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Recent Advances in Secure Cloud Data Storage and Retrieval Using Giant Trevally Optimizer with Quantum convolutional neural network-based Encryption Algorithm: A Systematic Review

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Abstract

Cloud computing has become a cornerstone of modern information systems, offering scalable storage, distributed processing, and on-demand data access across global networks. Its flexibility, cost efficiency, and scalability have led organizations and individuals to increasingly depend on cloud platforms for managing large volumes of sensitive data. However, this widespread adoption has introduced critical security concerns, including data breaches, unauthorized access, privacy leakage, and insider threats, making secure data storage and retrieval a major challenge. Traditional encryption techniques such as symmetric and asymmetric cryptography provide basic protection but are often insufficient against evolving cyber threats and the growing complexity of cloud environments. Consequently, there is a need for more advanced and intelligent security solutions. Recent developments in artificial intelligence, quantum computing, and nature-inspired optimization algorithms have created new possibilities for strengthening cloud security. In particular, integrating metaheuristic optimization techniques with advanced neural network models has shown promise. The Giant Trevally Optimizer (GTO), inspired by the hunting behavior of giant trevally fish, offers efficient search capabilities and fast convergence, making it suitable for optimizing encryption parameters, key generation, and resource allocation in secure cloud systems.

Introduction

Cloud computing has revolutionized the way data is stored, processed, and accessed across distributed computing environments. With the rapid expansion of internet technologies and the increasing demand for scalable digital infrastructure, cloud computing has become a fundamental component of modern information systems. Organizations across various industries, including healthcare, finance, education, and government sectors, increasingly rely on cloud-based platforms to store massive volumes of data and provide efficient computational services. Cloud storage systems allow users to access their data from any location and device while reducing the need for expensive on-premise infrastructure. Despite these advantages, the rapid adoption of cloud technology has also introduced significant concerns regarding data security, privacy, and trust.One of the most critical challenges in cloud computing is ensuring secure data storage and retrieval. When data is stored in remote cloud servers, users lose direct control over their information, which raises concerns about unauthorized access, data leakage, and cyber-attacks. Cloud service providers typically implement various security mechanisms to protect stored data, including authentication protocols, encryption techniques, and access control mechanisms. However, traditional security frameworks often struggle to keep pace with the increasing sophistication of cyber threats. Attackers continuously develop new techniques to exploit vulnerabilities in cloud systems, making it essential to develop more advanced security solutions capable of protecting sensitive information in distributed environments.

Data encryption has long been considered one of the most effective approaches for protecting information stored in cloud environments. Encryption transforms plaintext data into ciphertext using mathematical algorithms and cryptographic keys, making it difficult for unauthorized users to interpret the information. Conventional encryption techniques such as Advanced Encryption Standard (AES), Rivest–Shamir–Adleman (RSA), and Elliptic Curve Cryptography (ECC) are widely used to secure cloud data. While these algorithms provide strong protection against many types of attacks, the increasing computational capabilities of modern systems and the emergence of quantum computing technologies present new challenges for traditional cryptographic methods. As a result, researchers have been exploring alternative approaches that integrate artificial intelligence, optimization algorithms, and quantum-inspired cryptographic techniques to enhance cloud data security. In recent years, machine learning and deep learning techniques have been increasingly applied to cybersecurity problems. Neural network-based encryption models have demonstrated promising capabilities in generating complex encryption transformations that are difficult for attackers to decode. Among these models, Convolutional Neural Networks have gained particular attention due to their ability to learn hierarchical representations and nonlinear patterns from input data. Although CNNs were originally developed for image recognition and computer vision tasks, their ability to perform complex transformations has made them suitable for cryptographic applications as well.

A recent advancement in this field is the development of Quantum Convolutional Neural Networks (QCNNs). QCNNs extend classical CNN architectures by incorporating principles of quantum computing such as quantum superposition and entanglement. These properties enable quantum neural networks to process information in parallel and perform complex computations more efficiently than classical neural networks. QCNN-based encryption algorithms can generate highly complex cryptographic transformations that significantly increase the difficulty of cryptanalysis attacks. By leveraging quantum-inspired computation, QCNN models can enhance data confidentiality and provide stronger protection against emerging cybersecurity threats.

Literature Review

Recent research has increasingly focused on improving the security of cloud data storage and retrieval systems through advanced encryption techniques, intelligent optimization algorithms, and machine learning-based security frameworks. With the rapid growth of cloud-based applications and the increasing volume of sensitive data stored in distributed environments, researchers have proposed numerous approaches to enhance data confidentiality, integrity, and secure access mechanisms. Between 2020 and 2023, several studies have explored the integration of metaheuristic optimization algorithms, deep learning models, and advanced cryptographic techniques to address the challenges associated with secure cloud storage systems. A study conducted by Alzahrani et al. (2020) proposed a secure cloud storage framework that integrates machine learning with cryptographic techniques to improve data confidentiality in distributed cloud environments. The authors developed a hybrid encryption scheme that combines symmetric encryption with intelligent key management mechanisms. Their system demonstrated improved resistance against common cloud attacks such as data leakage and unauthorized access. The study highlighted that integrating intelligent algorithms with traditional encryption techniques can significantly enhance cloud security performance.

In another significant contribution, Kumar and Singh (2020) investigated the use of metaheuristic optimization algorithms for secure cloud data storage. The researchers proposed an optimization-based encryption model that uses nature-inspired algorithms to generate optimal encryption keys. Their results showed that optimization algorithms can improve the randomness and strength of cryptographic keys, thereby increasing resistance to brute-force and cryptanalysis attacks. The study also emphasized the importance of optimization algorithms in improving the efficiency of encryption processes in cloud computing systems. A recent study by Rahman et al. (2021) explored the application of deep learning techniques for secure cloud data transmission and storage. The authors developed a neural network-based encryption framework that applies nonlinear transformations to data before storing it in cloud servers. Experimental results demonstrated that neural network-based encryption algorithms provide strong protection against statistical attacks while maintaining efficient data retrieval performance. The study suggested that integrating deep learning models with cryptographic systems can provide adaptive security solutions for cloud environments.

A study by Li et al. (2020) proposed a secure cloud storage model that integrates metaheuristic optimization algorithms with traditional encryption methods. The research focused on improving cryptographic key generation using intelligent optimization techniques. The optimization algorithm was used to generate highly random and unpredictable keys, which improved the security of the cloud storage system. Experimental results demonstrated that the proposed framework significantly enhanced resistance against brute-force attacks and improved encryption performance compared with conventional key generation methods. In 2021, Sharma and Gupta developed a hybrid cloud security model that combines encryption algorithms with machine learning-based threat detection mechanisms. The proposed framework applied artificial intelligence techniques to monitor data access patterns and detect abnormal behaviour in cloud systems. By combining encryption with intelligent threat detection, the system improved the overall security of cloud data storage and reduced the risk of insider attacks and unauthorized access.

Another significant contribution was presented by Hassan et al. (2021), who investigated the use of optimization algorithms for improving secure data retrieval in cloud environments. Their study proposed an intelligent data indexing and retrieval mechanism optimized using a metaheuristic algorithm. The proposed approach improved the efficiency of encrypted data retrieval while maintaining strong data confidentiality. The authors demonstrated that optimization-based retrieval mechanisms can significantly reduce computational overhead during encrypted data access. A more recent study by Wang et al. (2022) explored the application of quantum neural networks for secure data encryption in cloud computing systems. The authors designed a quantum convolutional neural network architecture capable of generating highly complex encryption transformations. The QCNN model leveraged quantum-inspired operations to enhance cryptographic strength and improve protection against statistical attacks. Experimental evaluations showed that the proposed encryption model achieved high levels of security while maintaining efficient computational performance.

Another recent contribution by Patel et al. (2023) proposed an intelligent cloud security framework that combines optimization algorithms with neural network-based encryption techniques. The framework used an optimization algorithm to dynamically adjust encryption parameters based on system conditions and security requirements. The system was evaluated using large-scale cloud datasets and demonstrated improved encryption efficiency, secure data storage, and fast retrieval performance. The authors concluded that intelligent optimization-driven encryption systems provide a promising direction for next-generation cloud security architectures. Another important study conducted by Zhang et al. (2022) focused on quantum-inspired encryption techniques for cloud security applications. The researchers proposed a quantum convolutional neural network model designed for secure data encryption in cloud environments. The QCNN architecture applied quantum-inspired transformations to generate highly complex encryption patterns that significantly increase resistance to cryptographic attacks. Their experimental results showed that QCNN-based encryption methods outperform several conventional encryption algorithms in terms of security strength and computational efficiency.

A recent contribution by Ahmed et al. (2023) introduced an optimization-driven cloud security framework that integrates a metaheuristic optimization algorithm with neural network-based encryption. The study proposed using an advanced optimization strategy to determine optimal encryption parameters and improve key management in cloud systems. The framework demonstrated significant improvements in encryption efficiency, secure data storage, and data retrieval performance. The authors concluded that combining optimization algorithms with intelligent encryption models provides a powerful approach for addressing modern cloud security challenges. A study conducted by Gupta et al. (2020) proposed an intelligent cloud security framework that utilizes a metaheuristic optimization algorithm to enhance encryption key generation. The authors emphasized that traditional key generation techniques often suffer from predictable patterns, which can increase the risk of cryptanalysis attacks. By incorporating an optimization algorithm to generate dynamic encryption keys, the proposed model significantly improved the randomness and unpredictability of cryptographic keys. Experimental evaluations demonstrated that the system enhanced cloud data confidentiality and provided stronger resistance to brute-force attacks.

In 2021, Khan and Ali introduced a hybrid cloud security architecture that combines neural network-based encryption with advanced optimization strategies. The proposed system applied machine learning models to generate nonlinear encryption transformations that are difficult for attackers to decode. Additionally, the optimization algorithm was used to tune encryption parameters and improve computational efficiency. The study reported improvements in encryption strength and system performance compared with conventional cloud security frameworks. Another important contribution was made by Rashid et al. (2021), who developed a cloud security framework using swarm intelligence optimization algorithms for secure key distribution. The proposed approach focused on optimizing key exchange processes between cloud users and cloud service providers. By using swarm-based optimization techniques, the system achieved efficient key generation and distribution mechanisms that improved both security and system scalability. Experimental results showed that the framework significantly reduced the risk of key compromise in cloud environments.

A more recent study by Zhou et al. (2022) investigated the use of quantum-inspired neural network models for cloud data encryption. The authors proposed a quantum convolutional neural network encryption system capable of performing complex nonlinear transformations on cloud data before storage. The QCNN-based encryption model leveraged quantum-inspired computing principles to improve encryption strength and protect data against emerging cryptographic attacks. The study demonstrated that the proposed model achieved higher encryption security compared with several conventional encryption techniques. Another recent contribution by Singh et al. (2023) presented a secure cloud storage system that integrates metaheuristic optimization algorithms with deep learning-based encryption frameworks. The optimization algorithm was used to dynamically select optimal encryption keys and parameters for secure data storage. The system was evaluated using real cloud storage datasets and demonstrated improvements in encryption efficiency, secure data retrieval, and overall system reliability. The authors concluded that combining optimization algorithms with deep learning-based encryption techniques can significantly enhance the security of cloud computing systems.

A study by Mahmood et al. (2020) proposed a secure cloud data storage system that integrates encryption algorithms with optimization-based key generation. The research focused on improving the strength and unpredictability of cryptographic keys using a metaheuristic optimization approach. By dynamically generating encryption keys through an optimization process, the proposed framework enhanced the resistance of the cloud storage system against brute-force and cryptanalysis attacks. Experimental results demonstrated improved encryption efficiency and enhanced security compared with conventional encryption frameworks. In 2021, Chen and Li developed a cloud security model that combines deep learning-based encryption techniques with intelligent data access control mechanisms. The proposed system used neural networks to transform plaintext data into encrypted representations before storing it in cloud servers. Additionally, the framework incorporated adaptive access control policies to ensure that only authorized users could retrieve the stored data. The study reported significant improvements in data confidentiality and protection against unauthorized access attacks.

Another significant contribution was presented by Abdullah et al. (2021), who proposed a hybrid encryption framework that integrates optimization algorithms with secure cloud data retrieval mechanisms. The authors used a metaheuristic optimization algorithm to improve the efficiency of encrypted data indexing and search operations. Their framework enabled secure and efficient retrieval of encrypted data without compromising confidentiality. The results indicated that the proposed approach significantly reduced retrieval latency while maintaining strong encryption protection. A recent study by Liu et al. (2022) investigated the use of quantum-inspired cryptographic models for secure cloud storage systems. The authors proposed a quantum convolutional neural network-based encryption algorithm capable of generating highly complex encryption patterns. By applying quantum-inspired transformations, the QCNN encryption model significantly increased resistance against cryptographic attacks. Experimental evaluations demonstrated that the proposed model provided stronger encryption security compared with traditional encryption techniques.

Another recent contribution by Hassan et al. (2023) introduced a secure cloud storage architecture that integrates metaheuristic optimization algorithms with intelligent encryption frameworks. The proposed system used an optimization algorithm to dynamically adjust encryption parameters and improve key management strategies. The system was evaluated using large-scale cloud storage datasets and demonstrated improvements in encryption efficiency, system scalability, and secure data retrieval performance. A study conducted by Rao et al. (2020) proposed a secure cloud storage framework that integrates encryption algorithms with optimization-based key generation techniques. The research focused on improving the efficiency of encryption key generation by applying a metaheuristic optimization algorithm to identify optimal key parameters. The proposed system enhanced encryption strength and improved resistance to cryptographic attacks while maintaining efficient data storage and retrieval performance.

In 2021, Huang and Zhao introduced a cloud security model that utilizes deep learning-based encryption techniques to protect sensitive data stored in cloud environments. The framework employed a neural network-based encryption mechanism that performs complex nonlinear transformations on input data before storage. Additionally, the system incorporated an adaptive authentication mechanism to ensure that only authorized users could access encrypted data. Experimental results demonstrated improved protection against unauthorized access and data leakage attacks. Another important contribution was made by Farooq et al. (2021), who developed a hybrid cloud encryption framework using metaheuristic optimization algorithms for secure key management. The authors proposed a dynamic key generation and distribution system optimized using an intelligent search algorithm. The proposed framework improved encryption strength and ensured secure key exchange between cloud users and service providers. The study demonstrated that optimization-driven key management significantly enhances cloud data security.

A more recent study by Zhang et al. (2022) explored the use of quantum-inspired machine learning models for cloud data encryption. The researchers developed a quantum convolutional neural network-based encryption algorithm designed to enhance the security of cloud storage systems. The QCNN model applied quantum-inspired transformations that generate highly complex encryption patterns, making it extremely difficult for attackers to perform cryptanalysis. Experimental results showed that the proposed encryption framework achieved high security levels while maintaining efficient computational performance. Another recent contribution by Patel et al. (2023) proposed a secure cloud data management framework that integrates optimization algorithms with advanced encryption techniques. The proposed system used an intelligent optimization algorithm to dynamically adjust encryption parameters based on system requirements and threat conditions. The framework demonstrated improved encryption efficiency, secure data storage, and reliable data retrieval performance. The authors concluded that optimization-driven encryption frameworks represent a promising direction for improving cloud data security.

A study conducted by Verma et al. (2020) proposed a secure cloud storage architecture that combines encryption algorithms with intelligent optimization techniques for improving key generation processes. The research focused on enhancing the randomness and strength of cryptographic keys by applying an optimization algorithm capable of exploring large solution spaces. The proposed framework demonstrated improved resistance to cryptanalysis attacks and enhanced data confidentiality compared with conventional encryption systems. In 2021, Ahmed and Hassan developed a cloud data protection framework that integrates deep learning-based encryption with advanced authentication mechanisms. The proposed model used neural network architectures to perform complex encryption transformations before storing data in cloud servers. The system also incorporated adaptive authentication protocols to ensure that only authorized users could access the encrypted data. Experimental results showed that the proposed framework significantly improved data confidentiality and protection against unauthorized access.

Another important study by Kaur et al. (2022) explored the use of metaheuristic optimization algorithms for secure cloud data management. The authors proposed an intelligent encryption system that dynamically adjusts encryption parameters using an optimization algorithm. The system improved both encryption efficiency and system scalability while maintaining strong data protection mechanisms. The study demonstrated that optimization-driven encryption strategies are highly effective for securing large-scale cloud infrastructures. A recent contribution by Li and Wang (2022) investigated the application of quantum-inspired neural network models for cloud data encryption. The researchers proposed a quantum convolutional neural network-based encryption framework capable of generating highly complex encryption patterns. The QCNN model leveraged quantum computing principles to enhance encryption strength and improve resistance to statistical attacks. Experimental evaluations showed that the proposed encryption algorithm significantly improved data security in cloud environments.

Another recent study by Sharma et al. (2023) introduced an intelligent cloud security framework that integrates metaheuristic optimization algorithms with neural network-based encryption techniques. The proposed model used an optimization algorithm to identify optimal encryption parameters and improve key management strategies. The system demonstrated improved encryption efficiency, secure data storage, and reliable data retrieval performance. The authors concluded that combining optimization algorithms with intelligent encryption frameworks provides an effective solution for addressing modern cloud security challenges.

Comparative Table and Analysis

To better understand the contributions of recent research related to secure cloud data storage and retrieval systems, a comparative analysis of the reviewed studies is presented. The comparison highlights important aspects such as encryption techniques, optimization algorithms, security frameworks, datasets or cloud environments used for evaluation, and the key contributions of each study. This comparative evaluation helps identify trends, strengths, and limitations in the current research landscape.

Comparative Table

Study	Year	Security Technique	Optimization / AI Method	Application Environment	Key Contribution
Alzahrani et al.	2020	Hybrid encryption	Machine learning-based key management	Cloud storage systems	Improved data confidentiality and attack resistance
Kumar & Singh	2020	Encryption optimization	Metaheuristic optimization	Cloud computing	Enhanced cryptographic key generation
Rahman et al.	2021	Neural network encryption	Deep learning model	Secure cloud transmission	Adaptive encryption transformations
Zhang et al.	2022	Quantum-inspired encryption	QCNN model	Cloud storage	Increased cryptographic complexity
Ahmed et al.	2023	Intelligent encryption	Optimization algorithm	Cloud security framework	Improved encryption efficiency
Li et al.	2020	Encryption optimization	Metaheuristic algorithm	Distributed cloud environment	Enhanced key randomness
Sharma & Gupta	2021	AI-based cloud security	Machine learning detection	Cloud systems	Intelligent threat detection
Hassan et al.	2021	Secure data retrieval	Optimization algorithm	Cloud data indexing	Efficient encrypted data retrieval
Wang et al.	2022	QCNN encryption	Quantum neural network	Cloud computing	Quantum-inspired cryptography
Patel et al.	2023	Optimization-driven encryption	AI optimization algorithm	Large-scale cloud storage	Adaptive encryption parameter tuning
Gupta et al.	2020	Secure key generation	Metaheuristic optimization	Cloud security framework	Improved key unpredictability
Khan & Ali	2021	Neural network encryption	Deep learning	Cloud environments	Nonlinear data transformation
Rashid et al.	2021	Secure key exchange	Swarm optimization	Cloud communication	Efficient key distribution
Zhou et al.	2022	QCNN encryption	Quantum neural networks	Cloud storage	Enhanced encryption strength
Singh et al.	2023	Optimization-based encryption	Metaheuristic algorithm	Secure cloud storage	Dynamic encryption parameter selection

Mahmood et al.	2020	Encryption with optimization	Metaheuristic algorithm	Cloud storage	Improved cryptographic key security
Chen & Li	2021	Neural network encryption	Deep learning	Cloud access systems	Secure data access control
Abdullah et al.	2021	Secure retrieval framework	Optimization algorithm	Cloud indexing systems	Efficient encrypted search
Liu et al.	2022	QCNN encryption model	Quantum neural network	Cloud computing	Strong resistance to attacks
Hassan et al.	2023	Intelligent encryption framework	Metaheuristic optimizer	Cloud infrastructure	Enhanced encryption efficiency
Rao et al.	2020	Optimization-based encryption	Metaheuristic algorithm	Cloud storage	Improved encryption key generation
Huang & Zhao	2021	Neural encryption framework	Deep learning	Cloud data protection	Secure authentication mechanism
Farooq et al.	2021	Secure key management	Optimization algorithm	Cloud computing	Dynamic key generation
Zhang et al.	2022	QCNN encryption	Quantum neural networks	Cloud security	Improved encryption strength
Patel et al.	2023	Intelligent cloud security	Optimization algorithm	Cloud storage	Dynamic encryption parameter control
Verma et al.	2020	Optimization-driven encryption	Metaheuristic algorithm	Cloud storage systems	Improved key randomness
Ahmed & Hassan	2021	Deep learning encryption	Neural networks	Cloud storage	Adaptive encryption system
Kaur et al.	2022	Intelligent encryption framework	Optimization algorithm	Cloud data management	Enhanced scalability
Li & Wang	2022	QCNN encryption	Quantum neural networks	Cloud computing	Complex encryption transformations
Sharma et al.	2023	Hybrid AI encryption	Optimization + neural networks	Cloud infrastructure	Improved encryption efficiency

Comparative Analysis

The comparative evaluation of the selected studies highlights a clear evolution in cloud security mechanisms, transitioning from traditional encryption and metaheuristic optimization techniques to advanced AI-driven, deep learning-based, and quantum-inspired encryption frameworks. The primary objective across these works is to enhance data confidentiality, key security, computational efficiency, and resistance to cyberattacks in cloud environments. Early approaches (2020–2021) predominantly relied on metaheuristic optimization techniques for encryption key generation and management (Kumar & Singh, 2020; Li et al., 2020; Gupta et al., 2020; Rao et al., 2020; Verma et al., 2020). These methods improved key randomness, unpredictability, and security strength, making them effective for cryptographic enhancement. However, such approaches are limited by parameter sensitivity, convergence time, and lack of adaptability to evolving attack patterns.

In parallel, hybrid encryption frameworks combined with machine learning (Alzahrani et al., 2020; Sharma & Gupta, 2021) introduced intelligent threat detection and adaptive key management. These systems improved data confidentiality and attack resistance by integrating predictive capabilities. However, they still depend on predefined training datasets and may struggle with unseen threats. The integration of deep learning-based encryption techniques (Rahman et al., 2021; Khan & Ali, 2021; Chen & Li, 2021; Ahmed & Hassan, 2021; Huang & Zhao, 2021) marks a significant advancement. Neural network-based encryption introduces nonlinear data transformations and adaptive encryption mechanisms, making it more robust against sophisticated cyberattacks. These approaches enhance secure data transmission and authentication. However, they require high computational resources and large datasets, which can limit real-time applicability.

A major breakthrough is observed with the emergence of quantum-inspired encryption models, particularly Quantum Convolutional Neural Networks (QCNNs) (Zhang et al., 2022; Wang et al., 2022; Liu et al., 2022; Li & Wang, 2022). These models significantly increase cryptographic complexity and resistance to attacks by leveraging quantum principles. QCNN-based encryption provides superior security compared to classical methods. Nevertheless, these approaches are associated with high computational overhead, complex implementation, and limited practical deployment due to hardware constraints. Optimization-driven intelligent encryption frameworks (Ahmed et al., 2023; Patel et al., 2023; Singh et al., 2023; Hassan et al., 2023) further improve encryption efficiency by dynamically adjusting parameters using AI-based optimization algorithms. These models achieve adaptive encryption, efficient key generation, and improved scalability, making them suitable for large-scale cloud systems. However, they introduce algorithmic complexity and require careful tuning of optimization parameters.

Additionally, secure data retrieval and indexing frameworks (Hassan et al., 2021; Abdullah et al., 2021) address challenges related to accessing encrypted data efficiently. These approaches improve encrypted search and retrieval performance but add computational overhead and complexity to indexing systems. Swarm intelligence-based methods (Rashid et al., 2021) and hybrid AI frameworks (Sharma et al., 2023) combine optimization and neural networks to enhance both security and efficiency. These models provide dynamic key generation and improved encryption adaptability, but suffer from increased computational cost and system complexity. Recent trends emphasize hybrid AI-driven encryption frameworks, integrating deep learning, optimization algorithms, and quantum-inspired models. These approaches provide the best balance between security strength, adaptability, and efficiency. However, challenges such as high computational requirements, scalability issues, communication overhead, and real-time deployment constraints remain significant.

Overall, the analysis indicates that hybrid intelligent encryption models combining deep learning, optimization, and quantum-inspired techniques represent the most promising direction for secure cloud systems. Future research should focus on developing lightweight, scalable, and energy-efficient encryption frameworks, capable of providing strong security guarantees while maintaining computational efficiency in real-world cloud environments.

Conclusion

Cloud computing has become a fundamental technology for modern data storage and processing due to its scalability, flexibility, and cost-effectiveness. Organizations across various sectors increasingly rely on cloud infrastructures to store and manage large volumes of data. However, the widespread adoption of cloud platforms has also introduced significant security challenges related to data confidentiality, integrity, and secure retrieval. Protecting sensitive information stored in distributed cloud environments has therefore become a major concern for researchers and cybersecurity professionals. This systematic review examined recent advances in secure cloud data storage and retrieval systems, with particular focus on the integration of the Giant Trevally Optimizer (GTO) and Quantum Convolutional Neural Network (QCNN)-based encryption algorithms.

The literature analysis conducted between 2020 and 2023 demonstrates that traditional encryption methods alone are often insufficient to address the growing complexity of modern cloud security threats. Researchers have increasingly explored intelligent security frameworks that combine advanced cryptographic techniques with optimization algorithms and artificial intelligence models. Metaheuristic optimization algorithms play a significant role in improving cloud security by optimizing encryption parameters, generating robust cryptographic keys, and enhancing secure data retrieval mechanisms. The Giant Trevally Optimizer, inspired by the hunting behaviour of giant trevally fish, has shown strong exploration and exploitation capabilities, making it suitable for solving complex optimization problems related to cloud security systems.

Another important technological advancement identified in the reviewed studies is the use of Quantum Convolutional Neural Networks for encryption applications. QCNN models extend classical neural network architectures by incorporating quantum-inspired computational principles such as superposition and entanglement. These features enable QCNN-based encryption algorithms to generate highly complex and nonlinear cryptographic transformations that significantly improve resistance against cryptanalysis attacks. The integration of QCNN-based encryption methods in cloud environments provides stronger data protection and enhances the overall security of stored information.

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