DICOM Server applied to Medical Image Processing

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Abstract

This work describes the design and implementation of a DICOM server that manages medical image studies for their further processing. It is based on connectivity specifications of a massive clinic standard, and has the capacity to manage studies and to run different processing algorithms, according to a decision making system by means of databases. The design provides great flexibility in terms of configuration and operations assignment, and permits compatibility with DICOM images transmission systems. The goal of the development is to apply automatic algorithms of clinical image processing carried out by research groups. By means of this system, it is possible to validate clinically new algorithms and employ them for the diagnosis and patient monitoring.

1. Introduction

The present work is framed within the Medical Image Management and Processing area and aims at managing multi-modal studies for image processing.

Generally, algorithms developed by research groups present inconvenients that make their validation and clinical implementation difficult. On the one hand, a highly trained medical and technical staff are required, who usually work in very demanding environments that make the use of the developed tools impossible. On the other hand, clinic validation of the algorithms requires a sufficient number of studies to achieve strong results. This task is generally performed by selecting studies and processing them manually.

In the above mentioned circumstances, clinic implementation of specific algorithms for different pathologies or modalities becomes impracticable. In order to overcome these difficulties, the design and development of a system that tries to associate processing algorithms research with their clinic implementation are presented in this work, implementing the DICOM standard [1] for the reception, treatment, and sending of such images.

2. Design

This system was designed for image processing management allowing the user to send studies for their processing and to receive the results.

The server, developed as a DICOM communication module, is configured to analyze each received study in order to determine if a set of predefined conditions are fulfilled. If this occurs, the corresponding processing algorithms of the corresponding studies are executed.

The studies can be received directly from a modality or a visualization workstation. The aim is to delegate to the server all complex processing calculations. It allows to speed up diagnosis and to provide new functions that visualization softwares do not generally have. This function solves problems associated with the minimum requirements needed for certain operations.

The system configuration and the state information are stored in data tables. The following three tables are used for the configuration: “Operation”, “Condition” and “Application Entity”. Each line of “Operation” defines a processing type that the server offers clients through different ports. “Condition” contains the list of condition for each operation. “Application Entity” stores the information of the destination entity for the results of the different operations.

The other function of the data system is the recording of the new incoming studies and the storing of information for their later monitoring. This information is also used as a decision making tool due to, the data of stored studies allows to define if the needed conditions for the beginning of a process associated to an operation have been fulfilled.

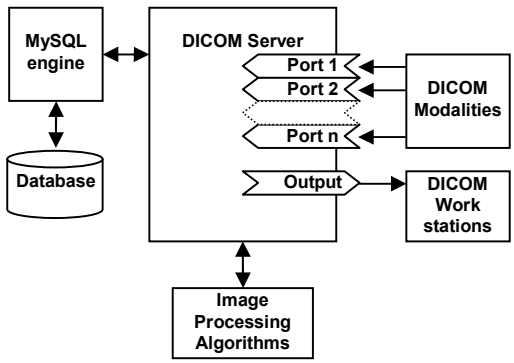

Figure 1 – System Overview

Another aspect to be considered in the design is that the management system must be capable of attending several clients simultaneously. The attention of different listening ports and the answer to the request of different

clients are independent processes. In informatics this is implemented by using execution threads. Each reception or sending task is implemented in an independent thread, allowing the system to deal with a request and to immediately wait for others. Figure 1 shows the general structure of the system.

3. Materials and methodology

The methodology employed comprises the following stages: Planning and requirement specification, Analysis, Design, Development, and Experimentation. Unified Modeling Language (UML) diagrams, widely spread, were used for the modeling process.

For the development of the system, GPL software tools were used exclusively. The Code::Blocks application, version 8.02, was chosen as the primary tool for the development of the server, associated with the MinGW compiler version 3.4.5. The database engine chosen is MySQL® version 5.0.

The CTN library (Central Test Node) [2] in its version 3.0.4 was used for the management of DICOM data and for the setting of associations.

The software was programed in C in order to have compatibility with CTN libraries. The query system to the database is carried out by using the API of MySQL included in the software itself.

The processing routines were provided by the people in charge of the project titled "Multimodal Medical Image Fusion and Analysis Applied to Diagnosis and Radiotherapy", carried out in conjunction with the Medical Technology Cabinet (*Gabinete de Tecnología Médica – GATEME*) from the School of Engineering of the National University of San Juan, Argentina, and the Foundation School of Nuclear Medicine (*Fundación Escuela de Medicina Nuclear – FUESMEN*) in Mendoza, Argentina. In that project, algorithms of high computational cost have been developed to achieve a good quality fusion among intra and inter modality images. These algorithms operate over PROCIMA libraries [3], developed by GATEME.

4. Results

The system has been tested at laboratory level at GATEME, and partially in the clinical environment at FUESMEN. During tests carried out at GATEME to verify the connectivity and the sending of studies, CTN [4] test applications and the eFilm Workstation visualization application, test version 2.1.4, were previously configured for the connection.

Different "Case Studies" based on the characteristics of the imaging processing algorithms developed were performed for the experimentation, namely:

- Intermodality/intrapatient registration for radiotherapy.
- Intramodality/intrapatient registration for treatment monitoring.
- Processing of single studies for diagnosis.
- Others.

The results obtained in the tests were satisfactory in general achieving the management of the study storing and the correct performance of the different treatment algorithms. At FUESMEN, tests for the reception and sending of studies of different modalities have been carried out, and the first algorithm for its clinic validation is been implemented.

5. Conclusions

This work has allowed the development of a Processing Server in accordance with DICOM standard. In this way, it is possible to integrate new processing algorithms to clinical environments. The application allows an automatic management of studies. The design presented in this work offers a system capable of making decisions based on a data set included in a DICOM object. The decision made determines which operation must be executed, which studies take part, and to whom the results must be sent.

The system can receive several studies, execute algorithms, or send results simultaneously using different processing threads. Operations, ports, conditions, etc., can be quickly modified by means of a SQL database.

For the design and the development of the server, GPL software tools have exclusively been used. This permits to improve and expand the research tasks performed in the region.

A weakness of the system is the necessity of employing automatic algorithms that require no user intervention. Even though there is a tendency to this kind of techniques, there is no possibility to interact with the user during processing tasks.

Regarding the implementation of the system in a clinical environment, it is necessary to execute it for a prolonged time in order to evaluate the system and algorithms.

6. References

[1] ACR-NEMA: Digital Imaging and Communications in Medicine (DICOM) Standard. Draft Versión 2007.

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7. Acknowledgments

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