An Ontology Visualization Tool for Indexing DICOM Structured Reporting (SR) Documents

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Abstract— In the medical fields, images and reports of patients are increasingly being held in a digital form. To overcome the problem of heterogeneity due to the use of different devices between the various specialties, DICOM SR standard (Digital Imaging and Communications in Medicine for Structured Reporting) has emerged. For the medical imaging community taking advantage of this standard to improve medical image retrieval systems become a challenging research issue. In this context, the aim of this paper is a preliminary contribution to an efficient indexing process of DICOM SR documents. We propose to guide this process with an ontology. We describe our motivations for building this ontology by reusing existing ontologies. Then, a specific ontology visualization tool is suggested for imagers to assist their indexing.

Keywords— Ontology reuse, ontology visualization tool, Owl, medical image retrieval, DICOM SR standard.

I. INTRODUCTION

In medicine, considerable advances made over the last years have improved practices related to patient diagnosis and therapy. In particular with the advent of digital imaging modalities, collections of reports with images are increasingly produced in a digital form. To take advantages of this rapid expansion, new research directions were taken in the medical image retrieval area. Developing medical databases supporting these heterogeneous data for efficient clinical applications intended to attract greater interest from the medical imaging community (radiologists, cardiologists...). Some solutions are suggested such as the DICOM SR standard (Digital Imaging and Communications in Medicine for Structured Reporting) and Content-Based Image Retrieval (CBIR) systems.

A CBIR system refers to the retrieval from image databases using information extracted from the content of images. Two categories of systems exist. The first one, called visual CBIR system, extracts automatically from images visual information such as color, texture, shape, spatial relationships for indexing the content of images [3]. The second category, called semantic CBIR system, indexes image content in terms of an interpretation of this content (image components and relations between components). When semantic CBIR systems interact with ontologies, we talk about ontology-based (or knowledge-based or concept-based) image indexing and retrieval (OBIR) [2]. The most referenced definition of an ontology is given by Gruber as a formal, explicit specification of a shared conceptualization. Ontologies are widely used in CBIR systems especially as a support of indexing or querying. In this paper, special emphasis is given to the semantic CBIR systems with the use of ontologies to assist image indexing. Our initial aim is a contribution to an efficient indexing process of DICOM SR documents guided by an ontology. A first solution is proposed and consists in a particular ontology visualization tool for imagers to help their documents indexing.

DICOM is the omnipresent standard used by imaging industry for the exchange and management of images in various medical fields (radiology, cardiology, dentistry, ophthalmology, dermatology...) [7]–[8]–[9]. Since 1993, this standard was centered only on the image. But now, DICOM is advancing towards the area of structured documents (SR). SR supplement provides the capability to link the clinical report to its DICOM images. From the computerized systems perspective, SR has many potential advantages, such as the production of well-organized and accurate reports and the ability to communicate results promptly. Consequently, improved diagnostic accuracy can be achieved with more speed, reduced overall costs, fewer errors and better management.

The rest of this paper is organized as follows. In section 2, a brief overview on related works is given. In section 3, we describe our motivations for building by reuse an ontology for indexing DICOM SR documents. Then, in section 4, to assist imagers in their tasks of semantic indexing, a tool is proposed to visualize this ontology in a multiaxial way. Its major characteristics and future incorporation inside a medical CBIR system are also mentioned.

2. RELATED WORKS

A review of content-based medical image retrieval systems can be found in [1]. Many systems have been developed on the medical image visual content but questions with respect to semantic gap, semantic descriptors are still unanswered and more desirable for medical applications. One key issue to be faced is the identification of semantic information from the visual data. In [3], a comprehensive survey on systems that attempt to bridge this information gap and challenges for such research can be found. Moreover, compared with types of medical images, CBIR systems that take into account DICOM and more recently DICOM SR are relatively inexistent. Currently, first applications (Osiris, IconoTech, DICOMEye...) are centered on viewing and conventional databases [10]. This is partly due to imaging devices from which such format is relatively difficult to obtain. Specific equipments are often required.

3. BUILDING AN ONTOLOGY FOR INDEXING DICOM SR DOCUMENTS

In this section, we explain our motivations to build an ontology for indexing DICOM SR documents.

3.1. Ontology plusses

Why ontologies can be used to support semantic indexing? An ontology provides a common and shared knowledge for modeling a domain (concepts, attributes, instances, axioms and relations), is understandable by a computer and can be also reused. Potential benefits are considerable and intended to more precisely and unambiguously express indexing and consequently better precision retrieval results.

3.2. A representation of imagers indexing levels

When we think about developing an ontology for indexing DICOM SR documents, we need to take into account the diverse points of view of the imager (the radiologist, the cardiologist, the dermatologist…) in front of its patients reports with their associated images. It is very difficult because an imager can establish various interpretations of its documents, objective ones and subjective ones. For these reasons, we suggest in Figure 1 to represent these viewpoints according four abstract levels: the contextual level, the visual level, the anatomical level and the pathological sign level.

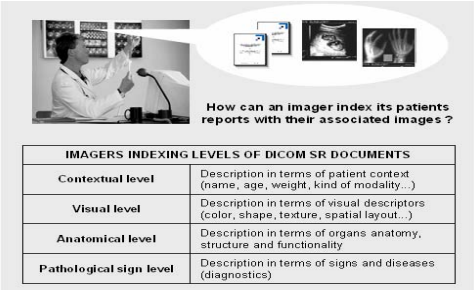

Fig. 1 Imagers indexing levels

3.3. Ontology reuse to build our ontology

Building an ontology from scratch with domain experts or from text analysis requires a huge effort of conceptualization and a lot of time. Moreover, we notice an ever-increasing number of online ontologies and libraries available on the web. Search engines such as Swoogle[1] and OntoSearch[2] have also started to appear to facilitate online search. For these reasons, ontology reuse is nowadays the most promising research domain for the ontology engineering community and diverse processes exist: mapping, merging or integrating, aligning or combining, extracting, enriching and translating [4]–[5]. According to our motivations and in the context of ontology reuse, first questions and difficulties arise [6]. Are there any similar existing ontologies, their heterogeneities, the reusing possibilities... Our future work is to introduce a strategy for building by reuse our ontology. In the medical field, a classification for the considerable number of existing ontologies is imperative and choosing which reuse process is more appropriate with respect to our representation of imagers indexing levels (Fig. 1) are initial research tracks.

4. AN ONTOLOGY VISUALIZATION TOOL FOR SEMANTIC INDEXING

The major goal of the work in this paper is to demonstrate a specific ontology visualization tool for imagers to assist their DICOM SR documents indexing. Its major characteristics and future incorporation inside a medical CBIR system are illustrated.

4.1. Tool characteristics

We have developed a bilingual tool (English and French) which visualizes ontologies in a multiaxial way. As shown in Figure 2 and in respect of our representation of imagers indexing levels (Fig. 1), four axes are created: the context one, the visual descriptors one, the anatomy one and the pathological signs one.

[1] http://www.swoogle.com
[2] http://www.ontosearch.com

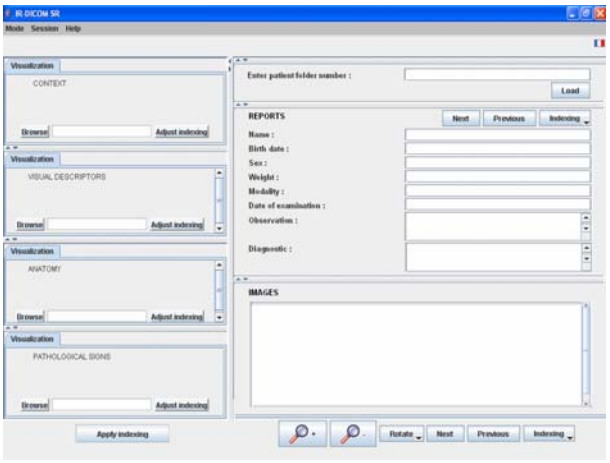

Fig. 2 Ontology visualization interface

After charging a DICOM SR document and before the indexing process, two scenarios of ontologies loading are possible. The first one allows imagers to load for each axis an ever-increasing number of ontologies. The second one offers to imagers the possibility to load fractions extracted from a specific ontology. Off-line ontology extraction activity will be conducted by tools. The Protégé Prompt plug-in one is very attractive and crucial in terms of its functionalities [11]–[12]. Ontologies are showed according to an arborescence view. For each ontology element (concepts...) a textual description is given (Fig. 3).

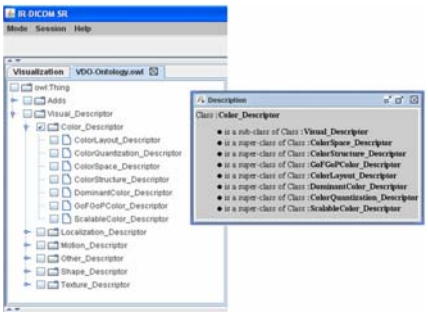

Fig. 3 Arborescence view of an ontology

4.2. A component of a future medical CBIR system

To improve medical diagnostic quality, an overview of our future medical CBIR system, called IR-DICOM SR (Indexing and retrieval of DICOM SR), is illustrated in Figure 4. DICOM SR documents will be firstly recovered from specific imaging devices and stored in a database. Then, imagers with the help of semantic indexing tools (the ontology visualization one and the results indexing visualization one) will index the database. As a result, each DICOM SR document will be described with a multi-dimensional vector called descriptor or index. In the retrieval mode, imagers or doctors will submit a query (an existing DICOM SR document extracted from the database) in search of similar DICOM SR documents. The system, with the help of a tool, will compute similarities between the descriptor of the query and those in the database. Finally, documents that are most similar to users query will be showed.

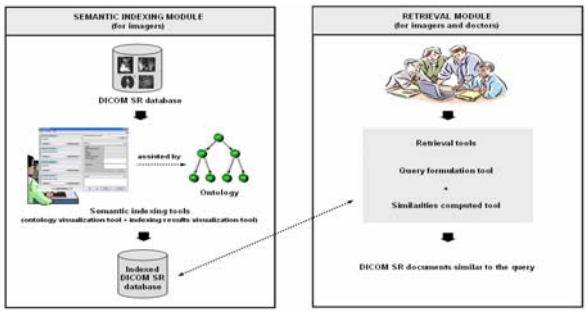

Fig. 4 Overview of our future medical CBIR system (IR-DICOM SR)

5. CONCLUSION

The work presented here is an initial contribution towards a future CBIR system for DICOM SR documents. Nowadays, the medical imaging community is increasingly aware of the potential benefit of these kinds of systems to improve diagnostics quality. We are currently planning to confront our approach with initial concrete experiences in bones and joints radiology. Clearly, our first results require consolidating and several extensions are possible for the tool. It would evolve as a future plug-in of Protégé to make it possible for the users to visualize their ontologies in a multiaxial way.

6. REFERENCES

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