Radiologic Image Library for Pathology Related Searches

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Abstract

Clinical environments require that Information Systems provide efficient access to the stored data. The actual effort is devoted to the evolution from archives towards integrated databases, including both data and images, allowing the researcher as well as the clinician to perform longitudinal and transversal studies, based on keys, lemmas and notes describing both pictorial and pathological features.

The present study aims to apply to a medical information system, tools and methods, derived from computational linguistics, to allow the navigation, annotation and creative analysis of the stored data (in particular radiologic images of cardiological and pneumological patients) for longitudinal and transversal studies.

1. Introduction

The requirements of an efficient Information System are: 1) easy access to clinical data and reports from the instrumental lab; 2) access to image archives for analysis and comparisons; 3) quickness in retrieval of images and reports from large archives; 4) immediate availability of the instrumental lab output for all the involved clinical departments; 5) a standard arrangement of the whole set of clinical data (including images) to allow easy interchange with other external healthcare units; 6) safety of transactions and access to "private" data. By focusing the attention to the archives of digital images, the actual services are restricted to image saving and simple recovery on the basis of simple queries (eg., identification data of the patient).

At present, the DICOM standard rules storage, transferring and sharing of cardiac images provided by different modalities, such as Magnetic Resonance Imaging, Nuclear Medicine, Computer Tomography, Digital Angiography, Digital Radiology, employing headings for the correct patient, healthcare and protocol association, together with image display and security [1].

New requirements are now coming out of the clinical and research needs, for what concerns the exchange, integration, sharing, and retrieval of images. In particular, the medical operators ask for the capability to get suitable results related to peculiar image features, as well as to intrinsic clinical meaning. Telecommunication technologies, joined to computational tools, could offer a wider potential range of employement. However a characterization of the clinical digital images from the medical point of view is missing. The state of the art technology, the Simple Image and Numerical Report IHE integration profile (SINR), aims to feed a Report Repository, using the well known, though seldom used, DICOM Structured Reporting standard. There are also projects aiming to classify and to index the stored digital images by means pictorial "properties" and features, possibly allowing datamining processes [2,3].

At a first glance, the development of such systems requires large human and economic resources to fulfill all the statements enabling the transformation of a rough image archive into a multidimensional database. The simple solution of coupling the clinical image to the medical report is not sufficient to perform an exhaustive search of populations or samples of images having common features of interest. More sophisticated tools are needed, allowing a digital data treatment, not pre-set (like in the commercial multimedial CD-ROMs, where there is no challenge for a creative interaction with the stored material), but realized by means of the navigation, the analysis and the annotatation of peculiar evaluations, to be associated to the single image, as well as to parts of it, or to whole sets of images.

Such problems are really similar to those met by managers of text libraries, to allow longitudinal and transversal searches in large digital text archives. The here presented application, yet under development, aims to transfer the experience of Computational Linguistic researchers, acquired for the management of libraries, into a medical imaging environment: complex searches, based on keys, lemmas and notes introduced by a medical operator, can be performed, grouping together images on the basis of pictorial as well as pathological features. XML tools allow the tagging of the reports and notes, to relate keyword and keysentences to selected regions of interest on each image, according to Text Encoding Initiative standards [3]. This preliminary prototype

applied to radiological archives, including images of interest in cardiology as well as in pneumology, is presented.

2. Methods

A network-based local information system [5] has been set up at the CNR Institute of Clinical Physiology (IFC), by linking the digital radiology acquisition system, the computerized clinical report workstations, the administrative office, and the core of the system, a DICOM server hosting demographic, clinical and pictorial data, into a stand-alone functional island, and developed by using Open Source tools [6].

As a product for the project FAD (Digital Archives and Funds) of the Italian Cultural Ministery, a complex system has been realized at the the CNR Computational Linguistics Institute of Pisa [7], mainly organized as computational modules for the management (eg. browsing, annotation and analysis) of digital libraries of ancient manuscripts, for philologic research and classification purposes. The tool is characterized by hardware and software components, which make an authorized operator able to access archives of digital images (originally scanned manuscripts), to view selected records, to annotate observations, and to store them in a way that transforms the original archives into multidimensional databases. The software functions, aside the classical browsing tools, allow dynamic as well as interactive segmentation of the images, tagging, and annotation, creating XML compliant interchange files, following the Text Encoding Initiative standard rules [3].

The FAD system has been adapted and arranged to fit both the clinical radiographic archives and the IFC Radiology department information system. Owing to the main purpose to give, in this first prototype, an orientative pictorial delineation of the regions of interests, a JPEG compressed copy of the original DICOM image was used. Many of the original tools of the FAD application could be applied, just excluding the script transcriber (OCR functionality) as it was unuseful for the present project.

Text input derives from the radiologic report database, so to allow the operator to associate sentences to each region of interest set on the image. Also local notes can be added by the operator to focus the observer attention by means of synthetic propositions. Tagging of the words is performed by discriminating and classifying each world. For each image, all the words, are analyzed by tools provided by computational linguistics, so to create indexes of single words, lemmas or sentences, to be classified as keywords or keysentences. This operation can be performed semi-automatically if supported by suitable dictionaries, particularly needed when medical terms have to be aknowledged. The indexed keywords are available for the information retrieval tools, making the operator able to perform complex longitudinal as well as transversal searches through the image database, by selecting sets of images to which the keys are associated.

3. Results

Fig. 1 shows an example of annotation extracted from the report. The expert can identify in the pictorial area the region of interest which is described by the note on the right side. The software provides an analysis of the text which is tagged so to index words, as well as segments of phrases, which point to the coordinates of the marked area. Each word is tagged obeying to Text Encoding Standard rules, creating an XML compatible file. Indexes are created and fullfilled by taking into account all the extracted information.

Fig. 2 shows an example of browsing and search, starting from the single term. To the selected word, evidenced in the text, is associated a region of interest on the image. By performing an advanced search, it could be possible to present all the images available in the database and indexed with the same word.

Medical terms in the annotation window of Fig.2 appear with colors and can be linked to regions of interest on the image on the left side, so by clicking on each of them the observer can get evidence of the area to which it is referred.

It is also possible to export the annotations to other environments, by means of Extensible Markup Language (XML) files [8]. In facts, the use of XML as a mean to structure the data, easily allows a fusion of this technology with the new communication standard proposed by the Health Level 7 (HL7) organization for clinical data: the Clinical Document Architecture (CDA) [9-11].

4. Discussion and conclusions

The capability to associate annotations to parts as well as to whole records of digital image archives opens the doors towards a different employment of digital archives. In facts, this tool represents the first step to improve the informatic management of the digital document, to realize new tools and services to a user-friendly access of digital image libraries, to allow more easy and complete archiving, management, browsing and use of actually not accessible neither classified digital image archives also through Internet linking, to promote digital image clinical and research approaches; to create the basis for future developments of tools for safety and security of digital image archives and network transfers.

This type of approach with multidimensional databases containing images with structured information, can be advantageous when many users will exist, spread on a geographical network. In this optic, it is important to

define a common dictionary and an appropriate semantics so that more databases of this kind can be crossed to get more meaningful and exhaustive answers.

The operator behave like a "clinical image librarian" which can characterize each image and region of interest, by a suitable association of notes, words and sentences, which integrate any automatically detected information on image pictorial properties and features. The computational linguistic approach makes it possible that complex text information could be destructured into simpler elements, to be used to create transversal and longitudinal links and paths to determine different point of views and classification approaches of the database.

The tagged text, saved in XML format, and obeying to a standard system of rules, improves the management, navigation through the database, by allowing the generation of associations between different records, which are naturally characterized by any included simple or complex information.

The system appears able to give a challenge to the solution to the further problem to transmit any information (text and/or related images) to external users, so to be available in different clinical environments. In effect the actual trend towards (global) standards for the exchange, management and integration of data that supports clinical patient care and the management, delivery and evaluation of healthcare services [9-12]. The HL7 organization [9] started developing the HL7 protocol, specifically, to create flexible, cost effective approaches, standards, guidelines, methodologies, and enable healthcare information system interoperability and sharing of electronic health records. One of the new aspects in the third version of the protocol is the evolution of information encoding by using native extensible markup language (XML) [10] to describe the grammar or syntax of the language of healthcare and define it with information tags. XML technology offers users of the HL7 standard a plethora of additional possibilities to tighten medical interface specifications and expand data exchange possibilities, for instance by transferring information between different databases.

Though a prototype, this implementation represents the starting point for the future of the diagnostic, didactics and of the research in medical environment: it is the method to exploit the lost computer patrimony on innumerable bases of clinical image data.

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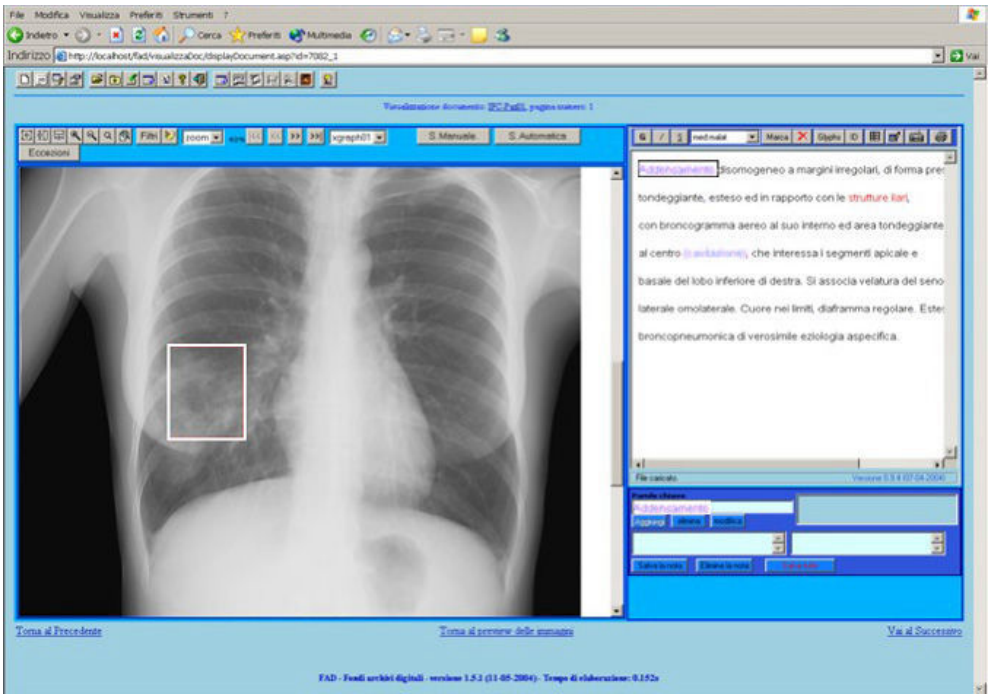

Figure 1. Example of tagged annotation; the word ‘focolaio” (densities) has been linked to the selected area region of interest on the picture.

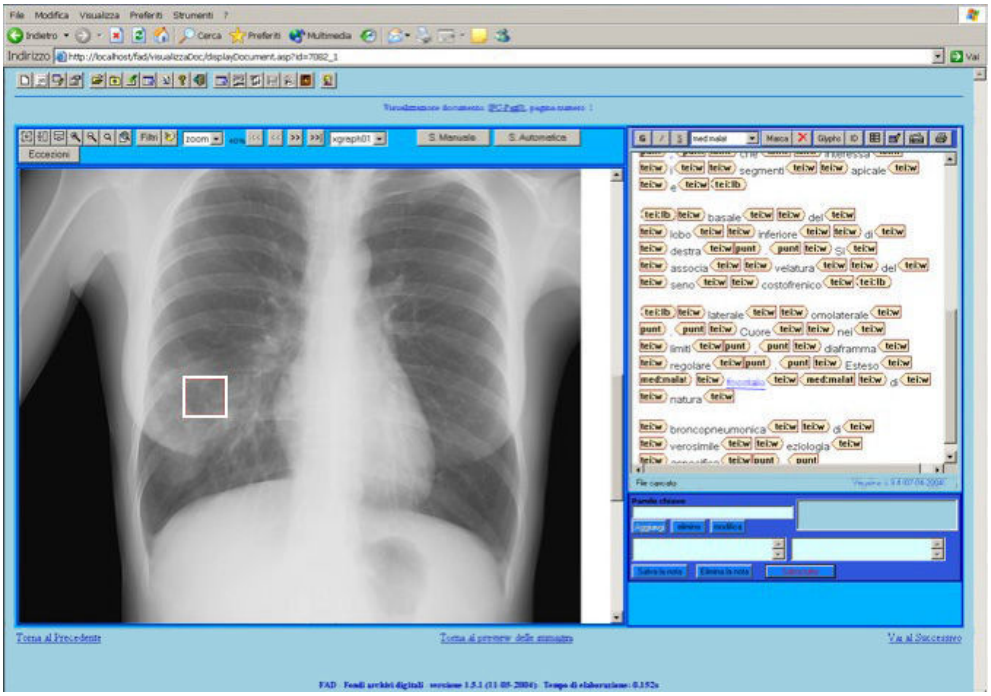

Figure 2. Example of search of regions of interest related to specific words: the region of interest on the picture is evoked by the queried word ‘addensamento’ (increased density). In color inside the text other ‘special’ words are in colour (‘strutture ilari’, hilar structures; ‘cavitazione’, cavitation), linked to other reagions of interest, not evidenced as not queried.