Review on big data application of medical system based on fog computing and IoT technology

Baoling Qin\textsuperscript{a}, Huiying Tang\textsuperscript{b}, Hongtao Chen\textsuperscript{c}, Liangyun Cui\textsuperscript{d}, Jianjie Liu\textsuperscript{e}, Xueke Yu\textsuperscript{f}

College of Electronic Information Engineering, Foshan University, Guangdong Foshan, China
\textsuperscript{a}2978879663@qq.com, \textsuperscript{b}1017833417@qq.com, \textsuperscript{c}247538141@qq.com, \textsuperscript{d}1243384137@qq.com, \textsuperscript{e}982083608@qq.com, \textsuperscript{f}1095132588@qq.com

Corresponding author and e-mail: Baoling Qin, 2978879663@qq.com

Abstract. From the current general situation of big data in medical systems, most of the medical system architectures of comprehensive related literature are based on cloud computing. With the deepening of big data application in the medical system, the drawbacks of medical network systems are apparent, for example, long network time delay, cloud computing overload, information leakage. A new intelligent medical system based on fog computing and IoT technology is proposed to effectively solve the problem of big data application through the comprehensive analysis of many works of literature. Compared with the traditional cloud computing model, the system which adopts a distributed fog computing model based on edge computing has the advantages of reducing network delay and plays its benefits of distributed, edge and decentralization. That the system takes advantage of IoT's features of multi-node, low-energy consumption and big data technology is a new type of medical system that integrates intelligence and big data application. The system is effective through the application and practice of many medical institutions. In short, this system has several characteristics. For example, it can effectively improve medical intelligence and big data processing ability, significantly reduce network delay, effectively improve data security and effectiveness, largely improve the management level and service quality of medical institutions, play the important role of artificial intelligence and big data in the medical field, and greatly improve disease screening rate and reduce misdiagnosis rate. Ultimately it leads to reducing the contradiction between doctors and patients, providing patients with more convenience, faster and more efficient service quality, and alleviating the current situation of difficult and time-consuming medical treatment.

1. Introduction
In recent years, with the continuous development of IoT technology and integration into various fields of society, different networked carriers have also been continuously increased, resulting in more and more data. Therefore, the processing requirements for data are also increasing. Thus, the demand for data processing is also steadily increasing. However, the problems of long-time data processing, easy
data loss, insufficient bandwidth resources, and network congestion, have begun to limit the application of cloud computing in some areas, where high-speed processing of data and quick feedback are needed. Especially in the medical system, whether to deal with the long queuing up time for drug retrieval or to reflect the patient's real-time physical condition by wearing a networked instrument for the patient, it is necessary to feedback the data obtained by the sensing device in a very short time. After processing and returning to the devices in the hands of people, these different types of data are transmitted from various sensors. If the system is still based on cloud computing, the system will be overburdened and even paralyzed. Aiming at the serious problems in the current big data application, an intelligent medical system based on fog computing and IoT technology is proposed. The purpose is to solve the problem of big data processing and application of medical service by using the characteristics of fog computing and IoT technology. [1] At the same time, using fog computing to uniformly migrate related data processing and applications to network edge devices, process and save them, and then transfer valuable residual data to the cloud server for storage or further processing. The mechanism effectively solves the pressure of system cloud computing, ensures the limited resources of the system to be applied to key tasks, and improves the real-time data processing capability of the medical system. Based on these characteristics, we will make full use of new big data security technologies to adequately protect the security of big medical data and prevent information leakage. This research has practical significance in the current medical system big data application.

2. Fog computing and architecture model of IoT technology
The fusion of fog computing and IoT technology is the hotspot of current network architecture model research. How to make use of their respective advantages to make the medical system more stable and advantageous service is the subject of our research.

2.1. Basic concepts and characteristics
Fog computing is an extended concept of cloud computing, and data communication processing is closer to the end-user. It is similar to but different from edge computing, which is to release some of the cloud's capabilities to the LAN of the IoT device such as the edge of the network, gateway or router to reduce the network and computing load of the cloud data center. However, fog computing cannot replace cloud computing. [2] It is mainly to expand and supplement the current cloud computing, and it is an enhanced version. In general, it is composed of a variety of weak performance, widely distributed functional computing devices. It is a distributed computing that extends the computing paradigm of the network center to the edge of the network. This kind of distributed computing can meet the demands of some areas where real-time data feedback is faster, such as intelligent transportation, intelligent industrial production, data processing of intelligent medical systems, etc. These features effectively reduce network latency and improve system computing power.

2.2. Architectural model
The architecture model of fog computing is based on the cloud computing model. A layer of fog is added between the mobile terminal and the cloud layer. The fog layer includes networking devices such as gateways and routers, which can process some data and use them. The data is uploaded to the cloud, and the edge layer is an essential part of IoT. It merges with the fog layer to form a new architecture. Its architecture is shown in Fig.1.
3. Analysis of big data application of medical system based on fog computing and IoT technology

Medical system big data includes different structural data such as pictures, images, data, etc., and puts a large amount of data to be processed into cloud computing. In addition to the burden, some data may not be processed, resulting in system stagnation or inability to work. Based on these, we use fog computing and IoT technology.

3.1. Medical system model

The widely used medical system is designed and built in the B/S structure. The system can be divided into three layers, namely the browser layer, the server layer and the database layer [3], as shown in Fig.2.

3.2. Fog computing and IoT technology fusion service framework

Fog computing is an extension of cloud computing. The use of cloud computing requires a lot of bandwidth. But the current wireless network bandwidth is still limited. In comparison, the bandwidth
requirements of fog computing are much lower, and a considerable part of the data can be realized by fog computing. [5]Localized computing for valuable data can still be transmitted through the cloud platform, but because a part of the data has been localized, it can significantly reduce the burden of the cloud while also saving costs. Integrating fog computing into the Internet of Things not only preserves the powerful features of cloud computing but also increases the speed of computing and reduces the computational cost.

The fog computing is closer to the end of the data acquisition than the cloud calculation, and the data transmission distance is closer, so the data transmission rate is fast. And a fog computing layer can be extended between the cloud centre and the device. The fog computing layer is deployed in the sensing layer of the Internet of Things. [6]The fog access point with computing and storage functions acts as the sensing node of the Internet of Things, enabling data collection, partial data, local processing and storage functions. These points can directly communicate directly with the IoT terminal in the area [7], and its converged service architecture is shown in Fig.3.

Figure 3. Fog computing and IoT integration services framework

3.3. Application Analysis of Artificial Intelligence and Big Data in Medical System

3.3.1 Application of AI in medical systems
At present, the fusion application of AI and big data is mainly based on fog computing (edge computing) and IoT technology which promotes its application and development in the medical field. Here are three examples. Firstly, the integration of hospital management and AI can not only effectively optimize resource allocation, improve hospital management efficiency and service quality, but also rationally optimize the information and time allocation of personnel, finance, materials and medical institutions and make up the loopholes of hospital management to the maximum extent. Secondly, the integration of medical image and AI, especially cardiovascular and tumor imaging. AI cardiovascular angiography can improve early screening and prevention of circulatory diseases in humans. [8] AI tumor imaging is particularly useful in enhancing the understanding and analysis of treatment and related technology solutions for human tumor diseases. At last, it can apply to disease diagnosis and prediction and AI fusion. Through artificial intelligence technology for timely and effective quality control for image capture, automatic analysis and diagnosis, unnecessary time-consuming can be avoided. Image screening can be effectively realized, and artificial intelligence technology is used to judge and predict the disease from the results of human behavior, biochemistry and imaging.

AI effectively promotes medical research and the standardization of medical data. For instance, it can use machine learning and natural language processing techniques to capture patient medical records and clinical variables automatically. It can also integrate multi-source heterogeneous medical data, structured Medical records and related literature to generate a standardized medical database to effectively achieve "secondary" utilization, reduce costs, and improve the quality and efficiency of medical services.
3.3.2 Application of big data in medical systems
Medical system data includes basic patient information, electronic medical records, medical imaging data, medical management, financial data, device parameter information, and meter data. These data are obtained by collecting various services from various subsystems of the medical system. They have basic data characteristics such as large scale, complex structure, fast growth, and huge potential value. In particular, due to this Class data collection comes from different medical edge devices, and inevitably, it will also have time, redundancy and privacy. Big data application analysis of medical data in the medical system can provide a more reliable basis for drug use, cause analysis, disease prevention and wearable device optimization.[9].

For the future development of medical systems, as the scale of medical data will gradually become larger. By mining medical data, analysis and processing, we can further improve the accuracy and timeliness of clinical diagnosis. Compared with the traditional working mode where diagnosing depends on the doctor's expertise and diagnostic experience, the big data medical system can accurately calculate and deliver more decision information to provide reliable data support for clinical diagnosis and effectively improve the accuracy and timeliness of diagnosis. For patients, they could reduce artificial misdiagnosis and time delays. There is no doubt that big data used in the medical field will gradually become more common because it can be used for diagnostic analysis and decision making.[10] But it is also necessary to pay attention to protecting data security and considering how to protect the balance of data privacy. Therefore, it still needs to be added access control strategy with adequate security and an effective data encryption method. Still, the premise is that it cannot affect the overall efficiency, minimize the contradiction between doctors and patients and improve the comprehensive quality level of medical technology and services.

4. Key Technology Analysis of Big Data in Medical System
The key technologies of big data in medical systems mainly include techniques such as data fusion mechanism, data migration, data replacement and security.

4.1. Big data fusion mechanism
The medical system has a lot of data, such as patient name, doctor number, device model, electrocardiogram, sound wave, medical record, image picture, etc. There must be an efficient data fusion mechanism to extract useful information from these massive heterogeneous data which are different specifications for using structured and unstructured data. We use a hybrid structured big data fusion mechanism that is a combination of a structured data center and an unstructured data management platform.[11]

A structured data center is a collection of multiple structured data sets that are constrained by database schemas to ensure data consistency, discipline, accuracy and integrity. [12] The unstructured data management platform is an application that uses heuristics to guide data fusion and knowledge acquisition. This fusion mechanism has different processing methods for structured data and unstructured data. The structured data is extracted and washed, and then written into the database directly, and the unstructured data is divided, washed and counted first. What’s more, the unstructured data is divided into two categories, a type that can be converted into structured data, another type of unstructured data that cannot be converted or dynamic. The first type is converted into structured data by various application techniques and then written into the database, and for the second type, the data center is managed separately using a special database[13]. Data fusion of a large number of heterogeneous data that has been collected and stored in the current big data situation: there are three ways of data fusion: data combination, data integration and data aggregation, from combination to integration to aggregation, and gradually complete various data. The deep interaction between the two, to achieve data fusion[14], as shown in Fig.4.
4.1.1 Data combination
The data combination is a data table formed by the characteristic information of individual data, which is structured data. Data can be directly written into the database, and the nature of the data attribute does not change.

4.1.2 Data Integration
Data integration gathers multiple data groups with the same attributes to form a data mart, and multiple data group marts form a structured data center.

4.1.3 Data aggregation
Data aggregation further aggregates multiple data marts into one subject data, and multiple topics are collaboratively operated in the data management platform to realize information sharing and fusion, thereby further forming a heuristic algorithm of the system, and continuously improving the algorithm. Then, this heuristic algorithm is used to guide the fusion of big data of the system to form a ring of system self-improvement. This is a feature of the hybrid structured big data fusion mechanism, as shown in Fig. 5.

![Figure 4. Big data fusion model](image1)

![Figure 5. Big data fusion heuristic algorithm model](image2)

This big data fusion mechanism can structure and standardize the core data besides. It can flexibly process both custom and unstructured data. This not only ensures the feasibility and availability of data after the integration of big data, but also improves the efficiency of data usage, greatly improves the utilization rate of resources and reduces the occupancy rate of resources, and is a medical system that is scarce for the original resources. It is a very good mitigation solution. [15]

4.2. Big data migration technology
In today's Internet-based healthcare systems, the number of users of information systems is increasing, and the resulting data is exploding. As information technology and big data applications continue to evolve, there is a need to improve and update information systems continuously. In this process, a large amount of data needs to be transferred to the new database, so data migration is particularly important.

Big data migration technology is a kind of technology that migrates a large number of data sets obtained through certain methods and time to a specific database or information system and implements hierarchical storage.

4.2.1 Big data migration technology features: extraction, conversion and loading.
- Data extraction
  The extraction process determines the extraction method for each data source, and data having a utilization value to the target host or system is extracted from the previously obtained data set. The extracted data is then cleaned, and data that is ambiguous, ambiguous, repetitive, incorrect, and incomplete is discarded.
- Data conversion
It is to convert the cleaned data into a specific data set according to the requirements of the new host system. The mapping relationship between databases in the old and new information systems is an important basis for extraction and transformation.

- **Data loading**
  Data loading is to use the load tool or self-written program to save the converted data set to a specified target database.

4.2.2 **Two big data migration technologies commonly used in medical systems.**

- **Logical volume migration technology**
  Connecting the host to an original volume and a new volume, and perform data synchronization mirroring between the original volume and the new volume. After the mirroring is completed, the original volume is detached for migration.

- **Data storage migration technology**
  Data storage migration technology can be divided into homogeneous storage and heterogeneous. It can complete the data migration work in a relatively short time. Therefore, it can be used in the case of long transmission distance, massive data collection and long interruption time. Therefore, it is suitable for the case, including the long-distance transmission, the big data collecting, and the not-too-long interrupt service time.

4.3. **Big data replacement technology**

In the medical system, the early accessed data may not be replaced with the most recently accessed data due to a large amount of data, the limited number and storage capacity of cache nodes and the low speed of processing data.

Big data replacement technology is a technology that establishes a data channel between two or more data terminal devices and then takes an optimal scheduling method to solve the replacement problem between a large number by determining the scheduling frequency of certain data sets. The principle is that nodes in the network can implement data exchange between devices connected to the other end according to a certain transmission mode. This technology - an extension of data exchange technology in the field of big data - enables us too efficiently and accurately coordinate the transmission of a huge number of data traffic between various devices and at the same time ensure the security of data. Today, there are quite a few big data exchange service applications, such as FTP/sFTP, Web Service, Dubbo, Oracle, Kafka[16], and so on.

The big data replacement technology of the medical system not only has the essential characteristics of the big data replacement technology but also has the function of data verification and data filtering of the big data replacement technology. Therefore, for smooth transmission of data, there are requirements for hardware configuration. The big data application of medical system based on fog calculation allows the processing and result of data to be placed in the bottom edge terminal, which can significantly reduce the pressure on the server and effectively improve the processing efficiency and transmission rate of the data. This application can meet the requirements of the medical system for big data replacement. Through distributed storage, much important information can be backup well. The sharing of big data is also facilitated. The application of fog computing and big data replacement technology in medical systems, which can significantly alleviate the current situation of excessive medical information, tight storage resources and slow data processing, is a trend in the future medical system.

4.4. **Big data security new technology**

Since the beginning of applying data to the system, the data security issues have become popular. For example, more and more data leakage, fraud, extortion and cyber-attacks have occurred. It is the same in medical systems; the core issues are patients' data leakage and medical fraud, and so on, which bring great trouble to them. A large number of cyber-attacks also appear in enterprise systems, causing instability factors for society. With the extensive use of big data and Internet of Things technologies,
cyberattack capabilities are increasingly powerful, so, it is necessary to improve the requirements of big data security technology. In addition to enhancing security technology functions, it is necessary to strengthen prevention and to use new security technologies to fight against advanced attacks on the Internet of Things. We also need to enhance digital business transformation and new computing technology applications, such as fog computing, edge computing, mobile computing and IoT technology.

A new big data security technology currently in use in medical systems.

- **Cloud platform load protection technology**
  This technology allows a single console to manage different types of workloads, infrastructure, and locations, including physical/virtual machines and containers, except for private/public clouds, enabling common security policies to be deployed in all locations.

- **Security proxy technology of cloud access**
  Multiple cloud services and applications are used within the enterprise, all of which are monitored by the cloud access security agent. The organization effectively implements security policies to deal with the risks of cloud services and ensure the compliance of all cloud services.

- **Deception technology**
  Deception technology can provide insight to detect malicious attacks and take proactive security measures to defeat the attackers. The solutions of deception technology cover multiple layers of the enterprise network, including the data, applications and endpoints of the entire network.

- **Endpoint detection and response technology**
  In the Internet of things, these security solutions monitor all endpoints of any abnormal / malicious behavior. The technology of endpoint detection and response focuses on detecting abnormal activities, and then investigates abnormal activities and repairs to mitigate the threat level.

- **Partitioning technology**
  It separates the application and work of virtual data center, and the security model of virtualization software assigns fine-tuning security policies to each partition or even each work.

- **Software peripheral technology**
  In the IoT system, different systems and enterprises have the same network connection. Software peripheral technology can enable companies to define the content of sensitive information they need to know, and can also effectively delete this information. It helps reduce the attack surface by checking the identity and status of the device before allowing it to access the application infrastructure.

5. **Conclusion**

The computational structural of distribution mode, aiming at the deficient application of big data of cloud computing platform in the medical service system, uses new IoT structure design with decentralization, making the utmost of fog computing and Internet of Things technology. It combines with the technical feature of artificial intelligence and the applied technology of big data to build a new medical service system. This mode reduces the network delay in data transmission in the medical system and the bandwidth requirements greatly and ensures high efficiency, accuracy and security of data transmission. On the one hand, it can provide users with intelligent information functions which can improve the comprehensive management level and efficient service quality of medical institutions, such as hospital information, queuing appointments, medical diagnosis and image analysis, disease screening analysis, medical results printing, medical checkout, etc. On the other hand, it can provide users with a more convenient and competent medical service to solve medical problems such as “difficulties in registration, long queues, network congestion, information leakage”. What’s more, it can improve the efficiency of medical diagnosis, reduce the rate of misdiagnosis, reduce contradiction between doctors and patients and provide the brand-new big data technology application services for the medical establishment.
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