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Challenges and Opportunities of Multimedia Database Management: A Systematic Review

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Abstract

With the huge amount of multimedia in the modern world, it is a must to optimize its performance more than ever. This systematic review delves into the challenges and opportunities of multimedia database management systems. The author identified the existing challenges hindering the optimal performance of the system by synthesizing related literature and studies, using thematic analysis, as storage, security, computational efficiency, interoperability, and real-time processing. Potential opportunities were also identified in the review, on the other hand, gaps and limitations were also unveiled. With these identified variables, ARK Multimedia Database Management Sphere was designed to have seven (7) features: storage, data modeling & indexing, retrieval and querying, real-time processing & performance, security & privacy, scalability, and interoperability features. The framework offers a comprehensive approach to address current multimedia database management systems' challenges, gaps, and limitations.

Index Terms: Challenges, Database, Database Management Systems, Multimedia, Opportunities.

I. Introduction

The advent of digital media has changed how data and information are being mitigated. Storing, managing, and retrieving types of media encompassing images, audio, video, and models are the critical functions of multimedia databases. This has grown at a significant rate and there is still a growing demand for fast storage and retrieval systems, the scope and complexity of database management systems (DBMS) have expanded significantly. Applications range from social networks, online video platforms, and digital libraries to surveillance and medical imaging systems. However, despite the crucial nature of the characteristics to be managed, managing multimedia data is a challenge owing to its large size, diversity of data, its unstructured nature, and computational demands.

With the advancement of computer technology, the crucial role of data management has never been important. The management of multimedia data falls under the ambit of the challenges that conventional relational databases cater to [1, 2]. To this end, rather than external audiences, multimedia data is unstructured and unique in that it has a different approach in terms of storage, retrieval, and processing. Therefore, for the effective implementation of multimedia databases, a range of data types and large amounts of space have to be made available for storage.

One of the most serious problems is the volume of multimedia files. High-definition videos, huge medical image files, and other similar data-heavy media files are difficult, not to say, expensive to store and sometimes even more than what a customary database management system can accommodate [3]. Furthermore, data coding and indexing let alone modeling is further made complex by the existence of multiple types of 3D, audio, video, and images. Such advanced forms of search and retrieval claim the need for the notion of complex algorithms [4]**.** In addition, however, the retrieval of multimedia data also brings difficulties because textual search methods are not appropriate in this environment where the multimedia elements are abundant. To achieve such requirements, VCR and ML-based CBIR methods have been proposed in the literature. However, they need high computing capabilities and complex algorithms [5, 6]**.**

The introduction of multimedia databases can be a game-changer in the face of these challenges. For instance, they make possible sophisticated applications in personalized recommendations, visual search programs, and analytics tools. Multimedia databases in e-commerce assist in generating tailored content suggestions, while in the case of healthcare, they assist in designing diagnostics technologies – media, video, and sensor-based [7, 1]. The newer technologies in AI and ML have also given more depth to multimedia databases allowing for automatic arrangement of data, improved tagging of contents, and better user experience. These technologies enable better handling of vast amounts of multimedia datasets, easing the scalability and the processing time for data [8].

This systematic review aims to evaluate the challenges, opportunities, and potential solutions in multimedia database management systems. It assessed the opportunities for enhancing efficiency, accuracy, and scalability in multimedia data management. Additionally, the review identifies significant gaps and limitations in current multimedia database systems. Based on these findings, the review proposes a comprehensive framework to address these challenges.

II. Research Methodology

The study utilized a systematic literature review of the issues, opportunities, and solutions for the management of multimedia database systems and employed thematic analysis that involves systematically identifying, classifying, and reviewing based on the key patterns with meaningful insights that apply to the research topic. These studies were reduced to 37 thorough related studies that met the research questions and addressed the designated objectives after 56 published works from 2020–2024 were chosen and reviewed. The research methods include searching using keywords from peer-reviewed articles and industry reports from academic index databases such as Google Scholar, IEEE Xplore, Springer Nature Link, IEETA, MDPI, Wiley, Science Direct, and Research Gate focusing on storage, data modeling, performance, querying, and conversion challenges. To gain applied knowledge of the real-world usage of multimedia databases, relevant case studies from e-commerce, healthcare, smart cities, and other sectors will be reviewed. Findings from the literature will be integrated to formulate key themes, gaps, and best practices. Such gaps and weaknesses will be used to suggest a comprehensive model that will seek to post the opportunities for improving the efficiency, accuracy, and the scalability of management of multimedia databases.

III. Results and Discussion

The management of multimedia data in database systems presents several challenges and opportunities. These challenges primarily stem from the various nature of multimedia data, large file sizes, performance demands, and data security requirements, especially as multimedia content proliferates in IoT, healthcare, smart cities, and other emerging applications. This discussion presents the key challenges, opportunities, and potential solutions in multimedia database management systems (MDBMS), drawing upon recent literature and highlighting the advancements in addressing the growing demands of multimedia systems.

A. Key Challenges in Multimedia Database Management

This review presents problems and issues identified in the reviewed literature. This includes issues in storage, data security and privacy, computational efficiency, data interoperability, and real-time processing.

TABLE I: PRIMARY CHALLENGES IN THE MANAGEMENT OF MULTIMEDIA DATABASES

THEME	CHALLENGES	STUDIES SUPPORTING THE THEME
Multimedia Data Storage	1. High volume and space requirements for storage. 2. Poor retrieval times and performance problems. 3. Scalability and management challenges.	Mahmoudi & Belarbi (2022), Babar et al. (2021), Bello & Asagba (2021), Yang et al. (2020), Li et al. (2021), Tanwar et al. (2020), Debauche et al. (2022)
Data Security and Privacy	1. Risks of illegal access and piracy in cloud storage. 2. Inadequate IoT security solutions. 3. Vulnerabilities in healthcare IoT systems.	Rekha et al. (2024), Hu et al. (2022), Deepa et al. (2022), Rathee et al. (2020), Gadde et al. (2024), Islam et al. (2021), Dhar et al. (2022)
Computational Efficiency	1. High-dimensional data leading to slower retrieval times. 2. High computational load causing latency issues. 3. Need for better algorithms.	Babar et al. (2021), Mahmoudi & Belarbi (2022), Yang et al. (2020), Maddumala & Arunkumar (2020), Sathio et al. (2024)
Data Interoperability	1. Difficulty in integrating heterogeneous multimedia data. 2. Challenges in managing diverse formats and protocols. 3. Need for resource management.	Yang et al. (2020), Sathio et al. (2024), Gao et al. (2021), Babar et al. (2021), Tanwar et al. (2020)
Real-time processing	1. Delays in processing due to latency and data congestion. 2. Difficulty in handling heterogeneous sensor data. 3. Strain on real-time processing in various industries. 4. Middleware limitations for unstructured events and inefficiency with unseen object classes.	Debauche et al. (2022), Yang et al. (2020), Tanwar et al. (2020), Gasser (2023), Sathio et al. (2024), Aslam & Curry (2021)

a. Multimedia Data Storage

Due to its high volume and space requirements, multimedia data storage continues to be one of the most pressing concerns within its system. According to [5], the increasing volume of multimedia data presents a risk that needs to be addressed. Similarly, [9, 8] noted that large-scale multimedia content results in poor retrieval times and performance problems for conventional storage systems. This finding is further supported by [10] who discovered that the scalability and management of multimedia data are impacted by heterogeneous multimedia sensors, communication problems, and cloud storage limitations. [11] also focused on the challenge of searching through vast video datasets. Furthermore, [10] emphasizes this issue, highlighting how IoT devices generate massive multimedia datasets that strain existing storage infrastructures, particularly in the healthcare and smart city sectors. [12] also discovered issues with storage and data congestion in IoT multimedia systems, which further hinder performance and cause problems in several academic and professional domains. These studies emphasize the need for improved storage options to guarantee efficiency in data handling and retrieval, especially for large-scale and heterogeneous multimedia data.

b. Data Security and Privacy

Another significant issue is the security of sensitive multimedia data, especially in IoT and healthcare domains. Numerous studies focus on the security issues related to IoT-based systems and cloud-based storage. For instance, [13] draw attention to the dangers of illegal access and cloud-based multimedia content piracy. In addition, [15] highlights problems with the efficiency and scalability of current IoT security solutions for multimedia data. Furthermore, [16] points out that the variety of data formats in healthcare IoT systems makes them vulnerable to malicious exploitation and security threats. Accordingly, [17] considers that inappropriate users and cyberattacks are notes affecting cloud storage. Moreover, [18] highlights the problems of latency and security of sending a considerable amount of multimedia data in MIoT. Finally, [19] primarily indicates the security-related problems and inefficiencies of such approaches in IoT systems that are centralized, especially for multimedia data sharing. These challenges stress the need for improved security frameworks to protect sensitive multimedia data, especially in critical applications like healthcare and smart cities.

c. Computational Efficiency

Multimedia database systems also face substantial and complex dimensionality and computational efficiency issues. Tasks involving content-based retrieval and feature extraction frequently involve high-dimensional data, which results in computational inefficiencies. [9, 5] point out that a multimedia dataset's high feature count may lead to slower retrieval times. Additionally, [10] reiterates that important resources are a must especially in the context of computational load processing as it consequently results in performance bottlenecks and latency issues. [2, 4] highlights that the performance of traditional data management systems will jeopardize the aspect of scalability with large and expanding data sets. The difficulties in the dynamics of data processing can be compromised as it increases redundancy and adds the computational costs, particularly, when features are extracted from high-dimensional data. In conclusion, traditional data systems failed to optimize data management with the increasing volume of data and its dimension, notably emphasizing the need for intervention such as effective algorithms and methods.

d. Data Interoperability

In an environment with heterogeneous devices and platforms, data interoperability remains a significant challenge. [10] made it clear that this issue emerges across diverse sensors and communications systems in

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IOT networks when managing multimedia, emphasizing the complexity in managing data efficiency. In a similar vein, , [4] emphasizes the barriers of applying multimodal data from different sources such as conflict in management and classification. [20] also offered solutions enabling smooth communication of resource management systems as well as the integration of different multimedia data types in IOT settings. [9] further highlighted multimedia data integration but noted the complexity in attaining standardization and compatibility of different technologies in IoT systems. Finally, [1] pointed out that exchanging and managing data formats is a complex challenge especially in the context of different sectors such as healthcare, smart cities, where multimedia data must be present from different IoT devices. These studies define the importance of addressing data interoperability to enhance the efficiency of multimedia systems.

e. Real-time Processing

Real-time processing of multimedia systems presents significant challenges in certain applications. [12] outline how challenging it is to ensure near real-time processing in IoT multimedia systems, especially in applications involving virtual and augmented reality, where latency and data congestion cause delays. [10] highlighted how issues in managing heterogeneous data for sensors from Internet of Things systems cause problems to decide rapidly since real time processing is interfered with through the slow rate of processing and vast computing requirements. [1] further observed that the enormous amounts of multimedia data produced by these devices often swamp current system structures in smart cities as well as health care to experience delays during processing or retrieval. Similar to this, [3] discussed how industries like healthcare and entertainment are posing a lot of pressure on current technologies because processing big datasets in real time requires lots of processing power. [4] also mentioned that real-time data clustering and classification in multimedia systems is challenging, especially when using multimodal data and deep learning approaches. Finally, [12] identified challenges in the Internet of Medical Things (IoMT), highlighting issues with multimedia event processing in smart city applications focusing on the middleware limitations for unstructured events and inefficiencies with unseen object classes. These findings highlight the need for advancements in real-time data processing to support time-sensitive multimedia applications.

B. Opportunities in Multimedia Database Systems

Multimedia databases offer numerous opportunities across various domains due to the increasing amount of multimedia content (images, video, audio, text, etc.) being generated. This includes efficiency, accuracy, and scalability of data management.

TABLE II: OPPORTUNITIES FOR INNOVATION IN MULTIMEDIA MANAGEMENT

THEME	OPPORTUNITIES	STUDIES SUPPORTING THE THEME
Efficiency	1. Improved resource utilization for large datasets. 2. Optimization of bandwidth usage and latency for better performance in multimedia systems. 3. Adaptive compression techniques. 4. Improved software artifact	Bello & Asagba (2021), Nauman et al. (2021), Wang (2020), Tanwar (2020), Gasser (2023, Prajapati et al. (2021), Anshari (2024), Zhao et al. (2022)[6]

	visualization, search trajectory, and SBSE optimization processes.	
Accuracy	1. Feature extraction and dimensionality reduction for improving classification accuracy. 2. Cross-modal representation for accurate video-text retrieval. 3. Content-based image retrieval using CNNs. 4. The 15Vs model improves real-time performance and data accuracy.	Maddumala & Arunkumar (2020), Li et al. (2021), Mahmoudi & Belarbi (2022), Zheng et al. (2024), Sathio et al. (2024), Mahabadi & Abdolazimi (2024)
Scalability of Data Management	1. Enhanced scalability in IoMT systems via edge and cloud computing. 2. Multi-tiered architectures for scalable multimedia data management. 3. SDN-based forwarding and HetNet for scalable multimedia systems. 4. Enhanced BDA tools for better insights, efficiency, and policy recommendations in industrial settings.	Yang (2020), Gao et al. (2021), Babar et al. (2021), Debauche et al. (2022), Tiwana & Singh (2024), Sultan & El Sayed (2023), Dhar et al. (2022), Ikegwu et al. (2022), Thang et al. (2022)

a. Efficiency

Research on multimedia database management systems has been available, and it is essential for tackling performance issues and problems like processing time, storage systems, and resource management. To begin with, [8] focused on the processing, storage, and retrieval of large data sets. They highlighted the need to establish a specialized database management system for large data sets that are capable of accommodating large data sets for IoT multimedia devices. In data-intensive environments, their suggested multimedia database management system (MMDBMS) architecture allows for improved resource utilization while preserving high performance. Similarly, to enhance the Quality of Experience and Quality of Service in multimedia Internet of Things applications, [23] leveraged advanced computational technologies by investigating the integration of edge computing, cloud computing, and Software-Defined Networking (SDN). Optimizing bandwidth usage and lowering latency, improves processing efficiency and data transmission. Performance in settings with a lot of data. This enhances data transmission and processing efficiency by optimizing bandwidth usage and reducing latency. [24] investigated multimedia integration for problem formulation and optimization in Search-Based Software Engineering (SBSE). They improve software artifact visualization and optimization procedures while addressing the intricacy of software challenges and metaheuristic algorithms. Notably, [25] has worked on adaptive compression techniques for efficient data handling and proposes an adaptive Huffman coding algorithm tailored for sensor data compression in Wireless Sensor Networks (WSNs). This algorithm mitigates the limitation of memory and computing efficiency, thus, improving the performance of cloud applications. In the act of removing redundancy, the user will benefit from optimal performance by generating more storage and facilitating smooth data handling in a setting of limited computational capabilities. In addition, [1] focused on optimizing big data management in IoT systems. He applied the integration of advanced compression, and machine learning techniques, beneficial for smart city environments and healthcare systems as the data accumulation could pile up and compile a huge volume of multimedia for its records and cases. Efficient algorithms are used to process data in real time, greatly enhancing storage and retrieval capabilities in IoT-integrated MMDBMS. Finally, [3] incorporated multimedia analytics for query optimization. By doing so, the development of the querying process and through data analytic tools and algorithms became faster in retrieving processes and better multimedia management. This approach is particularly beneficial for applications that need quick decision processes like video-streaming services and e-commerce. Finally, [7] highlighted the efficiency of multimedia tools in e-learning by enhancing user engagement through interactive features. By optimizing pedagogical strategies and improving learner interaction, multimedia tools contribute to better educational outcomes and more effective learning experiences. Building on this, [6] also emphasized the efficiency of multimedia in enhancing engagement, particularly in the context of financial accounting education.

b. Accuracy

The need for transparency, precision, retrieval of data, and classifications is crucial for data management systems. The mentioned studies outlined the opportunities and approaches to enhance accuracy through advanced technologies and methodologies. Combining advanced feature extraction techniques with dimensionality reduction, [2] proposed the WbFEM -MMB (Weighted-based Feature Extraction Model for Multimedia Big data) feature extraction and dimensionality reduction for reducing noise and optimizing computational efficiency. This helps for accuracy particularly in large data sets as it enhances classification features. [11], on the other hand, introduce the Sentence Encoder Assembly (SEA) model for cross-modal representation for text-video retrieval. This model achieved advanced retrieval accuracy as it balances the encoder-specific representation for text queries and video data. This is highly advantageous for multimedia systems that need accurate video search input based on text like entertainment or educational applications.

[26] proposed a 15Vs model for processing large image data in IoMT and big data applications. They address the issues of slow processing and poor real-time performance in traditional classification methods. The 15Vs model enhances real-time performance and improves data accuracy in these applications. In addition, using Convolutional Neural Networks (CNNs), [5] highlighted the shift from traditional metadata-based retrieval to content-based image retrieval. This approach evaluates visual features such as colors, shapes, and lines which leads to better retrieval accuracy. This also decreases the possibility of reliance on incomplete or wrong metadata which helps to develop precise applications for image search and video indexing. Furthermore, deep metric learning for object deep reidentification has been the focus of [27]. He combined it with multi-view data to improve the accuracy of object reidentification. This leads

to easy recognition and tracking of objects at any camera angle which in turn, leads to the precision of task-like surveillance and smart city monitoring, thus helping real-world scenario mitigation. Finally, [4], utilized deep learning techniques together with multi-modal data and blockchain technology to enhance classification accuracy. In addition to improving multimedia data classification, this integration guarantees data security and integrity. This approach is very vital for a secure setting like finance and healthcare.

c. Scalability of Multimedia Data Management

The need to process and manage large volumes of data is crucial across various domains. To begin with, [10] introduced the edge and cloud computing architecture which aims to enhance the scalability of the Internet of Medical Things (IoMT). This solves the challenges of heterogeneous multimedia sensors and communication bottlenecks while leveraging cloud resources for data analytics and storage. This approach helps healthcare applications to be reliable in handling complex multimedia sets. In a similar vein, [20] modify and improve the DIKW (Data-Information-Knowledge-Wisdom) framework to improve scalability in IoT systems. This approach aims to mitigate and manage large-scale data sets and secure multimedia data processing. The framework helps with decision-making and scalability in handling multimedia datasets.

[21] addressed the scalability challenges of Big Data Analytics (BDA) in industrial applications, focusing on data generation, storage, visualization, and processing, and proposed enhanced BDA tools to improve efficiency and provide better insights for large-scale industrial settings.

In addition, [9] proposed multi-tiered architectures for handling big data in media in IoT-based environments. Data processing pipe-line segmentation within layers enabled this architecture to be scalable for real-time execution in applications ranging from traffic and healthcare monitoring to surveillance. It, therefore, enables efficient data handling while supporting decision-making within environments with the large sets of multimedia data. Also, [12] highlights the contribution of distributed edge architecture towards the elimination of data congestion and improving real-time processing of IoT systems. The edge architecture eliminates latency by processing data near the source and improves scalability, especially with resource-intensive applications such as augmented and virtual reality, a reality where quick fast response times are critical.

Moreover, [28] proposed a method known as ND-LPN (Non-Deterministic Least Path Network) SDN-based multimedia data forwarding approach that improves scalability through traffic prioritization, reduced packet loss, and optimized resource allocation in multimedia systems. This is especially appropriate for data management in large-scale networks like smart cities or industrial IoT setups. The use of HetNet for managing the control of multimedia traffic having high bandwidth and low latency over 5G networks has been investigated by [29]. Optimizing the process of traffic management with suitable resource allocation, HetNet delivers an effective scalable solution in a network of different networks and different devices for delivering multimedia content. It goes well with applications of real-time scenarios, like live streaming and video conferencing, where scalability and dependability are crucial. Another proposition was a blockchain-based security architecture to protect multimedia data in IoT networks [30]. This solution prevents malicious access, duplication of information and brings about privacy concerns that contribute to better security and scale for the network. Lastly, the decentralization of a blockchain model brought by [19] also includes IPFS to achieve the goals of security and scalability with privacy. This method makes handling data in IoT systems more secure and effective, particularly in the healthcare industry. The model provides a scalable solution that preserves data integrity and allows for large-scale operations through decentralization of storage and retrieval

C. Key Gaps and Limitations in Current Multimedia Database Systems

Despite the potential advantages of multimedia database systems, there remain issues that prevent their wide acceptance and optimal performance. A major issue found is **storage and scalability**, especially in the cloud-based environment. That issue remains unsolved even as the dataset grows with a hard time to counteract increasing data repositories. **Indexing and retrieval** is another area of improvement because multimedia retrieval often requires non-traditional and complex query methods. Another issue that needs pressing attention is over-reliance on well-annotated metadata as this can be a big problem in obtaining efficient or accurate search results. **Data heterogeneity** also is a problem in this aspect. Compatibility management in diverse file formats and smooth integrations require sophisticated integration mechanisms. This creates an issue of cohesive systems which can effectively handle diverse data sets. There is also still an issue with the performance associated with large volumes of multi-data.

Performance bottlenecks are evident in tasks like encoding, decoding, compression, and retrieval that demand high computational resources. Real-time processing and streaming can affect this performance as latency affects the overall efficiency of the system and the satisfaction of the user. **Privacy and security** are also one of the concerns. Some files especially in critical sectors like healthcare and finance should have strong encryption to avoid unauthorized access. Moreover, intellectual property rights management through watermarking and copyright protection is still an ongoing issue. Without such protections, the risk of data breaches and unauthorized use increases. There is also a **lack of universal standards** in database management systems. The fragmentation in system approaches and methodologies creates compatibility issues that do not allow for the establishment of uniformity and interoperability among different systems. On the other hand, **content understanding** or extracting meaningful information for meaningful search is a significant limitation of MMDBMS. Some of the systems do not provide advanced models or artificial intelligence for semantic analysis. Moreover, current systems often fail to infer the **context or intent** behind multimedia data usage, limiting their ability to deliver relevant and insightful results.

Another challenge is the **cost** because it requires huge infrastructure investments in terms of hardware and software. Smaller companies or individuals will find such systems less affordable because operational costs, such as updating systems, scaling, and processing multimedia, are too expensive. There are so many difficulties when dealing with multimedia data in real-time, like live video streams. Bottlenecks often arise in systems not designed for high-throughput processing, leading to lags and reduced efficiency. **Real-time functionality** requires sophisticated architectures and a significant amount of processing power. Lastly, MMDBMS's interaction and user interface frequently **lack sufficient functionality**. These systems might be challenging for non-technical users to use because they lack user-friendly interfaces. Furthermore, a **lack of interactivity** in multimedia retrieval and presentation, such as the inability to edit content or apply dynamic filters, lowers user satisfaction and engagement.

To effectively address challenges, gaps, and limitations identified in this current undertaking, the ARK Multimedia Database Sphere was developed.

Fig. 1. ARK Multimedia Database Sphere Framework

In the **storage feature**, the exponential growth and unstructured nature of multimedia data demand scalable solutions like cloud-based storage and compression techniques to manage large datasets efficiently. In a similar study conducted by [31], when data is stored on a multi-cloud platform, the significant problem of vendor lock-in that comes with a single cloud platform is removed.

Addressing issues in the data **modeling and indexing feature**, the heterogeneous and high-dimensional nature of multimedia data calls for AI-driven data modeling and advanced indexing methods, such as high-dimensional indexing, to enhance search efficiency. The classification of indexing techniques, including Artificial Intelligence (AI) Indexing, Non-Artificial Intelligence (NAI) Indexing, and Collaborative Artificial Indexing (CAI) Indexing, was examined and discussed by [32] to assist future researchers in selecting appropriate techniques according to their needs. According to the comparison study's findings, CAI techniques are ideally suited for retrieval on sizable, real-time streaming datasets.

Similarly, in the **retrieval and querying feature**, traditional text-based queries prove inadequate for multimedia, necessitating content-based retrieval and AI-powered search techniques leveraging visual and auditory features. The amount and accessibility of videos have significantly increased due to recent technological advancements. Large video collections can now be stored in computer systems thanks to increased memory capacity. To properly utilize these collections, it is essential to have tools that make access and management easier. [33] proposed a multimedia retrieval method that starts with a text-based query that has two primary components and puts the needs of the user first: (i) a new multi-level and deep-semantic video classification indexing method and (ii) a query expansion mechanism and relevance feedback system to improve the results based on the user's feedback.

Real-time applications, such as IoT and healthcare, highlight the need for optimized performance in the **real-time processing and performance feature**, which can be achieved through edge computing and AI-driven decision-making processes. [34] suggested a real-time cloud-based platform for computer vision applications that incorporates a toolkit of the machine and deep learning algorithms for processing images and videos. The platform can process large databases and operate in real-time. Users can access the various algorithms without having to download, install, and configure software or hardware thanks to the automatic integration and configuration of the relevant libraries and hardware drivers. The platform was assessed using three different types of algorithms: (i) image and video processing toolbox. (ii) Image classification and object localization using deep learning architectures. (iii) Images indexation and retrieval. This assessment proved our platform's ability to handle diverse data types, including images, videos, and more.) and is appropriate for large amounts of data.

Security and privacy feature critical challenges, especially in cloud-based and decentralized systems, requiring robust solutions like blockchain for data integrity and privacy-preserving encryption technologies. Due to the increase in MMBD, the privacy, integrity, and authenticity of information systems can be impacted by malicious attacks or external threats, so it is imperative to safeguard this data. Therefore, to protect the system from these unwanted malicious attacks, [35] presented the current issues in MMBD and security approaches and effective security mechanisms to deal with these issues and also, focused on multimedia big data security and privacy. It also listed security precautions and instructions to follow when using MMBD.

Scalability, a persistent issue in the **scalability and integration feature**, can be addressed through cloud-based distributed systems and deep learning for seamless integration of diverse data sources. [36] developed scalable data lake architecture that is combined with cutting-edge deep learning methods to efficiently handle and examine massive amounts of IoT data. The suggested approach makes use of Apache Spark for data processing and model training, Apache Kafka for real-time data ingestion, and Apache Hadoop for distributed storage. Complex temporal and spatial patterns in IoT data were captured by implementing deep learning models such as LSTM, CNN-LSTM hybrid, and GRU. The hybrid CNN-LSTM model in this study has shown the best performance with the lowest MAE and RMSE values. The research has indicated that scalable data lake frameworks and data strategies can incorporate deep learning models, bringing about significant improvements in scalability and predictive accuracy for Internet of Things applications.

Finally, smooth interaction across different interoperability features requires such models of advanced data conversion that are powered through the use of APIs to allow interoperability within these multimedia formats and systems. Such highly severe, quality-related constraints exist in ensuring reliable latency, storage space, bandwidth, and, at times, Quality of Service in handling multimedia data It is, therefore, very demanding to ensure that an underlying protocol stacks under the strict requirements in a pure implementation of IoMT.

The heterogeneity of multimedia sensors makes interoperability challenging. To comprehend the difficulties associated with smooth and interoperable communication in IoMT, [37] provided comprehensive IoMT protocol stacks in detail and examined their viability for multimedia streaming applications. To support multimedia applications of IoMT, [37] also investigated the cloud as a whole. The analysis of multimedia cloud examples reveals several drawbacks that open the door for edge computing in IoMT. Lastly, [37] offered a case study that demonstrates the importance of our research. The case study illustrated an in-home patient monitoring system that allows for interoperable communication between hospital medical staff and the linked multimedia streaming devices at home.

IV. Conclusions

Based on the review, the main issues were presented with multimedia database management systems. Nevertheless, despite these present-day challenges, the number of opportunities can be still potentially enhanced with exciting solutions for augmenting its performance. It was advised to have advanced techniques like adaptive compression technique, edge cloud computing, hybrid cloud systems, deep learning models like CNNs and cross-modal representation, edge computing, cloud-based solutions, distributed architecture, and hybrid computing. AI for empowering optimal performance and ensuring their efficiency, accuracy, and scalability. The research study suggests further scholars' research and studies for the revolution of multimedia databases that will be marked by intelligent, scalable, and context-aware systems capable of managing vast and diverse types of media such as the Internet of Everything, the Internet of Thinking (IoTk), and future technologies. Advances in artificial intelligence, cloud computing, AR/VR, and blockchain will continue to transform how multimedia data is stored, accessed, and processed, providing users with richer and more personalized experiences. Moreover, challenges related to privacy, security, and ethical use of data will need to be addressed as these technologies evolve. Additionally, it will spur growth and innovation in various fields, including education, healthcare, entertainment, and smart cities. The ARK Multimedia Database Management Sphere may offer a promising framework to tackle these issues.

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