

MUDRLite – AN ELECTRONIC HEALTH RECORD APPLIED TO DENTISTRY BY THE USAGE OF A DENTAL-CROSS COMPONENT

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Abstract: The EuroMISE Centre focuses on new approaches to the electronic health record (EHR) design. One of pilot applications developed within this applied research is the MUDRLite universal EHR system. The basis of this system lies in MUDRLite Interpreter that processes the instructions encoded in so called MLL Language and manipulates the database layer as well as the visual aspects of the user interface. As the set of predefined controls is limited MUDRLite provides an interface to include user-defined controls or modules. This interface can be used to offer graphically and functionally advanced components as well as new features of the EHR system. To gain MUDRLite's user-acceptance in the field of dental medicine we have developed a high-advanced component representing the dental cross, which is a crucial part of medical documentation in dental medicine. So called DentCross component, which is described in the paper more in detail, was included dynamically by means of the mentioned interface. The data model of this component originates in the so called Dental Medicine Data Structuring Technology Using a Dental Cross. This technology was applied by the authors of this paper for a Czech national patent under the No. PV 2005-229.

Introduction

Currently, most hospitals have an electronic form of health records integrated into their hospital or clinical information systems. But the systems are often more suitable for the hospital management than for physicians, the clinical part is not structured enough and the set of collected attributes is fixed and practically impossible to be extended. Physicians gathering information for the purpose of medical studies often use varied proprietary solutions based simply on MS Excel Sheets or similar office-software tools.

The European Centre for Medical Informatics, Statistics and Epidemiology (*EuroMISE Centre*) focuses on new approaches to the electronic health record (EHR) design. The participation in European projects as well as the CEN TC 251 [1] standards and the cooperation with physicians had produced much experience, which helped to develop a pilot EHR

system called MUDR (*MULTImedia Distributed Record*) [2], [3]. It is based on the three-tier architecture with an unusual data-storing approach based on so called knowledge base and data-file principles.

Within MUDR development an extra branch was separated simplifying both the MUDR architecture and the MUDR data-storing principles. It creates the *MUDRLite* EHR [4] application, which can be without problems deployed to a particular environment.

Materials and Methods

The MUDRLite architecture is based on two layers. The first one is a relational database. Currently, MS SQL server versions 7 and 2000 are supported. The second layer is a MUDRLite User Interface (MUDRLite UI) running on a Windows-based operating system.

The database schema corresponds to the particular needs and varies therefore in different environments, as opposed to the fixed database schema in the MUDR data layer. MUDRLite universality is based on a different approach. The core of MUDRLite – *MUDRLite Interpreter* – is able to handle varied database schemas. This feature often simplifies the way of importing old data stored with other databases or files.

All the visual aspects and the behaviour of the MUDRLite UI are completely described by an XML configuration file. The end-user can see a set of forms with various controls placed on them by appropriate XML elements. MUDRLite operates as a kind of commands' interpreter; it processes the instructions encoded in the so called *MLL Language* as described in [4] and manipulates the database layer as well as the visual aspects of the MUDRLite UI.

As the set of predefined controls is limited MUDRLite provides an interface to include a user-defined control or module. This interface can be used to offer graphically and functionally advanced components as well as new features, e.g. an advanced security policy, integration with other existing information systems, standards-based EHR communications.

To gain MUDRLite's user-acceptance in the field of dental medicine we have developed a high-advanced component representing the dental cross, which is a crucial part of healthcare documentation in dental

medicine. Its development was motivated by clinical practice in the dental medicine domain. The *DentCross* component was included dynamically by means of the mentioned interface.

Information storage in dental medicine is basically in the form of free-text-based documentation. In this case, data structuring is on a relatively low level and it is given by the filling characteristics of preprinted forms, which include more or less standardized symbols (e.g. "/" for *caries*, "-" for *pulpitis*, or "x" for a *tooth to be extracted*). Symbols are placed in the section corresponding to a particular tooth. Disadvantages of using such a system are the loss of detailed information on the localization, the size and the character of hard dental tissues defects. Structuring of further information on an oral cavity is not very high, information concerning changes of oral cavity mucosa, periodontitis, orthodontic anomalies, preventive oncological examinations, etc. are described in a limited space of one line of the form or together as *other findings* in the form of a free text.

On the basis of commercially available software products analyses we have found out that the application of these systems in the clinical practice is quite limited, the health record is not structured sufficiently, it contains a lot of a free text and a set of collected and structured attributes is meagre, practically without possibilities of any extension. Further analyses in the Industrial Property Office showed that not even among given patents and industrial models there are no suitable technologies for keeping electronic health documentation in the field of dental medicine. A survey showed only two relevant objects of industrial protection: the industrial model *Dental Cross Graphic Scheme*, the registration number in the Czech Republic is 25297 (no. 24791 in the Slovak Republic), whose proprietor is Dialog MIS, Ltd., Prague and the patent *Method for Displaying Dental Related Information, its Display Unit and Treatment Assistance Unit*, the registration number JP10229993, whose owner is Daryl Raymond Beech, Morita MFG, Japan. The industrial model of the Dental Cross Graphic Scheme protects the dental cross graphic modification implemented in the PC DENT application that combines advantages of dentition graphic illustration with automated generation of an examination plan. The Japanese patent protects automatism by which a dentist enters a proposal or a treatment technique in the graphic dental cross by a keyboard. Neither of these documents and applications overlaps the approach that we have used for the *DentCross* component development.

The *DentCross* component is implemented as a stand-alone library *DentCross.dll* that was completely developed for the .NET Framework platform [5] using the Microsoft Visual Studio .NET 2003 development tool.

A user-defined component is inserted by the *custom* element of the MLL Language with the following mandatory attributes: *dll* specifying the name of the assembly the component is implemented in, and *class*

specifying the name of the main class of the included component.

The MLL source code in the Fig. 1 places the *DentCross* component into a MUDRLite form.

```
<custom name="dxComp"  
  dll="DentCross.dll"  
  class="DentCross.DentCross"  
  posX="20" posY="60"  
  sizeX="810" sizeY="500"  
>  
</>
```

Figure 1: The MLL Source Code Placing the *DentCross* Component on a MUDRLite Form.

For the end user the *DentCross* component looks like a kind of a dental panoramic tomograph. This component is fully interactive and enables to record full structured dental medicine information that can be inserted user-friendly by mouse or keyboard. A dentist can choose among about 60 different actions, treatment procedures or tooth parameters that are displayed graphically and lucidly. The main features of the component can be stated as follows:

Form and shape of a tooth – various forms and shapes can be represented, e.g. permanent vs. deciduous tooth, various genetic diseases affecting the form of a tooth.

Exact position of a tooth – the position of a tooth can be precisely stored in two coordinates.

Primary and secondary caries – two types of caries can be distinguished – the primary and the secondary one.

Filling of a tooth – various filling materials can be used and mixed to fill in various parts of a tooth. The filling is stored and depicted graphically.

Root canal treatment – contemporary and definitive fillings are designed. The filling materials are stored and depicted graphically.

Agenesis of a tooth – if a tooth is undeveloped a special graphical mark is depicted.

Unerupted tooth – if a tooth is not erupted yet a special graphical mark is depicted to determine this state.

No space between teeth – if there is a tooth missing or unerupted and its space is closed this particular information can be marked.

Pulp and Periodontal pathology – various pulp and periodontal problems, e.g. pulpitis, necrosis, periodontitis, chronic periodontal abscess and its acute inflammation can be stored and depicted.

Crowns – e.g. full-metal crown, metal-ceramic crown, all-ceramic crown are designed with a colour variation by the materials used.

Partial veneer crowns – half-crowns and three-quarter crowns can be applied.

Bridge – various types of bridges, e.g. metal-ceramic bridges are also graphically designed in various combinations in the same range as in crowns.

Intracoronar restoration – inlay, onlay and overlay are supported. The range of materials is also stored and depicted graphically.

Post and core – post can be applied into the root of a tooth after root canal treatment to reconstruct the crown.

Implant – implant insertion is also marked graphically in the DentCross.

Dentures – complete denture, overdenture, as well as removable partial denture can be used in edentulous or partly edentulous patients.

Dentoalveolar surgery – some diagnoses from dentoalveolar surgery are supported, e.g. tooth extraction or apicectomy.

Pericoronitis – pericoronitis can be diagnosed, stored and depicted graphically in the stage of acute or chronic inflammation.

Calculus – the exact position of a calculus can be stored. A fine graphic representation helps to depict it lucidly.

PBI – the Papilla Bleeding Index is stored in database. It can be depicted graphically, however, because of the clarity reasons it is up to the dentist whether this functionality is turned on or off.

Mobility – the mobility of a tooth is stored. Similar to PBI index, the graphic representation of this information can be switched on and off.

Periodontal pocket – the representation of the periodontal pocket can be switch on and off in the same way as the mobility of a tooth and the PBI index. The periodontal pocket depth is typically marked in millimetres.

Bone resorption – the DentCross component enables to store and graphically present the information about patient's bone resorption.

Temporomandibular joint – the information about temporomandibular joint is included.

Treatment plan – in addition, the DentCross component includes a treatment plan combined with a calendar that enables to schedule the patients' visits and treatments.

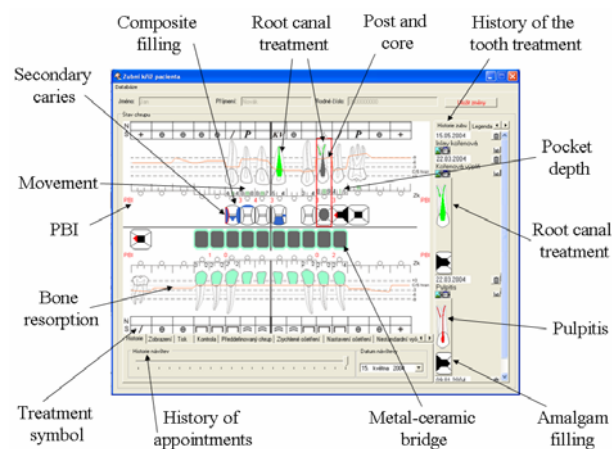


Figure 2: The DentCross Component – a Case Study Example.

Most of the mentioned features are already implemented in the current 1.63 version of the DentCross component while the others are currently under development and fine-tuning within the version 2 of the component. The first version of the component communicates in Czech language and an English version is being developed. Other translations are being prepared.

An example of the DentCross component can be seen in the Fig. 2. It represents the dentition of a 52 years old man in excellent general health in other respects. More information about this case study can be found in [6]. The corresponding tomograph image can be seen in the Fig. 3.

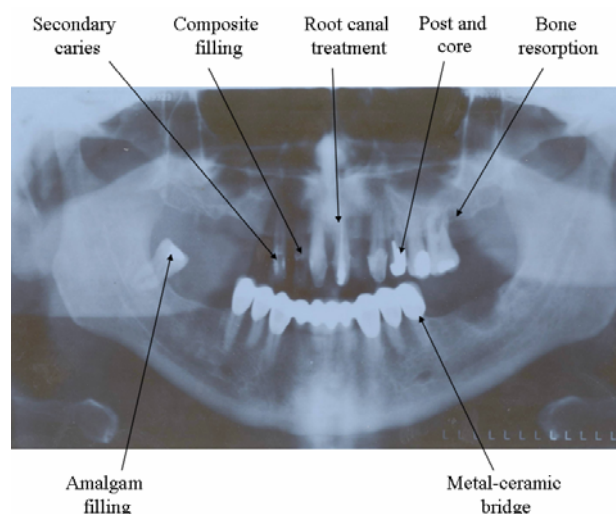


Figure 3: The Tomograph Picture Corresponding to the Situation Shown in the Fig. 2.

The data specification of this component determines the data model of the component in the relationship to the MUDRLite Interpreter and the MUDRLite database layer. This model originates from a logical data model that we have designed in close co-operation within the EuroMISE Centre. In total, it describes about 30 independent entities with more than 160 attributes.

Together with these colleagues we have further generalized this model to the so called *Dental-Medicine Data Structuring Technology Using a Dental Cross*. This technology was applied for a Czech national patent under the No. PV 2005-229. To summarize the technology we could state that it is based on a model where there are various actions connected to a patient, those actions can be related to a particular tooth or to a set of teeth that can be treated in various ways. The model distinguishes among various treatment methods, e.g. traumatic treatment, dentoalveolar surgery, specific treatment of child patients, or preventive treatment. The model includes the information about caries, and fillings and crowns that are localized using a common mechanism. Furthermore, it structuralizes prosthetic and orthodontic information, information about the treatment of a root canal, various teeth's characteristics,

e.g. anomalies, vitalities or traumatic injuries, in various localizations. The description of the model is based on a so called E-R model [7], [8] including various entities and relations.

Results

Within our research and development our aim was to keep on the already initiated cooperation in the research field of structuring of dental medicine health documentation among researchers from the Department of Medical Informatics, Institute of Computer Science AS CR and the Department of Prosthodontics, First Faculty of Medicine of Charles University in Prague and General University Hospital, who are joint in the EuroMISE Centre. The main goals were to setup new technologies and to develop software tools to help with the data structuring in the dental medicine field. We have proposed a new technology called *Dental-Medicine Data Structuring Technology Using a Dental Cross*. This technology was applied for a Czech national patent under the No. PV 2005-229.

In the field of dental medicine, not only a way of data structuring is important but also a form of transparent graphic presentation and editing. For these purposes MUDRLite disposes of interfaces enabling to connect graphic and high advanced functional components. The DentCross component was designed and is nowadays being evaluated and fine-tuned by cooperating computer scientists and physicians. It has verified the component itself as well as the mentioned MUDRLite interface.

Discussion

The collectively developed technology of information structuring the field of dental medicine by the dental cross gives the possibility of advanced electronic health documentation application in this field. Accomplished analyses of the current state of commercially available software products and patent technologies suggest that the software support of keeping health documentation is on a relatively low level. The primary motivation why we have started this research and development was that we believe that it can be increased significantly by implementation of interactive graphic dental cross components. This advanced form of health documentation will lead to an easier and more complex treatment plan based on the bigger amount of relevant information, which is concentrated transparently in the dental cross. The assumption is that this is the way to bring benefit for the patient as well as it has the potential to reduce the expenditure for dental health care by means of sharing structured electronic health record and thus reduce the amount of needlessly repeated examinations.

Conclusions

The development of information technologies brings changes in the view on storage and classification of data in health care. In dental medicine this need is stressed by the necessity of a transparent record of the whole dentition and individual accomplished examinations in a concentrated form from several points of view. The information record in a graphic structure of the dental cross accelerates dentist's decision-making and it enables a more complex view in suggesting a treatment plan. An easy transcript of the preceding state with a simultaneous history storage of each tooth according to the change of dates is an advantage. Dentists are open to use electronic records and several companies have been engaged in these problems for several years as structuring of data in medicine is constantly changing with changes of legislative amendments and with a prospect of keeping documentation only in the electronic form.

An indisputable advantage of medical data structuring is its contribution to the field of science and research. The possibility of extracting structured data for research purposes is another asset of the DentCross component.

Acknowledgments

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