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ADVANCED SYSTEMS FOR RELIABLE STORAGE OF BIOMEDICAL INFORMATION

ПЕРЕДОВІ СИСТЕМИ НАДІЙНОГО ЗБЕРІГАННЯ БІОМЕДИЧНОЇ ІНФОРМАЦІЇ

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Abstract. *This article examines state-of-the-art systems and emerging technologies designed to ensure the reliable, long-term, and secure storage of biomedical information, especially in the context of the rapidly growing volume of healthcare-related data. It explores the full lifecycle of biomedical data management—from initial data acquisition through sensors, wearable devices, and IoT systems, to processes of validation, analysis, and secure long-term storage. Particular attention is given to the role of electronic health records (EHRs), which serve as the backbone of modern digital healthcare, enabling centralized storage of patient histories, diagnostic data, and treatment protocols.*

The paper highlights the advantages of cloud technologies, which offer scalable and flexible storage infrastructures while supporting real-time access and ensuring the protection of sensitive personal data. Blockchain technologies are analyzed as a promising solution for establishing immutable, transparent, and decentralized records of medical information shared between institutions. Additionally, the role of artificial intelligence is emphasized in optimizing data storage efficiency, accelerating data processing, and automatically detecting anomalies or inconsistencies in large datasets.

The study also addresses current international standards and regulatory frameworks concerning data security, system interoperability, and access to biomedical records. It outlines key challenges including the harmonization of different data formats, growing cybersecurity threats, patients' privacy rights, and the ethical implications of processing sensitive health data. The paper concludes that an integrated, multi-layered approach that leverages cutting-edge technologies is essential for improving healthcare quality, advancing biomedical research, and building resilient digital health ecosystems.

Анотація. *У статті розглянуто передові системи та інноваційні технології, що використовуються для забезпечення надійного, довготривалого та безпечного зберігання біомедичної інформації в умовах зростаючих обсягів даних у сфері охорони здоров'я. Детально описано ключові етапи роботи з біомедичними даними — від їхнього збору за допомогою сенсорів, носимих пристроїв та IoT-рішень до етапів обробки, верифікації, аналізу та довгострокового зберігання. Особливу увагу приділено електронним медичним записам (ЕМЗ), що є основою сучасної цифрової медицини та інструментом для централізованого зберігання медичних історій пацієнтів, результатів аналізів і лікувальних призначень.*

Проаналізовано переваги використання хмарних технологій для масштабованого зберігання медичних даних з одночасним забезпеченням доступності та захисту персональної інформації. Окремо висвітлено можливості застосування блокчейн-технологій для створення незмінного й прозорого середовища обміну медичними даними між різними установами. Зазначено потенціал штучного інтелекту в контексті оптимізації зберігання, швидкої обробки великих обсягів інформації та автоматичного виявлення аномалій у даних.

У роботі окреслено сучасні міжнародні стандарти, вимоги до безпеки, сумісності систем та доступності медичних даних. Звернено увагу на основні виклики, зокрема необхідність узгодження між різними форматами даних, загрози кібербезпеки, питання прав пацієнтів на конфіденційність та етичні аспекти обробки біомедичної інформації. Зроблено висновок, що інтегрований, багаторівневий підхід із використанням сучасних технологій є запорукою підвищення ефективності медичного обслуговування, розвитку біомедичних досліджень і створення стійких цифрових екосистем охорони здоров'я.

Keywords: biomedical information, data storage, blockchain, cloud computing, electronic health records, artificial intelligence, data verification, health technologies
Ключові слова: біомедична інформація, зберігання даних, блокчейн, хмарні обчислення, електронні медичні записи, штучний інтелект, верифікація даних, медичні технології

Introduction

Modern systems for reliable storage of biomedical information are characterized by a high degree of security, scalability and compatibility with various standards and technologies. Verification of biomedical information is a critical process that ensures the accuracy, reliability, and consistency of data. This is essential not only for clinical practice, but also for scientific research to avoid errors and misinterpretations of data. Blockchain technologies are gaining more and more popularity in the field of biomedical data due to their ability to provide a high degree of security, transparency and immutability of information. The storage of biomedical information in big data is a key aspect of modern medicine and bioinformatics. It is important that the information is stored securely, reliably, and is easily accessible for analysis. The storage and processing of biomedical information requires methods to ensure the accuracy, credibility and immutability of the data.

1. Biomedical Data Registration

Biomedical data registration is an important process in the field of medicine and healthcare that allows us to monitor and analyze the health status and health potential of patients. The main stages in this process include:

1.1. Obtaining information:

The collection of biomedical information using sensors is an important part of modern medicine and scientific research. This allows us to monitor and analyze physiological parameters in real time, supporting the diagnosis, treatment and prevention of various diseases. Sensors are usually built into wearable devices, medical devices, or diagnostic devices. Another commonly used method of data collection is surveys and medical records, in which patients provide information about symptoms, illnesses, and previous medical history. Some of the main methods and technologies used to collect biomedical information using sensors are:

- **Electrophysiological sensors**
  - **ECG (Electrocardiography):** It registers the electrical activity of the heart, is used to diagnose arrhythmias, heart attacks and other heart diseases.
  - **EEG (Electroencephalography):** It measures the electrical activity of the brain and is used to diagnose neurological disorders such as epilepsy.
  - **EMG (Electromyography)**: It measures the electrical activity of muscles, which helps in the diagnosis of muscle and nerve diseases.
- **Sensors for physiological parameters**
  - **Pulse oximeters**: Measure blood oxygen saturation and pulse used in respiratory disorders and monitoring of patients with lung diseases.
  - **Blood pressure sensors**: Common in smartwatches and medical devices for measuring blood pressure.
  - **Temperature sensors**: They measure body temperature, used to monitor infections and inflammatory processes.
- **Breath Analysis Sensors**
  - **Capnography**: It measures the concentration of carbon dioxide in the exhaled air, it is used to monitor patients during surgery or intensive care.
  - **Spirometry**: It measures the volume of lung function and is used in the diagnosis of lung diseases such as asthma and COPD.
- **Optical and photoelectric sensors**
  - **Infrared and optical sensors**: Used to measure blood flow and oxygen saturation through wearable devices such as fitness bracelets.
  - **Optical Skin Sensors:** They are used to measure skin hydration and metabolic processes.
- **Biochemical Sensors**
  - **Glucose meters:** They measure the level of glucose in the blood, mainly used by people with diabetes.
  - **Biosensors for blood analysis:** They are used to detect various biomarkers associated with metabolic and infectious diseases.
- **Motion sensors**
  - **Accelerometers and gyroscopes:** They measure body movement and position, used in rehabilitation, orthopedics and to monitor activity in athletes.
  - **Inertial Sensor Systems:** Measure the position and orientation of the body or parts of it to assess motor activity.
- **Wearable devices**
  - **Smartwatches and fitness trackers:** They combine multiple sensors such as pulse oximeters, ECGs, accelerometers, and temperature sensors to continuously monitor health.
  - **Implantable sensors:** They can be placed in the body to continuously monitor specific parameters such as glucose levels or pressure in the arteries.

These methods and devices are widely used both in clinical practice and in scientific research for a better understanding of the human body and diseases.

1.2. Data transmission:

The collected data from the sensors is transmitted to the data management system. These data may need to be transformed or standardized so that it is suitable for storage, processing, and analysis. The transmission of data from biomedical sensors to control systems can be carried out in several main ways:

- **Wired communication**:
  - **USB**: It is often used to directly connect devices to computers or controllers.
  - **RS-232/RS-485**: Standard serial communication interfaces widely used in industrial automation and medical devices.
- **Wireless communication**:
  - **Bluetooth**: Popular for short distances, it allows you to connect sensors to mobile devices or computers.
  - **Wi-Fi**: Suitable for long-distance data transmission and integration into network infrastructure.
  - **Zigbee**: It is often used in IoT applications, offers low power consumption, and is suitable for multi-device networks.
- **Mobile networks**:
  - **GSM/3G/4G/5G**: They allow data transmission from sensors located in remote areas to control systems using mobile networks.
- **Internet of Things (IoT)**:
  - Devices with built-in sensors can transmit data directly to the cloud or to local servers via IoT platforms.

1.3. Information verification:

At this stage, automated checks are carried out on the collected data for accuracy and consistency. The process goes through specialized algorithms to detect errors (artifacts), check for duplicate records and other inconsistencies. Manual control by medical specialists is also possible. Validating data collected from biomedical sensors is a critical step in ensuring the accuracy and reliability of information. Some basic inspection approaches and methods are:

- **Sensor calibration**:
  - Regular calibration of devices to ensure that measurements are accurate and in accordance with established standards.
- **Linking to reference values**:
  - Comparison of data with reference values or standardised ranges for normal and anomalous values.
- **Using algorithms to verify data**:
  - Development of algorithms to check the logic of data, such as identifying abnormal values or anomalies.
- **Duplicate measurements**:
  - Conducting repeated measurements of the same parameters to confirm the data obtained.
- **Tests and control groups**:
  - Using test groups (e.g. control subjects) to compare metrics and certify results.
- **Time sequence analysis**:
  - Checking data for sequences and trends over time, which may suggest problems with sensors or measurements.
- **Audit and quality control processes**:
  - Implementation of procedures for regular auditing and quality control of the collected data to ensure compliance with standards.
- **Feedback from users and experts**:
  - Gathering feedback from healthcare professionals to validate data results.

Performing these steps can significantly improve the reliability of data collected by biomedical sensors and ensure patient safety.

1.4. Data storage:

After verification, the data is stored in reliable databases that ensure security and confidentiality. Storing biomedical data after verification is important for its safe management and easy access. Here are some of the main methods for storing this data:

- **Local databases**:
- Using relational databases (for example MySQL, PostgreSQL) for structured data storage that provides easy access and processing.
- **Cloud Solutions**:
  - Data storage in cloud platforms (for example AWS, Google Cloud, Microsoft Azure), that provide scalability, integration with AI/ML tools, and secure backups.
- **Specialized health data management systems**:
  - Use of (Electronic Health Records) systems that are designed for the safe storage and management of personal health data.
- **Distributed Storage Systems**:
  - Use of technologies such as blockchain to ensure security, transparency and data protection in distributed storage.
- **Backup method**:
  - Regular data backup to prevent loss using various methods, such as physical media (e.g. external drives) and cloud solutions.
- **Data encryption**:
  - Protect sensitive data through encryption, both at rest and in transit, to protect information from unauthorized access.
- **Standardized storage formats**:
  - Use of standardised formats (e.g. DICOM for medical images, HL7 for health data) to ensure interoperability in exchange and storage.

- **Integration with analytical tools**:
  - Ability to connect storage systems with analytical and BI tools to perform better data analytics.
  - The choice of method depends on the specific needs of the organization, security requirements, regulatory standards, and the need for data accessibility.

1.5. Analysis of information from doctors:

Medical professionals analyze the collected and verified data in order to draw conclusions about the patient's health, make a diagnosis, including confirming the chosen treatment strategy. This process involves several stages:

- **Data collection.**
  - **History:** Gathering information about previous illnesses, hereditary factors, symptoms, and lifestyle. This includes interviews with the patient and a review of their medical history.
  - **Physical examination:** The doctor performs an examination to detect clinical signs related to the patient's complaints.
  - **Diagnostic tests:** They include laboratory tests (blood, urine, etc.), imaging studies (X-ray, magnetic resonance imaging, etc.), electrophysiological tests, etc.
- **Data verification**
  - **Comparison with previous data:** The new data is compared with the patient's previous medical records to see if there are any changes.
  - **Interpretation of results:** Medical professionals review the results of tests and examinations, evaluating their accuracy and credibility. This may also include confirmation through repeated tests or consultation with specialists in the relevant field.
- **Analysis and interpretation.**
  - **Diagnosis:** After collecting and verifying the data, the doctor makes a reasonable medical diagnosis. He uses clinical manuals, medical algorithms, and his expertise to determine what condition the patient has.
  - **Prognosis:** The likely course of the disease, potential complications and possible treatment outcomes are evaluated.
  - **Risk factors:** It is analyzed if there are other factors that may worsen the patient's condition, such as comorbid diseases, age or hereditary factors.
- **Treatment selection.**
  - **Choice of therapy:** Doctors use the collected and verified data to determine the most appropriate treatment. This may include drug therapy, surgical interventions, or lifestyle changes.
  - **Personalization of therapy:** The therapy is individualized according to the characteristics of the patient – his genetic predisposition, the presence of allergies, previous reactions to medications, etc.
- **Monitoring and Tracking.**
  - **Monitoring results:** Doctors monitor how the patient responds to treatment through repeated examinations and tests.
  - **Feedback:** If necessary, therapy can be changed depending on the patient's response and new data.

This process requires careful data collection, clinical expertise, and the use of appropriate tools to optimally treat patients.

- **Documentation and reporting:**
  - The results of the analysis and observations are presented to the patient and other doctors on the team, which may include recommendations for further tests or treatment. Decisions need to be documented in detail to ensure traceability and transparency.

2. Systems and technologies for quality storage of information packages with biomedical information

The storage of biomedical information must meet the requirements for security, confidentiality, quick access and compatibility between different systems regulated by the EU regulations and legislation when ensuring the security of the transfer and storage of medical information. Some of the key systems and technologies used in this area are:

2.1. Electronic Health Records.

EHRs are digital versions of patients' medical records. They store detailed medical information about patients including medical history, laboratory results, imaging and treatments. They are compatible with standards such as HL7, FHIR and allow integration with other medical devices and applications such as: Epic, Cerner and Allscripts.

- **Main characteristics of EHR:**
  - **Complete medical history**: An EHR contains complete records of the patient from history and physical examinations to diagnostic results and medication prescriptions. This includes:
    - Laboratory Results
    - Imaging studies (such as X-rays, MRIs)
    - Records of surgical interventions and treatments
    - Vaccination status
    - Data on allergies and drug reactions
  - **Process automation:** EHR systems automate routine tasks, such as data entry, recipe generation, sending review reminders, and more, which increases efficiency and accuracy in healthcare professionals' work.
  - **Easy access and sharing of information:** Healthcare professionals can access a patient's health records from a variety of locations and in real-time, which is especially useful in emergencies or when they need to consult with other specialists. This facilitates communication between doctors from different hospitals and clinics.
  - **Health status tracking:** EHR allows doctors to monitor how a patient's health status is developing over time, being able to analyze trends and treatment outcomes. Patients can also access their records through dedicated patient portals.

○ **Improved safety and accuracy:** The use of an EHR reduces the risk of errors when filling in information by hand, such as spelling mistakes or misinterpreting handwritten notes. This also allows for more accurate management of prescriptions and prevention of adverse drug interactions.

○ **Compatibility with other systems:** EHR systems can be integrated with other healthcare technologies, such as laboratory systems, medication management systems, or even with real-time patient monitoring devices (such as heart rate monitors, blood pressure monitors, etc.)

The main challenges facing electronic health records (EHR) include ensuring high protection of personal data, the need for staff training and integration into existing infrastructure, as well as interoperability issues that make it difficult to exchange information between different healthcare facilities. Ultimately, EHR systems are transforming the healthcare industry by providing better patient care coordination, increased accuracy, and greater efficiency in the work of healthcare professionals. Process automation reduces administrative costs and improves the quality of healthcare.

2.2. Cloud storage solutions:

Cloud platforms provide scalable and flexible storage space for large volumes of biomedical data. They are distinguished by their high availability and automated backup capabilities. They are powerful tools for data analysis and processing in compliance with regulatory requirements such as GDPR. Some of the most widespread platforms are: Amazon Web Services (AWS) [1], Google Cloud Healthcare[2] and Microsoft Azure for Healthcare [3].

- **Amazon Web Services (AWS)**

○ **AWS HealthLake:** Specific cloud solution for storage and analysis of health information. AWS HealthLake enables healthcare organizations to transform unstructured data into a standardized format FHIR (Fast Healthcare Interoperability Resources) and use them for analysis and research.

○ **S3 (Simple Storage Service):** AWS It offers secure, scalable cloud storage that can store and protect sensitive biomedical information, including medical imaging and laboratory data.

○ **Compatibility:** AWS offers regulatory compliance tools, such as HIPAA, for healthcare organizations that store and process health information.

- **Google Cloud**

○ **Google Cloud Healthcare API:** This platform was created for storing, analyzing, and exchanging health information. It supports standards such as HL7, FHIR, and DICOM (for medical imaging).

○ **BigQuery:** Google Cloud offers a powerful big data analytics platform that is suitable for processing biomedical information. It can integrate data from different sources for deeper analytical insights.

○ **Security and Compliance:** Google Cloud provides a high level of security and compliance with various regulatory requirements, such as GDPR and HIPAA.

- **Microsoft Azure.**

○ **Azure Health Data Services:** A platform that stores and manages data in standardized formats such as FHIR and DICOM. It allows healthcare organizations to analyze and visualize medical data.

○ **Azure Blob Storage:** Scalable cloud storage that can store medical images, lab results, and other large files.

○ **AI and data analytics:** Azure offers artificial intelligence (AI) and machine learning tools that can be used to analyze biomedical information, including to predict diseases and personalize treatments.

- **IBM Cloud**

○ **IBM Watson Health**[4]**:** A platform specializing in the processing of health information. Watson Elt uses AI to analyze biomedical data and provide insights for diagnosis and treatment.

○ **Cloud Object Storage:** IBM offers safe and scalable storage for sensitive information by adhering to standards such as HIPAA and GDPR.

○ **IBM Blockchain:** This technology can be integrated for greater transparency and protection of medical data.

- **Oracle Cloud**

○ **Oracle Health Sciences**[5]**:** Dedicated cloud platform for healthcare and biomedical research. Oracle Cloud provides tools for clinical research, health information management, and analytics.

○ **Сигурност:** Oracle offers a high level of security and regulatory compliance, which is critical in storing sensitive biomedical information.

- **Epic Systems (Epic Cloud)**

○ **Epic Cloud**[6]**:** Epic is one of the leading electronic health record companies and offers its cloud-based health data storage and management service. The platform is used in many hospitals and healthcare facilities around the world.

○ **Interoperability:** Epic offers the ability to easily exchange data with other healthcare systems through standards such as HL7 and FHIR.

Cloud solutions make it much easier for healthcare organizations to manage and analyze vast amounts of biomedical data, while providing reliable protection and regulatory compliance. They provide access to data from different locations in real time. Many of these platforms support health data exchange standards such as HL7, FHIR, and DICOM.

2.3. Specialized biomedical databases:

These databases are designed specifically for storing and managing biomedical information. They contain a variety of information such as genomic sequences, protein structures, clinical data, drug interactions, and other types of biomedical data. They support structured and unstructured data, offer tools for sharing data between researchers and institutions. Examples of specialized biomedical databases are:

- **Genomic databases**

- **GenBank (NCBI):** One of the largest databases of DNA sequences. It stores and provides access to genomic data from various organisms.
- **Ensembl:** A platform for analysis and visualization of genomic data of different types. Supports gene data, genomic variants, and genome annotations.

- **Clinical databases**
  - **ClinicalTrials.gov:** A database that provides information on ongoing and ongoing clinical trials worldwide. It contains information on the methodology, results and stages of clinical trials.
  - **SEER (Surveillance, Epidemiology, and End Results Program):** A database that collects and analyzes data on the incidence and survival of cancer patients in the United States.
- **Pharmacological databases**
  - **DrugBank:** A database that provides information about drugs, their chemical composition, mechanism of action, interactions and other pharmacological data. It is used both in clinical medicine and in scientific research.
  - **PubChem:** It contains chemical data about molecules, their properties and related biological activities. Maintains information on biomedical molecules used in laboratory research and therapies.
  - **PharmGKB:** A database that stores information on the interaction between genes and drugs, focusing on pharmacogenomics, for the purpose of personalized treatment.
- **Epidemiological and population databases.**
  - **GISAID:** A global initiative to share data on viral genomes, especially on influenza viruses and SARS-CoV-2 (the virus that causes COVID-19). This database is important for tracking mutations and epidemiological trends.
  - **dbGaP (Database of Genotypes and Phenotypes):** Contains data on the relationship between genetic variants and phenotypic characteristics (such as diseases) from various population studies.

Biomedical databases support research and the development of personalized medicine by accessing vast amounts of genetic and clinical data. They facilitate the diagnosis and optimize the treatment of diseases, allowing specialists to discover new therapies. Standardized data improves collaboration between different medical and research institutions. The main challenges to using biomedical databases include the need for high security to protect sensitive information, integration difficulties due to different standards, and the need for advanced analytical tools to process large amounts of data.

2.4. Blockchain Technologies:

When working with biomedical information sets, they are used to verify and protect medical data. Blockchain provides decentralized storage and recording of data, which makes unauthorized changes to information difficult. Each record of biomedical information is encrypted and time-stamped, ensuring verifiability and immutability of the data. Blockchain provides an extremely high degree of data security and traceability. The main blockchain technologies are:

- **Ethereum**
  - Ethereum is an open-source decentralized blockchain platform that supports smart contracts and enables the creation of decentralized applications (DApps), including in healthcare. In biomedicine, Ethereum provides automated and secure data exchange between hospitals, patients, and researchers through smart contracts and encrypted, decentralized records. An example of an application is the MedRec platform, which uses Ethereum to manage and track electronic health records.
- **Hyperledger Fabric**
  - Hyperledger Fabric is an open-source blockchain platform developed by the Linux Business Applications Foundation that provides a permissive infrastructure suitable for industries such as healthcare where data privacy is important. In biomedicine, it allows for the secure exchange of sensitive information between authorized participants such as hospitals and pharmaceutical companies, maintaining the confidentiality of transactions. An example of an application is MediLedger, which uses Hyperledger Fabric to track pharmaceutical supplies and manage the supply chain.
- **Corda**
  - Corda is a permissive blockchain platform developed by R3 designed for business transactions on private networks, which also finds application in healthcare. It provides a secure and direct exchange of medical data between healthcare organizations, complying with regulatory requirements such as HIPAA and GDPR. Transactions are visible only to the parties involved, which guarantees high confidentiality. Corda's applications in healthcare include clinical data management, drug supply chain tracking, and decentralized clinical trials.
- **Blockchain-as-a-Service (BaaS) platforms**
  - Large cloud providers offer blockchain-as-a-service (baath) solutions that allow healthcare organizations to use blockchain technologies without building and maintaining their own infrastructure. These platforms are easy to integrate with other systems and are tailored to the needs of enterprises. Examples include the Microsoft Azure blockchain, used to securely store health information and track supply chains, and the IBM blockchain, which assists in medical records management, medical device tracking, and clinical trials.
- **Algorand**
  - Algorand is a high-performance blockchain platform offering fast and low-cost transactions, making it suitable for healthcare. It supports both public and licensing networks and provides infrastructure for health information management and clinical trials. Through smart contracts, Algorand automates the exchange of medical data, complying with industry regulations.

Blockchain technologies have wide applications in the storage of biomedical information. They provide secure and decentralized access to electronic health records (EHRs), allow patients to control access to their medical data, and increase transparency in clinical trials. Additionally, blockchain facilitates the traceability of drug supply chains, preventing counterfeiting, and manages the safety of biomedical devices by traceability of their history.

2.5. (DMS) - Data Management Systems.

These are software solutions for collecting, storing, managing and analyzing biomedical data. Examples of DMS include Oracle Health Sciences, SAS Clinical Data Management. What is special about them is that they support integration with various data sources, offer powerful analytical tools, provide a high degree of security and compliance with standards. The storage of biomedical information in big data is a critical aspect of modern medicine and bioinformatics. It is important that the information is stored securely, reliably, and is easily accessible for analysis. Data Management Systems (DMS) play a key role in storing, organizing, and analyzing biomedical information. They provide centralized management of large volumes of sensitive data while ensuring security, availability, and regulatory compliance. In the context of biomedicine, such systems are used to manage electronic health records (EHR), clinical research, genomic and other types of data.

2.6. Standards and protocols for working with medical information and data:

Modern trends in e-health indicate in an indisputable way that the exchange and management of clinical data should be based on internationally recognized standards and technical specifications in medical informatics. One of the established standards for the exchange of electronic health information is HL7 (Health Level Seven) [7]. Another modern health data exchange specification that uses web standards is FHIR (Fast Healthcare Interoperability Resources). DICOM (Digital Imaging and Communications in Medicine) is a standard for the management and transmission of medical images.

2.7. Artificial Intelligence and Machine Learning:

It is used to analyze large volumes of biomedical data to detect patterns, predict diseases, and personalize treatments. Apply to embed in existing systems to improve data processing and analysis.

Artificial intelligence (AI) plays an increasingly significant role in the creation of systems for high-quality storage of biomedical information, contributing to the automation of processes, improving security and optimizing the management of huge volumes of data. AI aids not only in storing data, but also in processing, analyzing, and extracting important insights that can be used in medicine and biomedical research. Biomedical information is often very diverse in its structure (genomic data, medical images, laboratory results, health records). AI algorithms, especially those based on machine learning (ML) and deep learning (DL), can automatically categorize and index data based on its content, making it easier to store and subsequently access it.

3. Conclusion

Modern biomedical information storage systems continue to evolve, integrating the latest technologies and standards to ensure greater security, efficiency, and availability of data. This is necessary to improve the quality of healthcare and promote medical research. Verification of biomedical information requires a combination of automated and manual methods, standards, and regulatory procedures. New technologies such as artificial intelligence and blockchain significantly improve data security and accuracy, but still manual verification and expert opinion remain indispensable in cases of higher complexity. Blockchain technologies offer significant benefits for the storage and management of biomedical data, including increased security, transparency, and control over the data. However, their successful implementation requires overcoming some technical and regulatory challenges. With the advancement of technology and the development of standards, blockchain has the potential to transform the way biomedical data is managed and shared, improving the quality of healthcare and facilitating research. Methods for quality storage and organization of biomedical data include a wide range of technologies that ensure their reliability, security and accessibility. With the right choice of databases, Big Data tools and verification and protection mechanisms, effective management of biomedical information can be achieved, which is the basis for future medical innovations and discoveries.

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