An Adaptive Virtual-Reality User-Interface for Patient Access to the "Personal Electronic Medical Record"

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Abstract

The PREPaRe system (*Personal Repository for Electronic Patient Records*) is a patient-oriented internet-based information system that is able to store, combine, process and visualize all types of medical data that are part of a "personal electronic medical record". Patients differ in levels of education and subjective needs. Therefore, a patient-oriented information system should provide mechanisms to adapt to these varying demands. This paper describes the virtual reality user interface of the PREPaRe system and the adaptation mechanisms employed.

Keywords

Electronic Patient Record, Adaptive User Interface, Virtual Reality, Information System

1. Introduction

Computers are used in medicine to improve quality and efficiency in healthcare processes [1]. Increasingly, medical institutions integrate all types of patient related electronic data into an "electronic patient record" (EPR). All EPRs that are created during a patient's lifetime by different medical institutions can be defined as an "electronic health record" (EHR) [2].

Medical healthcare focuses on the patient. Therefore, patients, if interested, should have the possibility to participate more actively in their personal healthcare process. They should be able to collect data from their EHR and other medical information in a "personal electronic medical record" (PEMR). The PREPaRe system (*Personal Repository for Electronic Patient Records*) is a patient-oriented internet-based information system. It provides patients with the possibility to store, retrieve, combine, process and display all types of medical data that are part of a PEMR.

An important factor for the usability of such a system is the design of the user interface. As a virtual environment is the natural way of recognizing and examining spatial representations of anatomic or pathologic information, our system offers the patients access to a 3-D information system embedded in a virtual reality model of a real hospital. Usually medical data can be found in the appropriate departments, e.g. CT images in the radiology department. When volume data sets exist, a patient is able to use 3-D visualization and interaction to gain as much information as possible.

As patients differ, they should be able to select the presentation of data according to their personal needs and available technical infrastructure. Therefore the PEMR also contains information about personal preferences of the individual user as well as modes of access rights etc. When a patient requests access to his or her data, the data are dynamically collected from their specific storage system, pre-processed and composed according to these preferences. By modifying the preferences, users can personalize their access to the system.

2. Methods

2.1. Visualization of the hospital

The graphical user interface of the PREPaRe system is realized as a computer model of a hospital that provides the medical information in a three-dimensional context to allow patients spatially oriented access to their medical data [3]. Sitting in front of the PC at home, a patient selects with a web browser program such as Netscape Navigator, Internet Explorer or Opera, the web pages of the hospital. The virtual representation of the hospital, a VRML model, is downloaded and visualized in a plugin module. The patient enters the virtual hospital. There, he or she is able to obtain information about diseases and their treatment in general, and is able to become acquainted with the hospital, its departments and facilities (see Figure 1).

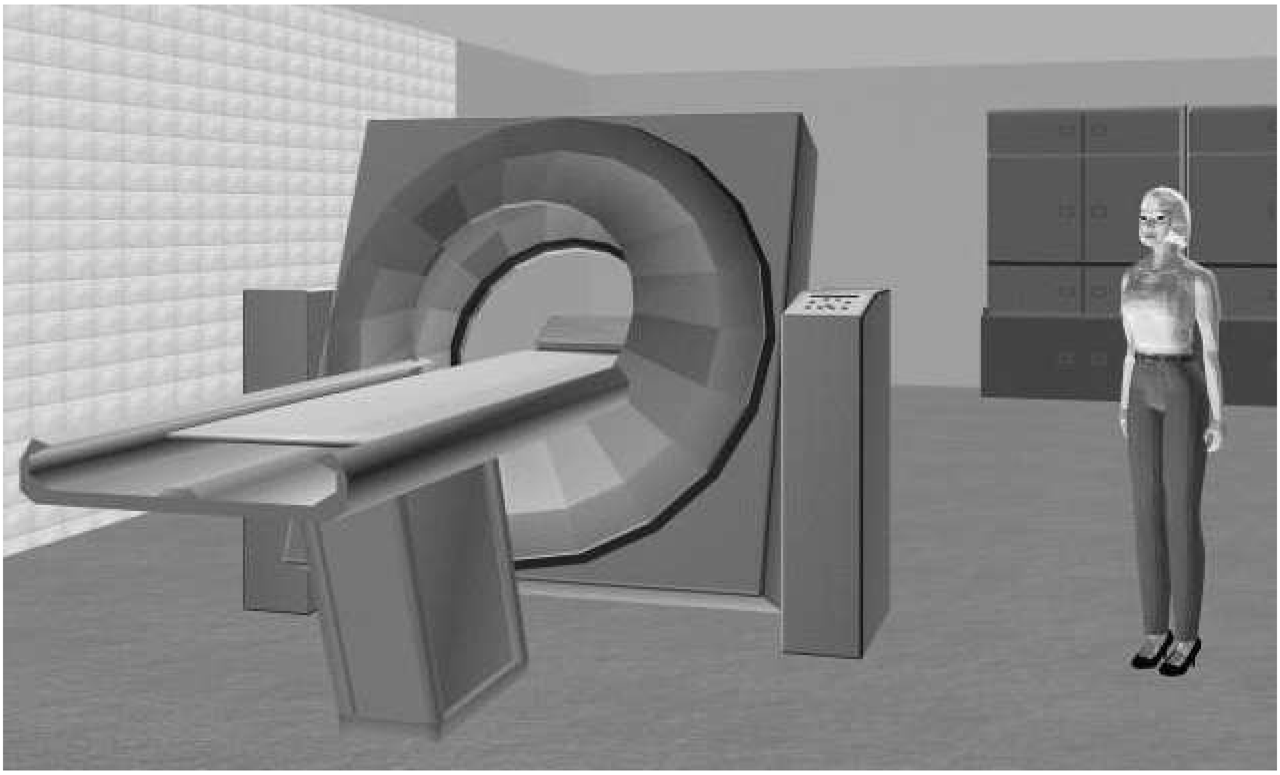

Figure 1: Presentation of the CT scanner

While "strolling" through the building, the patient not only sees rooms equipped with technical apparatus but also meets doctors, nurses and other clinic personnel and also other patients paying a visit. It is planned that the user will be able to talk and interact with them. First results of the realization of the so-called virtual actors will be presented in [4].

2.2. Visualization of patient data and diagnosis

After enrolling at a registration desk, the patient can retrieve and visualize the data of his or her personal electronic medical record. Therefore according to personal preferences, it is possible to select either a three-dimensional representation of the data (see Figure 2) or to change to the conventional two-dimensional display of the texts and images.

Figure 2: Viewing the patient´s data

To be able to provide an integrated form of access to the medical data that are usually created, modified, transmitted and stored by a variety of different clinical systems, the PREPaRe system architecture was developed and is presented in detail in [5]. It does not only allow “access from outside” to the clinical data but also provides means to ensure integrity and safety during transmission.

If there are patient data originating from tomographic diagnostic modalities such as CT or MRI, these can serve to create patient specific models employing suitable algorithms. The most important step in these procedures is recognizing and assigning the image contents to the patient´s anatomy. The currently widely used programs need interactive semiautomatic or manual segmentation and classification, which takes up a lot of valuable time and effort and requires some expertise. The objective of our current research in this area is to define well-suited procedures to provide automatic assignment of different modalities, body regions and organs for special situations.

As depicted in Figure 3, attempts are being made to combine patient data with a priori information such as that found in anatomic atlases. To determine the procedures, employment of diagnostic information (e.g. ICD codes or keywords in diagnosis texts) will be tested. From the segmented data that can be computed using these methods, classified volume data and derived surface data can be calculated by further pre-processing steps. They are the basis for the visualization that follows.

Patient-specific data for the visualization can be VRML models that can be displayed in publicly available web browser plugins. We are also developing special rendering engines that allow hybrid rendering of medical volume data combining volume rendering methods with the display of surface data. The hybrid rendering allows medical data to be visualized within the three-dimensional hospital environment [6].

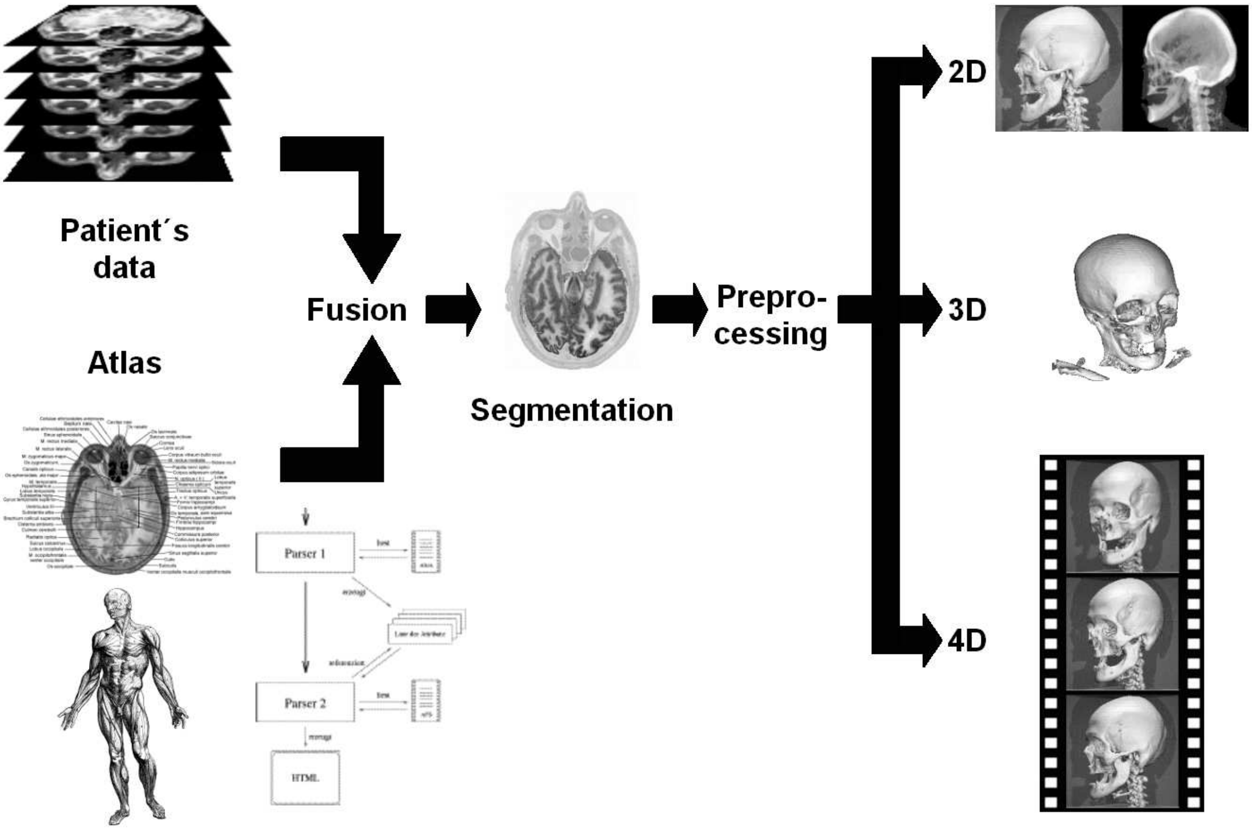

Figure 3: Generation of patient-specific 3D models

2.3. Visualization of the treatment

The visualization will not only allow patients to look into their own bodies and to be provided with a spatial representation of their diseases (for example the localization of a pathology in an organ). It is also intended to use patient data within interactive therapy simulations to enable the patients to inform themselves in advance about a treatment they are to undergo (see Figure 4)

2.4. Adaptation to patients´ individual demands

The basis for patient-specific access to the medical data is a repository that gave the project its name: the "Personal Repository for Electronic Patient Records" (PREPaRe). This contains the data of the Personal Electronic Medical Record (PEMR): references to the clinical data, text and multimedia data provided by the patient, access permissions and personal preferences.

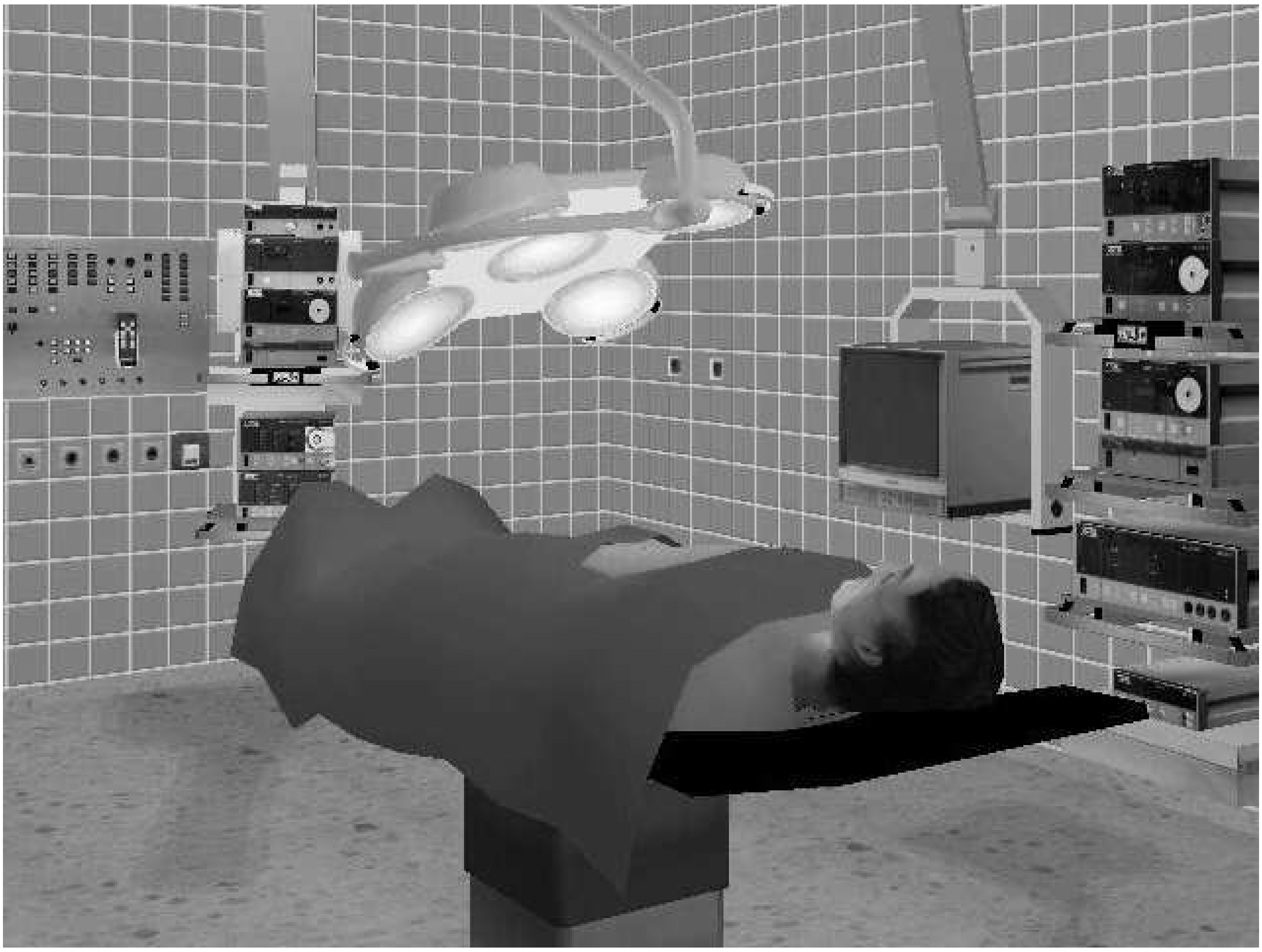

Figure 4: In preparation for surgery...

After authentication to the system which can be performed either by entering a user ID / password combination or by applying an authenticating chip card (e.g. the equivalent of a Health Professional Card [7], [8]) the patient can request access to the PEMR data. The tasks of the PREPaRe portal are based on a schema of layers: The request management layer collects the data dynamically from their specific storage system, the document adaptation layer implements user specific pre-processing, adaptation and composition, the data conversion layer transforms internal data representations into web documents and the session management layer administers the status of the sessions for each patient.

Patients can personalize their access to the repository by modifying the preferences: They can select which tools to use for the presentation, modification and visualization of a specific data type or interaction with a model representation, depending on the available systems. According to personal needs, functionality and parameters of the tools can also be adapted. The selected preferences are stored as a part of the PEMR data.

As patients own the data of their PEMR, they can work with the data, e.g. make personal annotations or add new or modified images. They also can use the referencing mechanisms of the PEMRs meta-information to connect their data to other data, in order to enhance their data with related information, or e.g. to compare results. In the PEMR, access references are stored in the meta-data of a master patient index. They can be different in format, depending on the system that holds the data. The PEMR is coded in XML [9]; all processing is done using Java servlets, XSL [10] and XSLT [11].

The internet allows access to the PEMR at any time from almost anywhere in the world. An individual will be able to provide a complete patient history and all medical information required if he or she suffers any health problems far from home. The physician has to be given the appropriate access rights by either being supplied with the individual's “electronic patient card” or by being granted access to specified information for the specified health care unit during a connection to the portal.

3. Realization

The PREPaRe system is being realized as a medical internet portal (see Figure 5). A standard internet browser displays the user interface. The portal system is a distributed system of specialized data and media servers accessible by an enhanced web server using Java's remote method invocation mechanisms.

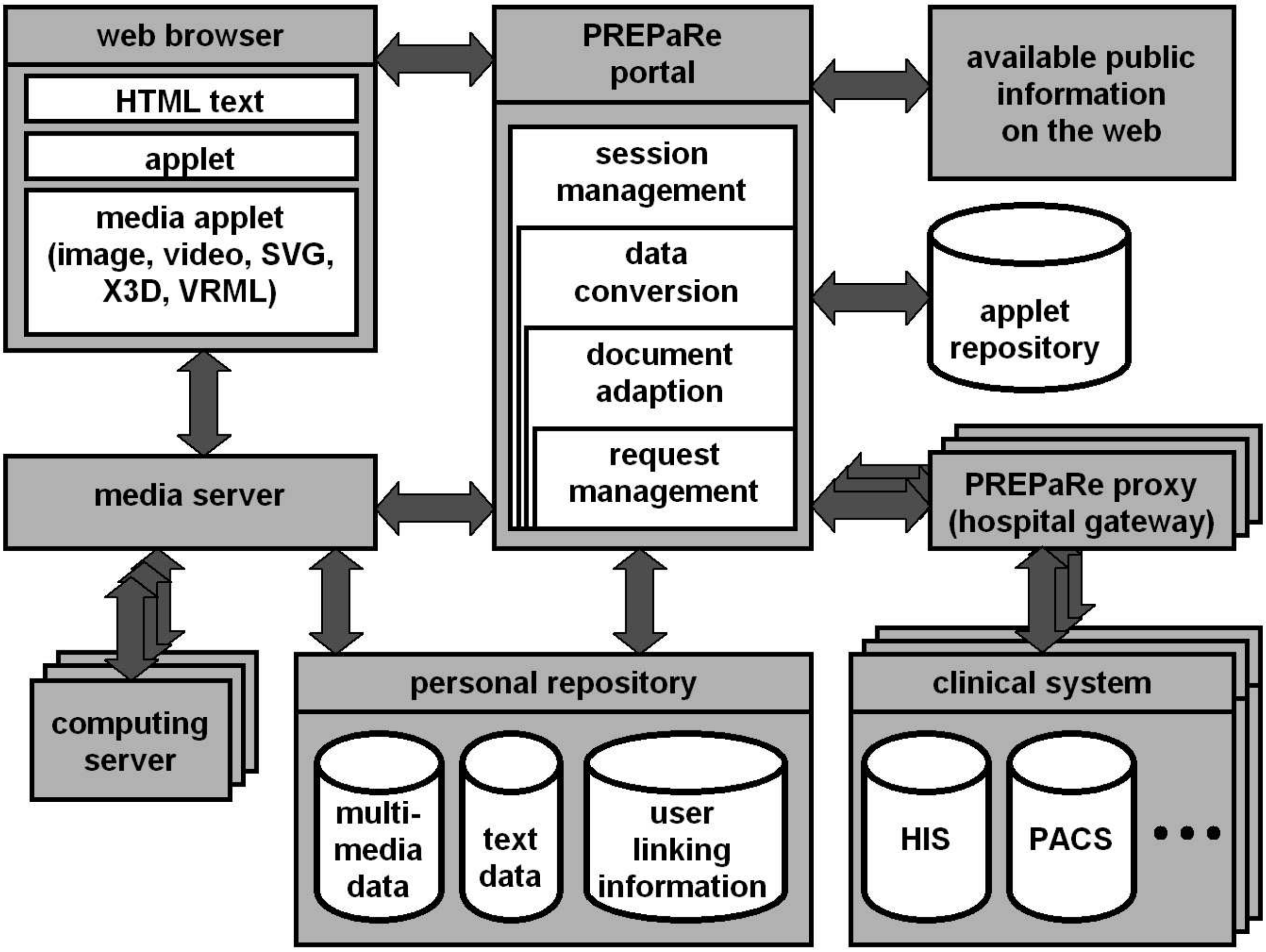

Figure 5: Architecture of the PREPaRe system

The core of the processing of the PEMR data is a Java servlet that parses the requests, manages the session, distributes the requests to the specialized servers, and collects and transforms the data for the visual display. The internal state of the session is kept in a DOM [12] representation of the user specific information and the “documents” the user has created during that session. A “document” is an XML coded meta-structure that contains only the references to the document parts.

Depending on the selected user interaction, additional parameters, the actual session status and the user preferences, a new document is created. For textual documents, the “presentation” of the document - a webpage coded in HTML containing various multimedia components - is constructed: First the document's components (texts, images, media streams, active components, etc.) are retrieved from their respective locations in a local database or on remote servers. User-specific data are utilized to modify the components according to the user's preferences. Then XSL style sheets and XSLT transformation mechanisms are applied and a HTML format is created and transmitted. During this step appropriate applets and media tools are inserted as instances of active components. Finally, the result is sent to the browser. The changes are realized by transmitting the respective data to the server where they are used to construct the next document and eventually are stored as new data in the PEMR.

To realize the interaction between the three-dimensional virtual hospital environment running on the patient´s web browser and the PREPaRe portal, a media server is employed. The media server accepts requests for various types of multimedia data, provides secure communication channels for streaming data (e.g. video sequences) and serves as an interface between the web browser and the portal for all types of interaction that cannot be handled via HTTP.

4. Conclusion

The PREPaRe system allows patients to integrate all medical data that interest them into a personal electronic medical record. It potentially enables interested persons, e.g. patients or their families, to use all available information, services and technologies for improving medical care on a worldwide basis.

The virtual reality user interface providing 2D, 3D and 4D visualization of medical data and therapy simulation provides an intuitive access to all of the information available in the “virtual hospital”. It provides the possibility to view and understand medical data using advanced visualization tools until now only available to experts.

User-oriented adaptation of the components and tools employed offers an easy way to become acquainted with the comprehensive set of tools step by step and to configure the look and feel of the user interface according to the user’s own needs.

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