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Application of Cloud-Driven Intelligent Medical Imaging Analysis in Disease Detection

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Abstract: ***The integration of cloud computing and artificial intelligence (AI) in medical imaging has revolutionized disease detection and diagnosis. This paper explores the application of cloud-driven intelligent medical imaging analysis, highlighting its ability to manage and utilize massive datasets efficiently. By leveraging the vast storage capacities, high computing power, and robust data security of cloud computing, coupled with the precision and speed of AI algorithms, medical imaging processes are significantly enhanced. The development of intelligent systems enables real-time data access, remote consultations, and mobile solutions, which improve the accessibility and availability of medical resources. This synergy not only alleviates the workload on radiologists but also supports better patient outcomes through advanced diagnostic capabilities and seamless collaboration across medical institutions. The ongoing advancements in these technologies promise to drive further innovation and enhance the quality of healthcare services.***

Keywords: Cloud Computing; Artificial Intelligence; Medical Imaging; Disease Detection.

1. INTRODUCTION

In modern medicine, medical imaging is paramount for clinical and differential diagnosis, forming a critical component of the medical process [1]. Currently, 70% of clinical diagnostic procedures in hospitals rely on medical imaging, which accounts for 80% of the data generated within these institutions. As the level of medical informatization improves, the volume of medical data is rapidly increasing. Hospitals frequently need to expand their data center storage capacities, often requiring substantial financial investments. However, many hospitals still use local area networks (LANs) [2-3] for imaging, leading to large data volumes, slow transmission speeds, limited sharing capabilities, and underutilized data, turning valuable medical information into a liability.

The application of cloud computing in the medical industry promises to usher in a new era of Data Technology (DT) [4-5]. Cloud-based medical data can be shared across regions and institutions, enabling broader access to essential medical resources for patients. By moving medical images to the cloud, hospitals can leverage cloud computing and storage technologies for rapid data retrieval, networked data sharing, and scalable applications. This transition offers doctors more convenient access to clinical image data and integrates with big data, the Internet of Things (IoT), and Artificial Intelligence (AI), creating vast new possibilities and added value.

The concept of the medical image cloud has emerged as a key area within cloud computing. Prominent Chinese companies like Alibaba, Tencent, and Huawei, along with international giants such as Amazon and Microsoft, are collaborating with traditional medical equipment and imaging companies like GE, Philips, Siemens, Carestream, and United Imaging. These collaborations aim to innovate and explore new frontiers in cloud-based medical imaging.

2. RELATED WORK

2.1 Medical image analysis

Medical imaging examination usually includes digital photography (DR), computed tomography [6] (CT), nuclear magnetic resonance imaging (MRI), ultrasound, etc., which is the most direct and most commonly used important disease diagnosis method at present. Medical data 80%-90% comes from medical imaging, and at present, medical imaging data in China is gradually growing at an annual growth rate of 30% [7]. However, in contrast, the growth rate of the number of imaging doctors is obviously insufficient, resulting in a serious imbalance between the number of imaging doctors and the number of patients, and it is difficult to ensure the quality and accuracy of doctors' work due to the excessive intensity of film reading. In addition, it takes a long time for imaging doctors to train and learn to meet the professional standards, and the training cycle is long and the cost is high. Therefore, digital and intelligent tablet reading software based on artificial intelligence (AI) came into being, aiming to improve the speed and efficiency of tablet reading, assist doctors in their work and reduce the burden on doctors. The implementation principle of medical image analysis algorithm involves several steps and techniques such as data preparation, feature extraction, model selection and training, model evaluation and optimization, deployment and application. The specific steps are as follows [8-10]:

(1) Data preparation and preprocessing:

Medical image data needs to be collected first, which may include different types of images such as [11] X-rays, [12] MRI, [13] CT scans, etc. These images may be affected by problems such as noise, low contrast, motion artifacts, etc., so pre-processing such as denoising, contrast enhancement, registration, etc. is required to ensure image quality and consistency.

(2) Feature extraction:

Extract diagnostic features from pre-processed images. These features may include shape, texture, density, intensity, etc. Traditional feature extraction methods include manual design of features based on image processing techniques, or deep learning techniques can be used to learn features directly from the original image.

(3) Model selection and training:

Select appropriate machine learning or deep learning models for image classification, object detection, segmentation and other tasks. Commonly used models include convolutional neural network [14] (CNN), recurrent neural network [15] (RNN), U-Net, Mask R-CNN, etc. After the model is selected, the model is trained using the annotated medical image dataset to learn how to classify, detect, or segment based on the extracted features.

(4) Model evaluation and optimization:

The test data independent of the training set is used to evaluate the model, usually using various indicators such as accuracy, recall rate, accuracy, F1 score, etc., to evaluate the performance of the model. According to the evaluation results, the model is tuned and optimized, which may include adjusting the model structure, hyperparameter optimization, etc.

(5) Deployment and application:

The trained model can be deployed to practical medical applications, such as imaging diagnostic systems in hospitals. In the deployment process, it is necessary to consider the real-time, stability and security of the model to ensure that the model can effectively assist doctors in diagnosis and treatment decisions.

2.2 Ai-assisted medical imaging diagnosis

In recent years, some studies have shown that the improvement of the classical convolutional neural network model can improve the segmentation efficiency of medical images, shorten the segmentation time, and reduce subjective bias. For example, Cui et al., Shanghai Jiao Tong University, proposed a method based on image blocks that can automatically segment brain MRI using convolutional neural networks, and the segmentation accuracy is as high as 90% in the segmentation task of thalamus and lateral ventricle [17]. Liauchuk et al. used the GoogLeNet network to detect lung nodules, and found that the AUC(Area Under Curve) for detecting lesions based on convolutional neural network was 0.969, while the AUC value of the traditional feature extraction method was 0.895.

Coronary CTA imaging intelligent diagnosis system, known as the "polaroid" of coronary diagnosis report, was successfully put into use in Wuhan Central Hospital in 2018. This system can help doctors to carry out automatic three-dimensional reconstruction and interpretation of coronary CT images, and automatically output a structured and standardized report that can label and express the lesions of each blood vessel, and imaging doctors only need to review and confirm and correct the results based on the automatic output. While the manual processing process of a single case is greatly reduced, it also greatly improves the work efficiency of image diagnosis, and helps radiologists reduce the time of coronary [18] CTA image processing from the original 40 minutes to about 5 minutes.

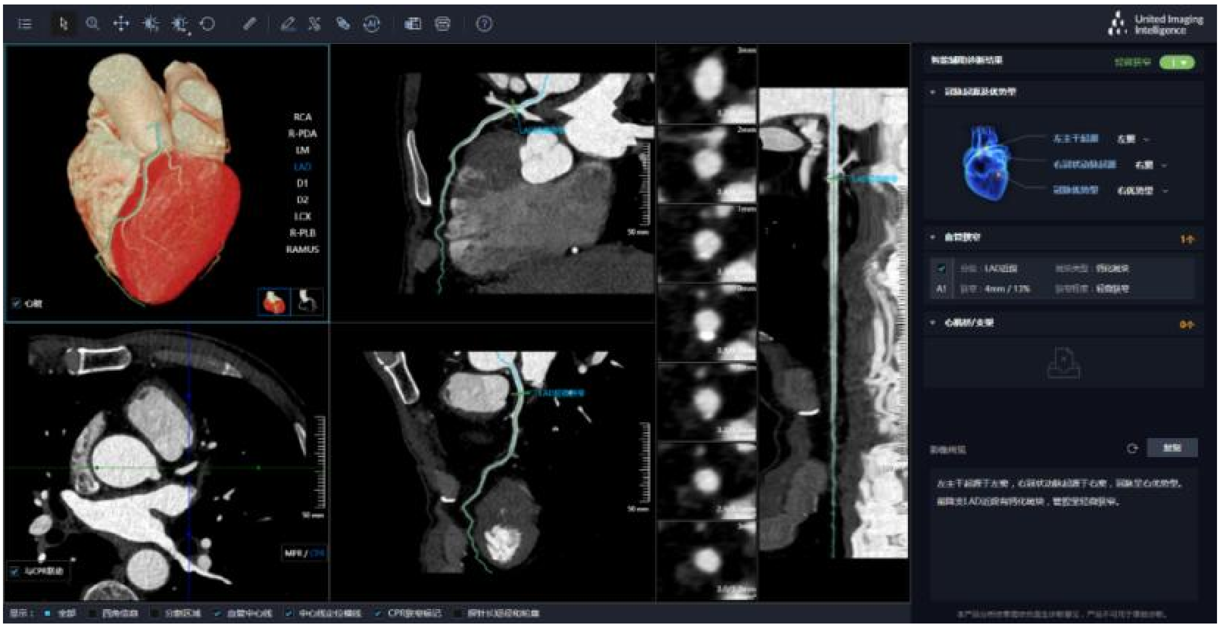

Figure 1: Ai-assisted medical diagnostic image analysis

Through patient information and image analysis, the size, location, shape, boundary, texture and other characteristics of the lesion can be extracted to predict the treatment response and evaluate the prognosis of the disease, which can help doctors better choose the appropriate treatment. Yang Yuejin's team selected 101 clinical variables as predicators based on coronary artery imaging parameters and clinical indicators of 23,173 PCI patients, used machine learning to build a prognostic MACE risk prediction model for PCI, and predicted the incidence of MACE events 12 months after PCI [19]. The results showed that the accuracy, sensitivity and AUC values of the MACE prediction model based on random forest algorithm were 88.66%, 79.58% and 0.96, respectively. It can accurately predict the incidence of MACE events after PCI, and then assist doctors to develop personalized programs for high-risk patients.

2.3 Advantages of cloud computing for medical diagnostics

(1) Mass Storage:

Youfu Network's data centers are strategically located in Beijing, Shanghai, and Shenzhen, covering key regions such as Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Guangdong-Hong Kong-Macao Greater Bay Area. This extensive layout meets the massive data storage needs of smart medical construction. The distributed structure of these centers offers excellent scalability, effortlessly handling petabyte-level storage [20]. The scale-out storage architecture enhances overall performance, enabling efficient expansion and effectively addressing the challenges of large-scale data storage and high-speed computing.

(2) Computing Power:

To address the computing power challenges in smart healthcare, Youfu's proprietary cloud leverages self-built data centers to provide significantly higher computing performance compared to traditional architectures. Coupled with Youfu's AI and big data applications, it fully supports various GPU applications and deep learning frameworks. This setup not only ensures high computing processing performance but also boasts a very high energy efficiency ratio, robust memory support, and significant [21] CPU architecture advantages, meeting the demanding requirements of smart medical computing power.

(3) Data Security:

Data security is paramount, especially given the sensitivity of medical information. Attacks on data centers can lead to serious data breaches and losses, affecting both organizations and patients. Youfu's proprietary cloud solutions offer professional data protection, supporting HTTPS/SSL security protocols and encrypted data uploads. Various methods and technologies are employed to ensure secure data transmission and access, providing excellent security services for the smart medical industry.

(4) Quality Service:

With nearly 20 years of experience in cloud computing data center operation and maintenance, Youfu Network provides a comprehensive service system. Their senior customer service team adheres to a "customer-centric" service philosophy, ensuring that customers and partners receive high-quality IT services and experiences [22]. Youfu Network commits to providing 24/7 service year-round, prioritizing customer needs and offering sustainable business protection that meets both domestic and international security and availability standards.

3. MEDICAL IMAGE CLOUD APPLICATION SCENARIOS

3.1 Image cloud storage

3.1.1 Scene definition

Medical image storage and backup is the transfer of medical image data from the existing hospital data center to other parks or third-party cloud platforms through the network, to achieve [23] PACS application backup image data disaster backup and permanent storage functions, to meet the needs of natural disasters, hard disk failure, hacker attacks, human damage and other cases, medical institutions can continue to provide stable external services. "Image cloud storage" is to store massive medical image data in the cloud, realize cloud storage and archiving of images, realize multi-point Dr Backup of image data, permanent storage and other functions, and solve the current storage and Dr Backup problems of image data. Image cloud storage is divided into data-level disaster recovery and application-level disaster recovery.

Image-level disaster recovery: Pay attention to image data. After a disaster occurs, the Dr Service platform relies on network-based data replication tools to implement asynchronous/synchronous data transfer between the production center and the disaster recovery center, ensuring that customers' original service data is not damaged.

Image application-level disaster recovery: [24-27] An application-level disaster recovery system is constructed based on data-level disaster recovery, that is, another set of application systems and backup network systems are constructed in the disaster recovery center. When the production environment is faulty, the disaster recovery center system directly takes over applications to continue running, reducing system downtime and ensuring business continuity.

3.1.2 Tae Tae application scenarios

Hospital HIS, CIS, PACS and other systems produce a large number of outpatient data, clinical data, user clinical treatment data and hospital operation and management data every day. Data security protection is the top priority of hospital information systems, and once lost, it will have a major impact on the normal production and operation of hospitals. Image cloud storage can realize "remote disaster recovery backup of image data", "historical image archiving", and "PACS application-level backup" to help hospitals solve the security of production and operation systems and data.

Image cloud archiving: For hospitals with PACS deployed, the storage space of hospital PACS is insufficient, which cannot meet the rapid growth of hospital data, especially image data. It is recommended to store high-frequency data locally and store historical archived data in the cloud, that is, rent third-party storage to expand storage space on the basis of hospital PACS. To ensure data integrity and reliability, it is recommended to deploy or rent two or more image cloud centers.

Image data remote Dr Backup: Used in hospitals with PACS deployment, without affecting the existing system, data backup in the cloud, and on-demand recovery after local damage. To ensure the reliability of hospital data, deploy remote storage disaster recovery (Dr) to back up hospital data and quickly restore services and massive data.

PACS application-level backup: The hospital has a complete information system. In order to prevent service interruption, Dr PACS are deployed. When the active PACS system fails, the Dr PACS system can take over application-level Dr, which improves the service continuity of the hospital after the PACS system fails. The active data center and Dr Data center can work in hypermetro or active/standby mode.

3.2 Analyze medical images in the cloud

Cloud-based storage and analysis of medical images significantly enhance the efficiency and accuracy of medical diagnostics. By leveraging cloud technologies, hospitals and medical institutions can store, process, and analyze medical images, perform film reading operations (such as image scaling, window adjustment, marking, and measurement), and carry out image auxiliary processing (including image contrast, image fusion display, and 3D reconstruction).A practical example is the use of cloud-based systems for advanced clinical applications such as intelligent image analysis [28-29], 3D reconstruction, high-density projection, one-click bone removal, virtual surgery, and 3D printing. In virtual surgery, for instance, surgeons can plan complex procedures using 3D models, which enhances surgical precision. A study conducted at a major hospital showed that using cloud-based 3D reconstruction reduced the time for pre-surgical planning from several hours to under 30 minutes, allowing for quicker and more accurate procedures.

Cloud image reading enables real-time processing and analysis of general imaging, supporting quick reading on various intelligent terminal devices. This mobility is crucial for on-the-go medical professionals who need access to images and reports anytime, anywhere. At a regional medical center, the implementation of cloud-based image reading allowed radiologists to access and interpret images from different departments and even remote locations. This led to a 25% reduction in turnaround time for diagnostic reports, significantly improving patient care.

By processing images in the cloud, client devices only need to decode and browse the images, which lowers the hardware requirements and enhances data security. A large-scale healthcare provider reported a 40% reduction in costs related to client-side hardware upgrades after transitioning to a cloud-based system. Additionally, only the necessary portions of images are returned to the client, minimizing data transfer volumes. A study in a multi-hospital network found that cloud-based image retrieval decreased network data transfer by 50%, resulting in faster access times and reduced bandwidth usage. Cloud systems integrated with AI can assist in diagnosing conditions more accurately. For example, an AI algorithm implemented in a cloud platform at a hospital network in China achieved a 92% accuracy rate in detecting lung nodules from CT scans, outperforming traditional diagnostic methods [30]. The cloud infrastructure also allows for seamless expansion and scalability. A healthcare group utilizing Amazon Web Services (AWS) for their imaging needs reported a 30% improvement in their ability to scale up storage and computing resources during peak times without compromising performance.

By utilizing cloud-based solutions, medical institutions can improve the accuracy and efficiency of medical imaging analysis, streamline operations, enhance data security, and provide better patient outcomes. These advancements demonstrate the practical benefits and transformative potential of integrating cloud computing with medical imaging.

3.3 Moving image cloud

Based on the medical image cloud system, doctors can access patient image data or diagnostic reports through mobile terminals anytime and anywhere in the hospital (ward, operating room, emergency room) and outside the hospital (at home or on a business trip).

The mobile image is the trend of The Times, and it is also the basis to solve the problem of graded diagnosis and treatment and remote consultation.

3.3.1 Mobile image reading, anytime, anywhere multi-terminal reading

Image in the cloud, doctors can use mobile phones, computers, tablets and other terminals to access image data at any time and anywhere, view and process image data, to realize any time, any place and any place, the network is accessible.

3.3.2 Doctors mobile ward rounds, real-time view of patient image information

During the ward round, the doctor can check the patient's electronic medical image and other information through mobile inspection RV or portable tablet computer [31-32], PDA and other mobile terminals, communicate with the patient to introduce the condition, analyze and record the change of the condition in real time, and provide suggestions for later treatment.

3.3.3 Move image reports to give or view image diagnostic reports in real time

The doctor reads the images in the hospital or outside the hospital through the mobile terminal, carries out the image reconstruction, reads the film, writes the diagnostic report, makes the diagnosis or participates in the consultation.

3.3.4 Remote first aid instruction and ICU intensive care

In an emergency case, the doctor on duty needs a consultation with a specialist when encountering an emergency special condition, while the specialist who is not in the hospital can use a handheld terminal such as Pad to receive medical images through the wireless network and make a judgment in time. Or through the mobile network, timely transmission of image data to the external expert consultation, saving the golden rescue time.

Through the video equipment and the data collector of the medical Internet of things, the physiological signs data of emergency patients can be collected in real time, and through the Internet technology and cloud platform, the ICU experts of comprehensive hospitals can carry out real-time remote monitoring and provide guidance for the grass-roots level of critical illness rescue, improve the level of grass-roots emergency aid, and effectively reduce the emergency mortality rate [33-34]. And provide 24-hour uninterrupted expert remote intensive care services to reduce ICU mortality.

4. CONCLUSION

The integration of cloud computing and AI in medical imaging significantly enhances the efficiency and accuracy of disease detection and diagnosis. Cloud-based solutions offer vast storage capacities, high computing power, and robust data security, addressing the challenges of managing and utilizing massive medical image datasets. AI algorithms further augment this by automating image processing tasks, improving diagnostic precision, and speeding up the diagnostic process, thus reducing the workload on radiologists.

The combination of these technologies facilitates the development of intelligent medical imaging systems that provide real-time data access and remote consultation capabilities. This improves the accessibility and availability of medical resources, enabling seamless collaboration across different medical institutions. Moreover, mobile cloud solutions allow healthcare professionals to access patient data and diagnostic reports anytime and anywhere, supporting remote consultations and emergency care, ultimately improving patient outcomes.

Overall, cloud-driven intelligent medical imaging analysis represents a transformative advancement in healthcare, promising more efficient, accurate, and accessible medical services. The ongoing development in cloud computing and AI is expected to further expand their applications, driving innovation and enhancing the quality of healthcare.

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