

DICOM Standard and Its Application in Radioinformatics

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ABSTRACT

The DICOM standard is the emerging standard in the field of medical informatics. It defines the standard network interface and data model makes the medical image equipment manufacturers on the standard network equipment interconnection, simplify the development of various types of medical image, promote open unrelated to the factory of medical digital image transmission and exchange, prompting the image archiving and communication system of PACS (Picture Archiving and Communication Systems) and the combination of various hospital information system HIS (Hospital Information Systems). Radiation therapy departments in many hospitals have purchased more than one manufacturer of radiotherapy planning systems, and treatment information has to be communicated using DICOM standards. The use of DICOM in radiotherapy is called DICOM RT. At home, doctors are not fully aware of its importance and researchers do not. This paper mainly discusses the implementation and application of DICOM and protocol in precision radiotherapy system. The main contents include: (1) DICOM RT defines a total of seven information objects, which play a pivotal role in the information exchange of radiotherapy system. Discuss the content of DICOM RT; discuss the development of radiotherapy technology at home and abroad. (2) At present, DICOM standard has been widely used in the field of medical informatics, but no authority can provide DICOM compatibility verification of imaging equipment or DICOM application system, which still has many difficulties in system interconnection, that is, the research and implementation of DICOM test method. (3) The application of DICOM in PACS system. (4) Impaired compression study without visual loss in medical images based on DICOM standard.

KEYWORDS

DICOM standard, DICOM RT, DICOM test tool, DICOM application, no visual loss damage compression

1. INTRODUCTION

DICOM (Digital Imaging and Communications in Medicine) Standard[1] is to standardize the exchange format and method of medical images and related information, By the American Society of Radiology (ACR, the American College of Radiology) and the National Federation of Electronics Manufacturers (NEMA, the National Electrical Manufacturers Association) Jointly launched the medical digital imaging communication standard. It solves the problem of interconnection between medical imaging equipment from different sources, promotes the development of medical imaging archiving and communication system (PACS, Picture Archiving and Communication Systems), and enables the integration of PACS system with other hospital information systems.

DICOM standard is the standard of medical image storage and communication, which has been adopted by many manufacturers of medical devices, medical diagnostic equipment and related medical diagnostic software at home and abroad, and has gradually become the international standard of medical image file formats and transmission protocols. DICOM has become the standard for medical imaging systems in North America, Europe, Japan, [2] and South Korea. PACS based on

DICOM is a medical image archiving and communication system. It is a composite medical image management system for automatic medical image acquisition, display, image post-processing, transmission, storage, query, retrieval, writing diagnostic reports, and viewing the running status of imaging equipment.

DICOM SR It provides a solid foundation for the unification of diagnosis reports, the direct sharing of patient information in various hospitals, the interaction of regional medical treatment and telemedicine and even the national hospital information. The DICOM standard evolved from the ACR-NEMA standard jointly proposed by the American College of Radiology (ACR) and the American Electrical Appliance Manufacturing Association (NEMA) in the early 1980s. Ideally, radiotherapy would be a doctor to pinpoint the shape, size and location of the tumor and target the lesion with the highest lethal dose. In order to help doctors accurately develop radiotherapy plans, it is necessary to compare and integrate the data of different radiotherapy planning systems, so as to obtain high-precision treatment planning. However, the equipment manufacturers, array, data format, not each other, in order to solve this problem, the international standards organization in the radiation therapy system data transmission and storage of DICOM protocol, namely DICOM RT, so through the different formats of data into a unified format, can realize data sharing, thus laid a foundation for the establishment of accurate radiotherapy system.

At present, the research on DICOM RT in China is still in its early stage. With the rapid development of computer technology, the application of DICOM RT is paid more and more attention. PACS research and development based on DICOM standards is still in its infancy.

2. DICOM SUMMARY

DICOM specifies the exchange format and method of medical digital imaging and related information, and has developed into an international standard in the field of medical imaging informatics. Now the most widely used are the DICOM 3.0 Standard, It covers almost all protocols for the acquisition, archiving, communication, display and query of medical digital images, A set of objects, including various types of medical diagnostic images and their related analysis, reports, is defined by open interconnection architecture and object-oriented approach, Defined the service class and command set for information transfer, exchange, And the standard response to the message, It details the technique of identifying all kinds of information objects, Provides an application to the network environment (OSI or TCP, Service support for IP), Structured defines the manufacturer's compatibility statement (Conformance Statement) [3]. The introduction and implementation of DICOM standard have greatly simplified the realization of medical image information exchange, promoted the research and development of tele-radiology system and PACS system, and due to the openness and interconnection of DICOM, it is possible to integrate with other medical application systems (HIS, RIS, etc.).

The DICOM standard is scalable, which has continuously expanded its content and eliminated unnecessary parts since its inception. DICOM standard has complexity, it covers a wide range of content, the acquisition, archiving, communication, display and query aspects of medical digital images. The DICOM standard also has some flexibility, allowing the medical imaging equipment manufacturers to flexibly adopt the corresponding part of the standard to support the DICOM standard according to the actual needs, without the need to implement all the content of the DICOM standard. Therefore, all imaging devices compatible with the DICOM 3.0 standard should have a compatibility statement.

DICOM Is a digital image communication standard that specifies the format and methods of medical digital image and related information exchange, which promotes the sharing of hospital image information and system interconnection. At present, DICOM standard has been widely used in the field of medical informatics, but no authority can provide DICOM compatibility verification of

imaging equipment or DICOM application system, which still has many difficulties in system interconnection.

3. THE DICOM TEST TOOL

To determine the actual compatibility of DICOM equipment, DICOM compatibility test is necessary to connect DICOM equipment to the actual information system for Australia 4 test. First of all, for some small and medium-sized hospitals whose information system has not been built or imperfect, there is no sufficient conditions to test the DICOM equipment to the actual system. For the DICOM standard developers, the cost of connecting the DICOM equipment and DICOM application system to the hospital information system test, the actual operation is troublesome, involving the migration of the equipment. Therefore, it is necessary to develop dedicated DICOM compatibility testing tools.

At present, a few organizations at home and abroad have discussed the DICOM compatibility test, and developed some DICOM compatibility test tools. Among them are the DVT [4], jointly developed by AGFA company and Philips company, and the CTN (Central Test Node) test program [5], developed by the Mallinckrodt Society of Radiology. Through our analysis, these existing test tools have defects in reliability, ease of use, clarity of results and other aspects, which cannot solve the current problems very effectively.

4. DICOM RT CONTENT AND APPLICATION

4.1. Linking of the DICOM with the DICOM RT

DICOM RT Standard and DICOM standard are relatively independent and necessarily related; in content, DICOM RT is the supplement of DICOM standard; in data type, RT data volume is extremely large and the structure is more complex; in information architecture and data coding, DICOM RT still uses DICOM architecture to encode image [6].

currently, DICOM RT Seven information objects are defined, That is: radiotherapy images (RT Image), Radiation therapy dose (RT Dose), Radiation Structure Set (RT Structure Set), Radiotherapy schedule (RT Plan), Radiotherapy record (RT Treatment Record contains 3 parts: RT Beams Treatment Record, RT Brachy Treatment Record, RT Treatment Summary Record). Each information object contains a class of corresponding real-world objects. An RT information object corresponds to a basic functional unit of the DICOM—— standard SOP class [7].

4.2. The application of the DICOM RT

The core of the radiotherapy system is the radiotherapy planning system, the key of radiotherapy planning system is dose accurate calculation and display, the dose of the doctor through the radiation planning system to calculate the dose on the patient, in 2D or 3D display dose distribution, by judging the patient's lesion is completely irradiation and the patient's normal tissue from irradiation to adjust and modify the treatment plan, until the plan can meet the requirements, after the plan and then input the correct planning parameters into the accelerator, to treat the patient. It is clear that the calculation of dose and the display of dose distribution play an important role in the radiotherapy system.

4.2.1. Evaluation toolbox for radiotherapy planning based on DICOM RT

Monte Carlo simulation is a relatively accurate method to evaluate radiation therapy dose distribution, especially for simulating non-standard volumetric dose distribution. [8-9], but its application is greatly limited due to its large calculation amount, time consuming and other reasons.

4.2.2. Visualization tool of radiotherapy simulation based on DICOM RT

The development of radiotherapy plan is an essential process. In addition to relying on advanced imaging equipment, visualization technology is very important. radiotherapy visualization technology mainly includes 3 D image reconstruction, dose calculation visualization and radiotherapy environment visualization.

4.2.3. The DICOM RT-based electronic medical record (EPR) system, the RT browser, and the RTPACS

DICOM RT EPR (Electronic Patient Record) system, it is based on the PACS concept on [10], the radiotherapy system in the module data through DICOM RT gateway into DICOM RT standard format after [11], the data in the server, and then a Web and client data transmission and sharing, while using the graphical user interface (GUI) way to display the tracked cancer patient treatment process.

5. APPLIED STUDY OF DICOM

The application of DICOM is mainly divided into three categories, including DICOM image format (conversion of DICOM and non-DICOM format, DICOM image compression, etc.), DICOM communication, and DICOM image acquisition.

5.1. The DICOM image format

The transformation of the DICOM image format mainly focuses on the transformation of static or dynamic non-DICOM and DICOM medical images. DICOM images are sometimes converted into non-DICOM images to facilitate carrying, browsing, and other systems. Conversion of the DICOM files and non-DICOM file formats must be clear about the DICOM and non-DICOM file formats and their associated rules. Zhang Hua [12] mainly studied the dynamic and static DICOM image transformation, analyzed the DICOM image and BMP image format, and introduced the non-DICOM image transformation of single-frame DICOM, and briefly analyzed the idea of multi-frame DICOM image for media flow synthesis. Based on the compatibility problem that the images generated by non-DICOM devices in most hospitals in China are not suitable for medical software systems, [13] adopted VC++ to realize the conversion of non-DICOM to DICOM medical images and the conversion of non-DICOM to non-DICOM images, and promoted the flexible use of non-DICOM images and DICOM images without restriction inside and outside the PACS system. Wail A. Mousa et al. [14] used MATLAB to design a DICOM image conversion general image program that can be properly adjusted according to the size and size of the DICOM image, which provides a reference for the development of medical image processing software. Bo Qiang Liu et al. [15] uses VC++ to convert DICOM into bitmap, and then convert bitmap into other general images. During the conversion process, brightness, contrast, image filtering, segmentation and other complex operations can be modified. The transformation of DICOM image generally relies on the existing image programming software to analyze DICOM and non-DICOM OM images and do the corresponding format transformation processing, or use the way of automatic non-DICOM image to DICOM image transformation. Generally speaking, image conversion adopts the object-oriented programming language with strong image processing ability (such as C++, PASCAL, etc.) and professional numerical computing and image processing programming software (such as Mathematica, MATLAB, etc.).

5.2. DICOM communication

DICOM communication is mainly based on the client / server mode, and realizes information transmission through the interaction between SCU and SCP service class. The DICOM standard is

the communication protocol followed by the PACS system. DICOM medical image storage, management, retrieval and other related applications should be built on the DICOM upper protocol layer of TCP / IP protocol. DICOM Communication is the use of object-oriented method to transfer information, which facilitates the development and design of communication model by object-oriented language.[16], which analyzed the DICOM network protocol hierarchy based on the TCP / IP protocol, focuses on the structure of the message service unit in DICOM and the communication process, and uses Visual C#. Net has developed a set of components that can realize all DICOM services, providing a good auxiliary platform for the complex communication and secondary development of DICOM communication programs in PACS. On the basis of detailed analysis of DICOM network communication model, [17] combined DICOM communication mechanism and TCPIIP protocol, and used Visual C + + to develop a DICOM network communication library that can realize image transmission, storage, query and other functions, which provided favorable professional data for the development of DICOM network communication in PACS system. Wei Xian Li et al. [18] adopts DICOM communication model, ECP server / ECP client, TCP / IP, database technology, etc., to realize the LAN intelligent in vitro counterpulsation (External Counter Pulsation, ECP) ischemic heart disease medical center system, which provides good technical conditions for the realization of networked diagnosis and treatment of heart disease. The implementation of DICOM communication generally relies on the software or hardware mode of C / S mode, and can realize the interaction between SCP and SCU in an object-oriented way. The DICOM communication model is easy to implement, and can be directly compatible with PACS system and TCP / IP network protocol, which is easy to realize the seamless connection between various systems within the hospital.

5.3. The DICOM image acquisition

DICOM image acquisition mainly relies on the PACS system for automated network acquisition. PACS performs fully automatic medical image acquisition. In most cases, the quality and integrity of the acquired images are better, but due to artificial setting and intervention, some of the images are lost in the acquisition. In order to reduce misdiagnosis and shorten the diagnosis time of patients, many scholars at home and abroad have made detailed research on the recovery of lost images. Duan ni et al. [19] using image acquisition gateway service technology, and through the use of DICOM Query / Retrieve (search / acquisition) service C-FIND class, the imaging equipment image sequence and acquisition gateway database image comparison, determine the lost image, and through C-MOVE and C-STORE image recovery, to reduce the loss of hospital and save the life of patients provides a reliable guarantee. S.L.Lou et al. [20] explored two methods for lost image recovery based on DICOM Query / Retrieve and no DICOM Query / Retrieve, and compared the advantages and disadvantages of both methods, both centered on determining whether the CT and MRI image sequences end. At the same time, S.L.LOU et al. also carried out clinical experiments. In contrast, DICOM Q / R can meet the standard of practice. When obtaining hundreds of image sequences, in order to avoid and reduce the loss of PACS image acquisition database data caused by artificial change of DICOM communication settings, DICOM Q / R are good functional units. It can be seen that DICOM Query / Retrieve service class can quickly and accurately recover the lost image, recover the loss of the hospital and save the cost of repeated examination of patients. DICOM Q / R Whether running on gateway servers or workstations, it adopts object-oriented programmable technology, which provides the possibility to realize the different object-oriented requirements of each hospital.

6. MAIN CONTENTS OF NONVISUAL LOSS COMPRESSION OF MEDICAL IMAGES BASED ON DICOM STANDARD

Medical images in standard DICOM format are read from four large imaging devices (CT, MR, DSA, CR) with standard DICOM interfaces. Under the condition that the image geometry size, resolution, acquisition mode and imaging site are completely consistent, the image is compressed with different

compression ratios with the JPEG compression algorithm only supported by DICOM standard. For example, use CR to obtain a chest image in real time, the image resolution is set to 2500 x 2000 pixels and read out by DICOM port, and with Applicare's Rad words JPEG software compression, compression ratio is set to 10:1,20:1,30:1,40:1,50:1. The original digital image and the compressed digital image are guaranteed to ensure that the same laser camera with DICOM port is used to release the film under the same conditions, so that the size and density of several CT of the film are exactly the same. The film was randomly numbered to determine about 30 respondents (the respondents could be radiologists and internal surgeons from different hospitals). The respondents were asked to arrange the six X-ray films in order from low to high compression ratio according to their own judgment. Based on the survey and statistical analysis of radiologists and internal surgeons, an image compression ratio that can be accepted by professional doctors does not affect the diagnostic effect. This compression ratio is the [21] obtained under the condition of the image geometry, resolution, acquisition mode, and imaging site imaging mode.

Transforming one of the four factors of image geometry size, resolution, acquisition method, and imaging site allows you to obtain a set of data. Statistical analysis of this set of data can find the influence of image geometry size, resolution, acquisition method and imaging site on image quality.

For a PACS system, the mode of acquisition and the imaging site are two frequently changing conditions when the image geometry and resolution are relatively fixed. For example, for MR, the brain, spine, trunk, facet joints and other parts have different requirements; for brain imaging, CT imaging and different imaging methods have different requirements for image compression ratio. Through the study of multiple imaging modalities and multiple imaging sites, a group of image compression ratios that can be accepted by professional doctors and do not affect the diagnostic effect.

The research focus is the acquisition and output of medical images in DICOM format; the implementation of JPEG compression algorithm; and the appropriate mathematical statistical analysis strategy.

7. SUMMARY AND OUTLOOK

With the development of information technology, The application of DICOM standard in PACS has exposed some drawbacks: in the PACS system based on DICOM standard, At its core is the DICOM network, All the medical image data and related text information in and out of the DICOM network shall be converted into the format and communication protocol through the gateway or interface; Medical images and associated text information are located in different systems (PACS, HIS, etc.), Information dispersion, Standards and protocols for different systems, And does not support distributed operations, So that the system cannot be fully shared; With the continuous upgrading and complexity of the system, The fault tolerance, openness, interconnection and maintainability of DICOM system are increasingly difficult.

In order to realize remote digital medicine, regional PACS, national and even global PACS, CORBA technology can be combined with DICOM standards to make full use of the advantages of both. Due to the drawbacks of DICOM, the DICOM standard will be limited to medical imaging devices and display workstations, and other DICOM workstations. The mainstream network design framework will adopt CORBA technology based on distributed object design, and CORBA based on three-layer PACS architecture technology will gradually replace the DICOM standard two-layer PACS architecture, which makes communication more compatible and information sharing, and is also an important means to truly realize hospital telemedicine [21].

DICOM is the standard that must be followed by the medical image format in PACS, and it is the basis of communication in the query, acquisition and acquisition of medical images. DICOM mainly aims at the application of image processing, telemedicine, hospital informatization, image archiving and communication functions of PACS system[22]. This paper mainly discusses the development

status of DICOM at home and abroad, and studies the current application of DICOM by classification, and finally discusses the prospect of DICOM by combining the advantages of DICOM and CORBA technology. With the development of hospital information system and the construction of telemedicine, the PACS system based on DICOM will develop towards the intelligent hospital information system of distributed network structure, large capacity medical image compression and storage, rapid and gradual transmission, complex processing and diagnosis of medical images, efficient data access and integrated communication.

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