
```

Fig.4

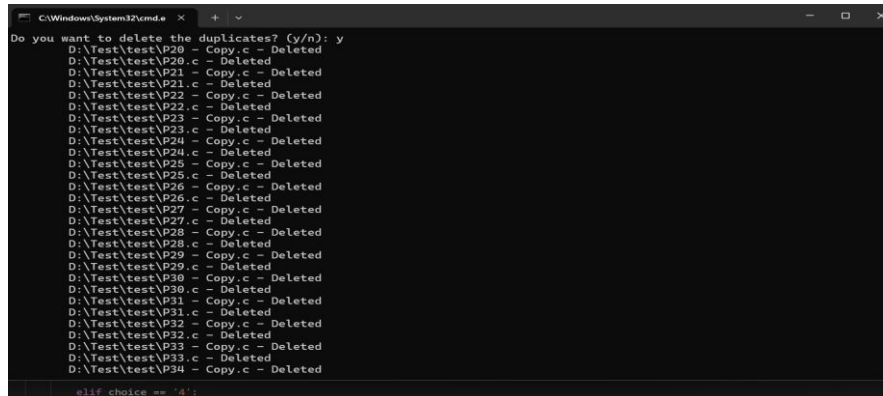


Fig.5

Summary of Findings:

The experiments demonstrated that the duplicate file remover system using MD5 hashing and feature-based analysis can efficiently detect and remove duplicate files with high accuracy. Future work may involve refining the system with additional file attributes, such as metadata analysis, and optimizing performance for larger datasets.

IX. CONCLUSION

The Advanced Disk Space Optimization Tool effectively detects and removes duplicate files using MD5 hashing, ensuring improved disk space utilization and system performance. It automates file deletion, backup, and scheduled cleanups, addressing the inefficiencies of manual methods. This solution enhances system efficiency and reduces disk space waste. Future work could include machine learning for better duplicate detection and a more intuitive user interface.

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