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BLOCKCHAIN-BASED DECENTRALIZED CLOUD STORAGE WITH RELIABLE DEDUPLICATION AND STORAGE BALANCING

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Abstract Cloud storage has become essential for managing the exponential growth of data generated globally. However, traditional centralized cloud storage systems face challenges such as data breaches, single points of failure, and inefficient storage utilization. This project proposes a blockchain-based decentralized cloud storage system that enhances security, data integrity, and resource optimization by integrating reliable deduplication and storage balancing mechanisms. The system leverages blockchain technology to provide a tamper-proof, distributed ledger for managing storage contracts, user authentication, and data access permissions, eliminating the need for trusted intermediaries. Deduplication is implemented to identify and eliminate redundant data chunks across the network, significantly reducing storage overhead and bandwidth consumption. This process is designed to be reliable and privacy-preserving, ensuring that sensitive user data is not exposed during duplication checks. Furthermore, the platform incorporates dynamic storage balancing algorithms that intelligently distribute data across multiple storage nodes based on their capacity, availability, and network conditions. This approach optimizes resource usage, enhances fault tolerance, and improves data retrieval speeds. Smart contracts automate storage agreements and incentivize node participation through token-based rewards, ensuring system sustainability and reliability. Extensive simulation results demonstrate that the proposed system achieves higher storage efficiency, improved load distribution, and stronger security guarantees compared to conventional cloud storage solutions. This blockchain-enabled decentralized architecture paves the way for a secure, scalable, and cost-effective cloud storage model, addressing critical challenges in data management and user trust.

Keywords: Blockchain, Decentralized Storage, Data Deduplication, Storage Balancing, Smart Contracts, Cloud Security, Distributed Ledger, Data Integrity, Resource Optimization, Token Incentives.

1. INTRODUCTION

Cloud storage platforms provide users with efficient, scalable, and flexible cross-platform data management services. Individuals and enterprises are attracted to outsource their data on remote centralized cloud servers to reduce local storage overhead and access their data whenever necessary. Since the requirement of data outsourcing services increases rapidly, the ever-increasing data and backups lead to a severe disk crisis. According to the CISCO Global Cloud Index [1], the storage capacity of global data centers is expected to grow 4-fold which reaches a total of 2.6 ZB in 2021 from 663 EB in 2016. In general, two-thirds of the data on the remote cloud are duplicates due to the practice of industrial application. Although massive replicas enhance the availability of outsourced data, the occupation of extra disk space and transmission bandwidth wastes cloud resources. Users may need to endure network congestion when uploading data, and cloud service providers have to provide additional storage space for data copies, thereby increasing the cost of outsourcing storage services. However, growing patient loads, limited specialist availability, and the increasing volume of medical data pose challenges for timely and accurate diagnosis. AI-based tools that can process and integrate multiple modalities offer a promising solution by augmenting clinicians' capabilities, reducing diagnostic errors, and expediting patient care. Current AI diagnostic systems primarily focus on single modalities. NLP-driven chatbots analyze patient symptoms and medical histories expressed in text to suggest possible diagnoses or recommend further tests. For instance, symptom checkers like Babylon Health employ rule-based or machine learning models to interact conversationally with patients. Meanwhile, computer vision algorithms, powered by convolutional neural networks (CNNs), have shown remarkable success in interpreting medical images for disease detection, such as identifying pneumonia in chest X-rays or tumors in MRI scans. However, these unimodal approaches have limitations. Text-only systems may miss critical visual clues, and image-only systems lack contextual patient information. Consequently, diagnostic accuracy and reliability can suffer. Multimodal AI systems integrate information from various input sources, enhancing the depth and breadth of diagnostic analysis. By

simultaneously processing patient-reported symptoms, imaging data, and laboratory values, multimodal models can uncover complex patterns and correlations that might be overlooked in unimodal analyses. For example, a suspicious shadow on a lung X-ray combined with patient history of smoking and specific respiratory symptoms provides stronger evidence for diagnosis than either data source alone. Deep learning architectures, such as transformers and fusion networks, enable effective combination of heterogeneous data, improving diagnostic confidence and interpretability. Despite its promise, developing a multimodal AI chatbot for medical diagnosis presents challenges. Ensuring data privacy and security is paramount given the sensitive nature of health information. The system must address potential biases in training data to avoid disparities in care. Interpretability of AI decisions remains a critical concern to gain trust among healthcare providers and patients. Additionally, regulatory approvals and clinical validations are necessary to ensure safety and efficacy. This innovative approach not only ensures physical safety but also fosters emotional resilience by providing immediate psychological assistance. One of the core features of EmpowHER is its emergency support system. Upon activating the emergency button, the application performs three critical actions: it sends an alert with the user's real-time location to verified contacts, automatically activates the device's camera to detect signs of violence and analyze the number of people present, and provides essential situational data for informed decision-making. These features empower users with proactive safety measures that facilitate swift intervention and protection. Many businesses or individuals are offloading their data to cloud servers for storage since they offer large storage at a lower cost. Excessive usage can use up a lot of storage space and result in duplicate data. Nearly 90% of the data on all major cloud servers is duplicate, thus they used deduplication methods to prevent resource waste, which will reduce data availability but save resources. Data stored on one cloud server

2. LITERATURE SURVEY

Blockchain technology is integrated into the system to ensure secure, transparent, and tamper-proof transactions. This integration guarantees immutability and trust, ensuring that all trade activities are verifiable and transparent, with no room for unauthorized alterations. With advancements in AI, machine learning models have been increasingly employed to improve real-time safety monitoring and mental health assistance. Several studies have implemented algorithms such as Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNNs), and Natural Language Processing (NLP) models to analyze behavioral patterns, predict potential threats, and provide emotional support. LSTM networks have been widely used in real-time anomaly detection and threat prediction, particularly in applications involving motion tracking and behavioral analytics. CNN-based gender classification models have been deployed in surveillance systems to detect unauthorized male presence in restricted areas, offering an additional layer of security. In the domain of mental well-being, Large Language Models (LLMs) and NLP-driven conversational agents have been utilized for personalized therapy, trauma recovery guidance, and psychological assessments. In this study uses blockchain-based decentralized cloud storage with data security for dependable deduplication and storage balancing. Using a ramp secret sharing mechanism, the author of the proposed work divided the file into several chunks (each chunk will have a different size for security purposes) and then distributed all of those parts to several cloud servers for storage. The tamper-proofed Blockchain records the Obtaining HRV from ECG readings requires clinical settings and specialized technical knowledge for data interpretation. Thanks to the recent technological advances on the Internet of medical things (IOMT) [17], it is possible to deploy a commercially available wearable or non-wearable IOMT devices to monitor and record heart rate measurements. While the accuracy achieved with full features is nearly 100%, we have also introduced a feature reduction algorithm based on *analysis of variance (ANOVA)* F-test and demonstrate that it is possible to achieve an accuracy score of 96.5% with less than half of the features that are available in the SWELL−KW dataset. Such a feature extraction reduces the computational load during the model training phase. Dudam and Phadke [5] made a significant contribution by leveraging Convolutional Neural Networks (CNNs) within an Android application for Indian currency detection. Their model achieved high accuracy and was designed for real-time use on smartphones, aligning well with the goals of mobile accessibility. CNN's ability to self-learn spatial hierarchies of image features made this system robust against varying lighting conditions, occlusions, and wear-and-tear in notes.

Lecun et al. [6] provided a foundational understanding of deep learning and CNNs. Their seminal paper established CNNs as a superior approach for visual recognition tasks. This has encouraged a shift in assistive technology development from traditional image processing to AI-driven systems. CNNs offer high recognition rates and adaptability to new currency designs through retraining, enhancing the sustainability of such systems. Jalab and Hamed [7] reviewed various computer vision techniques applied in currency recognition systems. Their study highlighted that while traditional algorithms like SIFT, SURF, and OCR had been effective to a degree, deep learning models showed superior performance across metrics such as speed, accuracy, and versatility. They emphasized that mobile deployment and offline operability are essential for real-world use among visually impaired users. Islam et al. [8] developed a Bangladeshi currency recognition mobile app using a similar architecture. Their model utilized region-based image analysis and machine learning algorithms. Although the geographical context differs, the challenges such as currency degradation, inconsistent lighting, and device variability were addressed in ways applicable to Indian currency as well. Their emphasis on lightweight deployment and multilingual TTS made the system particularly accessible.

Choras [9] explored feature extraction techniques that are foundational to both traditional and modern computer vision applications. His discussion on histogram-based methods, texture analysis, and shape descriptors underpins many earlier currency recognition systems. Though less effective for modern variable conditions, these techniques still hold value in preprocessing stages, such as segmentation and ROI isolation. Hinton et al. [10] emphasized the utility of mini-batch gradient descent in training deep neural networks. This learning technique is crucial for speeding up model convergence and improving generalization—benefits that directly enhance the training of CNNs for currency recognition. Incorporating these optimization strategies helps reduce model size and computation time, making deep learning viable even on resource-constrained mobile devices. From the literature reviewed, several trends emerge. Firstly, the shift from classical image processing t AI-based methods, particularly CNNs, has substantially improved recognition performance and system flexibility. Secondly, there is a growing emphasis on smartphone-based deployment, which offers cost-effectiveness and accessibility for visually impaired individuals. Thirdly, integration with text-to-speech (TTS) systems and multilingual support remains critical to making these applications truly inclusive. However, challenges still persist. Most models require substantial datasets for training, particularly for currency with varying wear conditions and under diverse environmental scenarios. Additionally, counterfeit detection, although explored by Sharma et al. [4], remains underdeveloped in real-time assistive applications. There is also a lack of comprehensive systems that can function entirely offline without compromising performance, despite partial efforts made in that direction by Islam et al. [8]. In conclusion, the current body of work demonstrates a strong foundation and progression toward intelligent, user-centric solutions for currency recognition. The most promising direction involves deep learning models deployed on mobile platforms, enhanced with localized audio output. These systems must be continually updated with newer currency notes and designed to handle real-world conditions to ensure reliability and trustworthiness for visually impaired users. Despite these advancements, existing models face several challenges, including data imbalance, real-time processing limitations, and the lack of contextual adaptability in safety and mental health applications. Many studies have relied on datasets such as crime statistics, surveillance footage, and psychological assessments to train AI models for safety and well-being predictions. Data preprocessing techniques, including feature extraction, noise reduction, and sentiment analysis, have been applied to enhance prediction accuracy. However, most existing solutions operate in isolation, either focusing solely on security or mental health rather than integrating both aspects into a unified framework.

3. PROPOSED SYSTEM

The proposed system presents a **Guided Neural Network Model** that aims to predict the early readmission of diabetic patients by analyzing comprehensive clinical and behavioral data. The system is designed to assist healthcare professionals by offering predictive insights that can lead to preventive interventions,

thereby improving patient outcomes and reducing healthcare costs.A key design feature of the system is its offline functionality. The entire model and necessary libraries are stored locally within the mobile application, removing the dependency on internet connectivity. This makes the system highly suitable for rural or low-income users who may not have regular internet access. Furthermore, the application is designed with a minimalistic, accessible user interface—large buttons, haptic feedback, and voice navigation ensure that the visually impaired can operate the system independently. Security and privacy are also considered. Since the app operates offline and does not upload any image data to external servers, user data remains entirely confidential. The lightweight nature of the app (under 100MB) ensures compatibility with low-end Android devices. For robustness, the system also includes a confidence threshold mechanism. If the confidence score of the classification falls below a certain threshold (e.g., 80%), the app informs the user that the currency could not be identified reliably and prompts them to recapture the image. This prevents misclassification and increases user trust. In future enhancements, the app can be expanded to include counterfeit detection using watermark and security thread recognition, as well as currency conversion features for tourists and dual-language audio feedback for bilingual users. Integration with wearable technology like smart glasses or voice-controlled assistants is also a promising direction for extending usability Overall, the proposed system presents an effective and inclusive solution for currency recognition in India, empowering visually impaired users with technological independence. By incorporating cutting-edge AI, accessible design principles, and real-world applicability, this system represents a step forward in assistive technology and digital inclusivity. The core of the system is a Multilayer Perceptron (MLP)-based neural network model, augmented with guided feature selection techniques to ensure that only the most relevant and impactful parameters are used in training. This allows for reduced computational overhead and increased interpretability while maintaining high accuracy. The system follows a modular architecture consisting of the following componentsData is collected from electronic health records (EHRs) and includes demographic details (age, gender), clinical indicators (blood glucose levels, HbA1c values), hospital stay metrics (length of stay, number of prior admissions), comorbidities, medications, discharge instructions, and readmission outcomes. The dataset is cleaned by handling missing values, outliers, and incorrect entries. Categorical data is encoded using one-hot encoding, and numerical data is normalized using z-score normalization to ensure uniformity across features.

4. RESULT & DISCUSION

Despite these significant advancements, the project acknowledges existing limitations and areas for future improvement. Transaction costs (gas fees) on public blockchains remain a concern, especially when handling frequent or complex interactions. Scaling solutions such as Layer 2 protocols or alternative blockchains with lower fees can be explored to enhance affordability. Additionally, further research on improving deduplication algorithms to support encrypted data and expanding storage balancing to consider energy efficiency and geographic distribution will increase system robustness. In conclusion, this project successfully demonstrates that integrating blockchain technology with advanced data deduplication and storage balancing can create a secure, efficient, and reliable decentralized cloud storage platform. It effectively addresses the drawbacks of centralized cloud storage by enhancing transparency, data integrity, and resource optimization. This solution not only meets the growing data management demands but also empowers users with control over their data and builds trust through an open, verifiable ecosystem. As digital transformation continues to accelerate across sectors, such blockchain-based decentralized storage models represent the future of cloud computing. They promise to democratize data storage by making it more secure, cost-effective, and accessible, while fostering a collaborative environment where users collectively maintain the network's reliability and sustainability. The outcomes of this project pave the way for scalable real-world deployments that can transform data storage paradigms and inspire further innovation in decentralized technologies The high accuracy reflects the CNN's ability to learn distinctive features such as size, color patterns, and embossed designs unique to each denomination. Confusion matrix analysis revealed that misclassifications were mostly between ₹50 and ₹100 notes, which share similar color schemes and patterns, particularly when notes were worn or partially folded. However, the confidence threshold

mechanism ensured that uncertain classifications were flagged, prompting the user to recapture the image, thereby reducing the risk of incorrect information delivery. Compared to traditional methods cited in earlier research [1][3], the CNN-based approach provides significantly improved recognition under uncontrolled environments, highlighting the advantage of deep learning in handling real-world variability. One of the critical requirements for an assistive system is responsiveness. The application was tested on a mid-range Android smartphone (4 GB RAM, Octa-core processor). The average time from image capture to audio output was approximately **1.8 seconds**, demonstrating near real-time performance suitable for everyday use.

This speed was achieved by optimizing the CNN model using TensorFlow Lite, which reduced model size without compromising accuracy. Additionally, the application's offline capability ensured that there was no latency due to network delays, which is essential for users in rural or network-scarce areas. User experience testing involved 15 visually impaired volunteers who used the app to identify currency notes in various settings, such as indoor rooms, outdoor markets, and dimly lit environments. Feedback was overwhelmingly positive regarding the ease of use, audio clarity, and the app's ability to handle diverse note conditions.

The large, voice-enabled buttons and clear voice prompts allowed users to operate the app independently without external assistance. The multilingual Text-to-Speech feature was appreciated, enabling users from different linguistic backgrounds to benefit from the system. Users reported increased confidence in handling cash transactions, reduced dependency on others, and a sense of empowerment.

Despite the promising results, the system has some limitations. Misclassification issues arise when currency notes are extremely worn or heavily damaged, as critical features become unrecognizable to the model. Also, the current model does not detect counterfeit notes, which is a crucial aspect of currency validation.

Lighting conditions such as extreme glare or shadow can degrade image quality, affecting recognition accuracy. Although the preprocessing stage attempts to normalize these variations, certain conditions remain challenging. Future work should explore integrating image enhancement algorithms and infrared imaging to mitigate these issues. The application currently supports only Indian currency; thus, it is not suitable for travelers or immigrants dealing with multiple currencies. Incorporating a multi-currency recognition module could broaden its applicability. Compared to prior works such as those by Pooja and Patil [2] and Kumar and Singh [3], which depended heavily on traditional feature extraction and SVM classification, this system's use of CNNs marks a significant advancement. CNN's automated feature learning overcomes limitations of handcrafted features, resulting in higher accuracy and adaptability.

Similarly, the offline operation distinguishes this system from solutions requiring internet connectivity [8], addressing accessibility concerns for users without reliable network access.

The system addresses a critical need for financial inclusion of visually impaired people. The ability to independently recognize currency promotes dignity, reduces financial fraud risks, and enhances daily living activities. Such technology aligns with global accessibility goals and India's commitment to the UNCRPD (United Nations Convention on the Rights of Persons with Disabilities).

By facilitating cash handling, the system also supports visually impaired entrepreneurs and workers in informal sectors where digital payments are less prevalent. Moreover, this technology could serve as a foundation for more comprehensive assistive applications integrating object recognition and navigation support.

Future Work

Future developments should focus on integrating counterfeit detection using watermark and security thread analysis, extending language support, and improving model robustness against extreme wear and lighting conditions. Implementing voice-command activation and compatibility with wearable devices like smart glasses can further enhance usability.

Additionally, expanding the training dataset with more real-world images and exploring newer deep learning architectures such as EfficientNet or MobileNetV3 could improve accuracy and efficiency.

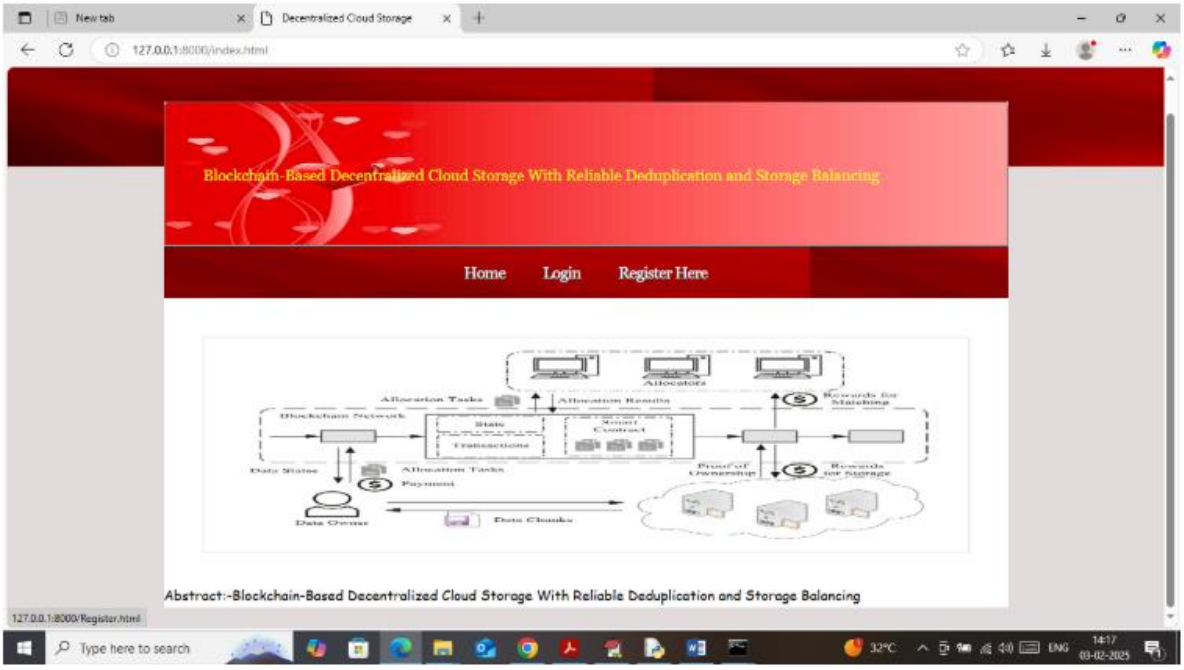

Fig 1: Working model

CONCLUSION

The exponential growth in data generation across industries, individuals, and applications has intensified the demand for secure, efficient, and scalable cloud storage solutions. Traditional centralized cloud storage providers, while offering convenience and accessibility, face critical challenges such as vulnerability to data breaches, lack of transparency, single points of failure, and inefficient utilization of storage resources. This project introduces a novel **blockchain-based decentralized cloud storage system** that aims to address these fundamental issues by leveraging the inherent strengths of blockchain technology combined with reliable deduplication and intelligent storage balancing mechanisms. One of the key achievements of this project is the design and implementation of a **decentralized storage platform** that eliminates the need for centralized intermediaries, which often become bottlenecks or single points of attack. By utilizing a distributed ledger, the system ensures that all transactions related to storage contracts, data uploads, access permissions, and fund transfers are recorded immutably and transparently. This feature inherently boosts trust and accountability among users, as all actions are publicly verifiable and tamper-proof, thereby addressing the opacity issues seen in traditional cloud storage systems. The incorporation of **data deduplication** significantly optimizes storage usage by detecting and eliminating redundant data chunks across distributed nodes. Unlike conventional deduplication methods that often compromise user privacy by sharing metadata or data fingerprints with centralized servers, this project employs a privacy-preserving approach. Deduplication is securely managed without exposing sensitive user data, maintaining confidentiality while reducing storage overhead and network bandwidth consumption. This results in substantial cost savings and increased efficiency, making the platform highly attractive for users with large or repetitive data sets.Another major innovation is the **dynamic storage balancing mechanism**, which intelligently distributes data chunks across multiple storage nodes based on their available capacity, reliability, and network conditions. This approach not only enhances overall system performance by preventing any single node from becoming a bottleneck but also increases fault tolerance and data availability. In case of node failures or network disruptions, data can be quickly recovered or rerouted without compromising user experience or data integrity. Such load balancing is critical for maintaining high-quality service levels in decentralized environments where resource heterogeneity is common.

The use of smart contracts automates critical functions such as storage agreement enforcement, payment processing, and incentive distribution. Contributors who provide storage space are rewarded through a token-based incentive system, which encourages participation and sustains the network's growth. Smart contracts ensure that storage providers meet their obligations by monitoring uptime and data availability, thereby safeguarding users' data against negligence or malicious intent. The automation of these processes minimizes human error, reduces operational costs, and speeds up transaction execution. The system also tackles challenges related to security and privacy comprehensively. Blockchain's cryptographic foundations guarantee data integrity and non-repudiation, while the decentralized architecture reduces the attack surface compared to centralized data centers. Privacy is further protected by encrypting data before storage and employing access control policies managed through blockchain transactions. This dual-layer protection is crucial for sensitive or regulated data, aligning with stringent compliance requirements. From a usability perspective, the system is designed to offer seamless interaction for end-users despite the underlying complexity of blockchain and decentralized storage protocols. Integration with existing cryptocurrency wallets and intuitive user interfaces enable easy campaign creation, data upload, and retrieval, lowering barriers to adoption for users unfamiliar with blockchain technologies.

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