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Computers in Biology and Medicine 38 (2008) 425–437

Computers in Biology and Medicine

www.intl.elsevierhealth.com/journals/cobm

Integrated multimedia electronic patient record and graph-based image information for cerebral tumors

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Received 24 January 2007; accepted 14 January 2008

Abstract

Current electronic patient record (EPR) implementations do not incorporate medical images, nor structural information extracted from them, despite images increasing role for diagnosis. This paper presents an integration framework into EPRs of anatomical and pathological knowledge extracted from segmented magnetic resonance imaging (MRI), applying a graph of representation for anatomical and functional information for individual patients. Focusing on cerebral tumors examination and patient follow-up, multimedia EPRs were created and evaluated through a 3D navigation application, developed with open-source libraries and standards. Results suggest that the enhanced clinical information scheme could lead to original changes in the way medical experts utilize image-based information.

Keywords: Multimedia electronic patient record; Anatomical graph; Neurology; Open-source software; Computerized knowledge-supported medical practice

1. Introduction

Designing electronic patient record (EPR) systems raises new challenges for integrating complex, evolving information contents and supports, as well as deciding what data format should be handled by healthcare information systems. Initially conceived to support healthcare costs analysis, the EPR has been expanding to integrate other kinds of data, in order to cope with hospital administration and medical practitioners' activity. Recently, emerging patient centred systems [1] that attempt to consolidate all relevant medical information, illustrate how both the quantity and the types of patient data needed for this EPR type are significantly increased compared to usual models. Moreover, computerized knowledge-supported medical practice and medical image processing interpretation tools generate new pieces of information, not taken into account by existing EPR applications. Initiatives to partially handle the changing content and data formats to be included into an EPR have been carried out in the form of isolated, disparate, and dedicated proprietary systems like hospital information system (HIS), clinical information system (CIS), picture archiving and communication systems (PACS), radiology information system (RIS), or EPR, among others, which deal autonomously with interdependent data subsets, being unable to interoperate. Even though standardization (i.e. health level seven—www.hl7.org) and industrial initiatives (i.e. integrating the healthcare enterprise—www.ihe.net) propose some solutions to the interoperability problem between proprietary applications, current systems remain locked with restricted or inexistent autonomous expansion possibilities.

Regardless of the actual incremental use of EPRs in HISs, and various efforts to conceptualize models adapted to clinical practice [2–5], a considerable amount of effort is still required to design new EPR-based systems that provide utilities beyond data listing tools [6]. An illustration of the research and development efforts required in designing new EPR systems is the need to integrate complex multimedia medical data, such

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doi:10.1016/j.compbiomed.2008.01.009

as text, image data volumes and sequences, pathology-specific knowledge, as well as 2D and 3D anatomical representations, in a single EPR application. For instance, even if images generated in clinical practice are stored by PACS along with 2D or 3D anatomical representations such as segmentation processing results, parts of the associated patient data are separately stored in the RIS and the respective specialty EPRs [7,8]. More sophisticated approaches intend: to provide remote visualization access to PACS images along with RIS patient data [9], or combined PACS–HIS–CIS data [10], using a client web interface, to integrate data management, transactions and user interfaces in a scalable emergency department information system [11], or to integrate some selected pieces of information (work list, reports and image visualization) from HIS and PACS [12]. Among the various multimedia medical data types, images and their associated computer-based interpretation reports are strongly involved in a majority of diagnosis procedures, because of their capability to allow for visualization and quantification of the anatomy and pathological findings, as well as the activity of multiple pathological processes. Furthermore, image-based interpretations and annotations are essential for therapeutic planning and patient follow-up. Despite their recognized importance, medical images, along with their segmentation results and the associated anatomical and functional knowledge, have not been yet fully integrated into conventional EPR structures.

This paper presents a unified approach that addresses the multimedia EPR domain of this large problematic, taking advantage of a detailed user requirements comprehension, and focusing on the integration into the EPR of the following components:

1. Prior knowledge specific to the anatomy, the function and the pathologies under study.
2. Medical imaging data.
3. Information extracted from medical images, after image segmentation.

In the context of this paper, neuroimaging provides comprehensive neurological diagnosis information for the characterization of morphological and biological alterations of cerebral structures, tumor grades and growth patterns, as well as tumor response to treatments and patient prognosis [13].

A methodological framework is proposed to construct a specialized neurological EPR, including patient-specific imaging data and graph-based information, derived from a generic anatomical model and knowledge base. Fig. 1 illustrates the EPR system functional scheme. An adapted graphic user interface (GUI) queries and visualizes the different EPR elements: 2D or 3D images, 2D or 3D segmented images, graph information, and patient data, depending on user interactions. The proposed implementation makes use of open software libraries, standards, and clinical ontologies, which are emerging paradigms gaining wide international acceptance [14]. Beyond the challenge of building a more comprehensive EPR data structure and content, it is also important to consider the potential EPR enhanced capability for reviewing clinical information extracted from medical images, toward an integrated therapeutic patient follow-up tool. Those enhanced capabilities concern only diagnosis support tasks, excluding functionalities like workflow or patient management.

A neurological examination scenario, related to brain tumors diagnosis based on the interpretation of magnetic resonance imaging (MRI) datasets, acquired with multiple protocols such as T1-weighted and T2-weighted, has been chosen to design the EPR framework and evaluate the 3D navigation application prototype. Based on a generic architecture, the

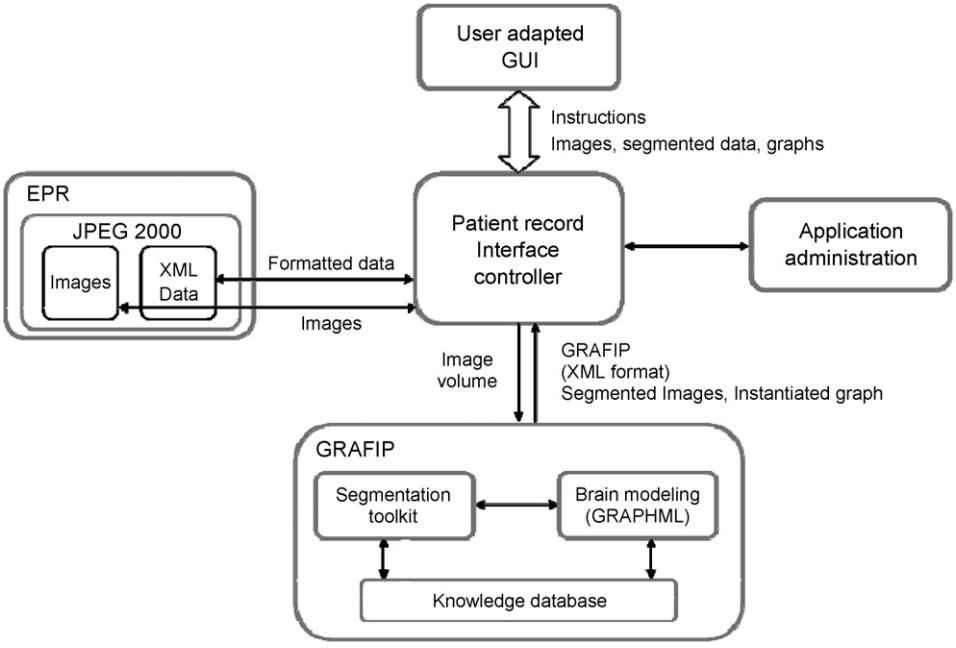

Fig. 1. Functional scheme of the proposed EPR application.