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A Method to Define and Design Tools for Hypermedia Medical Reports Management

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Abstract. In this paper methods and tools for assisting physicians in creating and organizing large collections of hypermedia reports are described. A method to automatically create a hypermedia network representing a collection of reports is defined. The design of a hypermedia report management system has been based on these concepts, and the methods, architecture and features of the system are illustrated. The medical report is modeled as a hypermedia structured document. In order to improve report compiling and reading facilities, graphical models libraries of the investigated anatomical structures are integrated in the hypermedia environment. In the system, the report collection is a hypermedia network offering an interesting approach to multimedia documents access.

1. Introduction

Medical report represents one of the most important documents in patient health care activities. It is used by the physicians to perform therapeutic strategies, it represents a comparison means in order to evaluate the progress of diseases, the post surgical patient state, or the efficacy of care. Moreover, it can be used for didactic purposes especially in imaging diagnostic: if supported by the images from which it has been originated, the report represents an instance of medical knowledge and practice. Fig.1 shows an usual situation: a clinical physician (or a surgeon) needs specialized information about a patient; he requests an advice to a radiologist who plans and then performs an exploration in order to provide such information. Actually most of diagnostic exams are based on images: the radiologist is responsible to "read" them in order to answer the specific question by the physician: relevant image contents are described and, if possible, a diagnosis is performed. Then the report is stored in some repository with its images and included in the patient folder: the requester physician can read it. Afterwards, reports and images can be looked up by the physician or by the radiologist again.

2. Objectives

It is not unusual that reports are not sufficiently complete and clear [1]. For example descriptions are not enough detailed, terminology can be ambiguous or incorrect. Besides, it is not efficient to archive the report, and the data (i.e. images) from which it has been built, with traditional paper based documents and slides. Electronic patient folder and PACS are coming up: they allow to store report and images, but the relationships between descriptions

and images contents are not directly maintained. These relationships represent most of the radiologist's knowledge.

The aim of our work is to provide methods and tools for assisting physicians in creating and organizing large collections of hypermedia reports. Hypermedia reports are documents in which structured data, plain text and multimedia data, are linked together to provide an integrated view of the exam results and relative diagnostic conclusion.

We defined a conceptual model for the medical report [2], and a method to automatically create a hypermedia network representing a collection of reports. The design of a hypermedia report management system has been based on these concepts. In this paper we describe the methods, the architecture and features of the system.

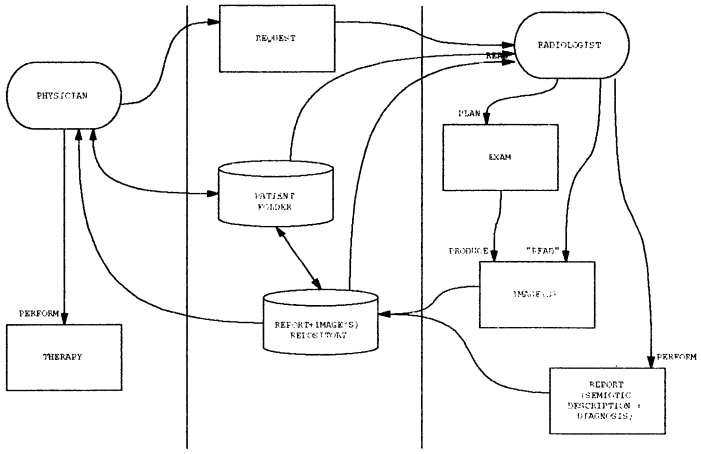

Fig. 1 Report life-cycle

In previous works [3] [4] [5], solutions has been proposed for the problem of medical reports management. In particular, [3] and [4] face the problem of the report retrieval, [5] deals with mapping narrative reports information into structured representation. All of them lack of terminological control and images management capabilities.

3. Methods

To overcome the ambiguity and incorrectness of plain text reports, we decided to use an on-line controlled thesaurus, to help and constrain the report writing activity. An on-line controlled thesaurus is a set of concepts of the domain of interest, hierarchically organized and automatically available while writing in a context-sensitive way. Each moment of the report writing activity is characterized by a terminological context, i.e. what the radiologist is writing, this constrains the thesaurus presentation to be limited only to the portion of concepts pertinent to the terminological context. In this way, the thesaurus plays the role of common terminological reference for all those who are involved in the diagnostic processes within a division. Guidelines for the definition and the implementation criteria of what we call an on-line controlled thesaurus has been done in the framework of the GALEN project [6][7].

As the medical report is a medium between physicians with different skills (radiologist/clinical, student/teacher), and often belonging to different organizations, it is important to find a new way of organizing data to obtain a report easily accessible and readable from both sides. A hypermedia document model fits well with the need of storing and presenting data relationships: the hypermedia links are a good means to capture, store and show the radiologist's knowledge a report implicitly contains. A hypermedia document is a hypertext where each unit of information (node) contains data from different media (graphics, images, sound, video). Hypermedia links represent the relationships between areas (anchors)

within the content of the nodes. Typically, clicking with the mouse an anchor area causes the link to be followed, leaving the anchor at the opposite end of the link displayed. A hypermedia management system provide to store multimedia nodes, anchors and links, in an integrated manner, and provide the user with access methods based on the browsing paradigm.
We model the medical report as a hypermedia structured document which consist of five main components [2]: general structured data about the patient, data about the exam, multimedia data (e.g. images), semiotic description of multimedia data, diagnostic conclusions.
Data about the patient represent a view of the personal data and anamnesis data from the patient clinical folder. Through these data, inter-report links can be created: they permit to browse all the reports concerning a patient. Following these kind of links can be useful, for example, to evaluate the results of current therapies over the patient; or to compare the health state of the patient before and after a surgical operation.
Data about the exam represent the diagnostic protocol chosen by the radiologist. Into this section we can find data about exam conduction, used contrast means, and so on.
The semiotic description consists in a list of clinical remarks, each associated with topological, morphological and qualitative characterizations. For example a part of a semiotic description could be the following.

"Presence, in the postpylorus, near the lower wall, of a deep ulcer lesion, 0.5 cm. wide"

The following table describes how this sentence could be modeled in our framework.

REMARK	TOPOLOGICAL CHARACTERIZATION	MORPHOLOGICAL CHARACTERIZATION	QUALITATIVE CHARACTERIZATION
ulcer lesion	in the postpylorus, near the lower wall	0.5 cm. wide	deep

Each remark and topological characterization into this part of the report can be an anchor which can originate a link to anchors on the multimedia data the radiologist is describing. These links represent intra-report relationships and allow the physician to immediately connect the semiotic descriptions with the images regions of interest they are referred to.
Through these anchors we construct even more complex inter-report relationship. For example reports containing the same remarks but belonging to different patients can be linked.
Multimedia data can be any kind of data produced by the exam. Actually we are considering only exams producing images (ACTs, NMRs, radiographs, etc.). On the images, the anchors are regions (mono or bidimensional) to be connected with the remarks and topological characterizations of the semiotic description. These regions are represented by simple graphic primitives (rectangles, circles, arcs, segments) and are drawn by the radiologist during report compiling phase.
In order to improve report compiling and reading facilities, we integrate graphical models libraries of the investigated anatomical structures in the hypermedia environment. The models can be a good reference for both the radiologist and the physician. The former can use them for quickly pointing the structure he is going to describe; the latter will have a simple visual reference for understanding report descriptions. The graphical models are designed by a domain expert, who sets up also the links between the graphical objects (GO) that constitutes the models and the corresponding anatomical terms (AT) in the controlled thesaurus.
In our system the report consists of a hypermedia document, linking structured semiotic description, digital images (which the description is referred to), and a graphical model of the structure investigated. All relevant medical terms (MT) and anatomical terms (AT) used in the description can be linked with the regions of interest (ROI) into the image. As the AT-GO links are stored in the system, the radiologist has to provide only one link (AT-ROI or GO-ROI) during report building, while the second one (GO-ROI or AT-ROI respectively) is provided automatically by the system itself.

The reports collection is a hypermedia network and can be represented by the conceptual schema represented in Fig. 2 [9]. The lower layer contains the documents organized into two sets (ellipses): the left set is composed by the textual sections of each report (patient data, exam data, semiotic descriptions, diagnostic conclusions), the right one contains multimedia data (i.e. images). The explosion of an element of each set is showed below. Links between the two set of this layer represent the ROI-semiotic description relationships, and they must be explicitly stored by the system. Links inside the textual section set represent relationship between the reports. This kind of link can be build up by queries over structured data. For example they represent links between all reports that belong to the same patient.
The thesaurus terms and the graphical models constituting the upper layer act as two sets of auxiliary data. Links over this layer model a semantic network representing the domain knowledge; they are set up manually by a domain expert and are persistent and static. In particular, links inside the graph model set represent spatial relationships between object representing anatomical terms, while links inside the thesaurus represent anatomical, physiological, pathological relationships between medical terms.
Inter-layer links are useful to create inter-document relationships. For example, we can have links between two semiotic descriptions, and related ROI, from two different reports (in the lower layer), if they refer to the same remark or anatomic part (in the upper layer).

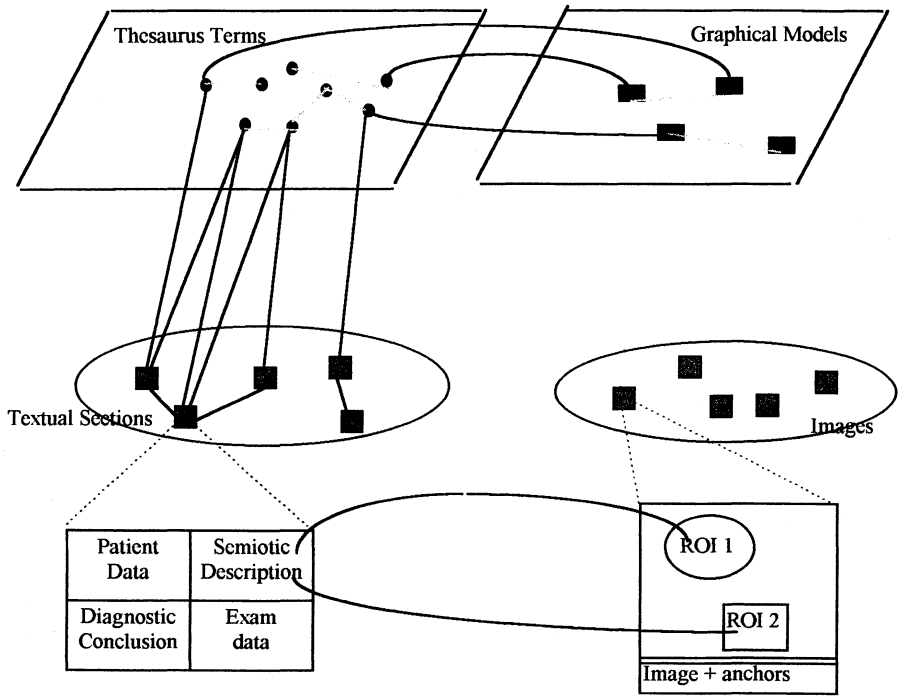

Fig. 2: Hypermedia conceptual schema

The Dexter hypertext reference model [11] has been chosen for implementing the node-anchor-link database, as it focuses on the node/link network structure, but purposefully it does not elaborate a model for nodes content and anchors structure. The hypermedia database has been implemented with an OODBMS (HP Odapter) on a HP 9000 workstation. The system integrates a preexisting patient folder system developed over a RDBMS (Oracle7).

4. Results

A simple prototype of the system has been developed using Visual Basic on Windows 3.1 platform. This prototype cannot manage the real images, but only the graphical models. Several endoscopists has tried the system to evaluate its usefulness. The reports produced are much more structured, rich of information and readable than the corresponding manually written ones. Moreover, the endoscopists found the system interface very friendly and easy to use. The HP-UX complete version of the system is actually being tested. Thesaurus and graphical model has been implemented for the endoscopy contest.

5. Discussions

A hypermedia system for the creation and management of medical reports has been presented. The system is based on the idea that text in a medical report can be structured in component parts, each containing medical terms referred to the multimedia data produced by the exam.
As browsing is the main feature of user-system interaction, this approach lacks of proper methods and languages to efficiently retrieve the interesting documents. The use of a thesaurus to create the hypermedia network could be a good starting-point to define proper approaches and methods to the integration of a hypermedia system with Information Retrieval and Database system. Systems providing either browsing or querying search strategies allow users access to a hypermedia by browsing after a query has been issued. Thus, users have access also to documents that do not match the query.
Our future work will be addressed to explore this integration issues and to verify the usefulness of some Internet-related hypermedia instruments, like HTTP servers and hypertextual languages. The aim is to define models and methods for the development of shared and geographically networked hypermedia medical systems.

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