MODELING MAGNETIC RESONANCE CLINICAL REPORTS OF THE LUMBAR SPINE USING OPENEHR ARCHETYPES

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Abstract - This work discusses the modeling of clinical data using openEHR archetypes. The openEHR project aims at developing an open and interoperable health computational platform, and an important component in this effort is the development of electronic health records (EHRs) that are clinically effective and interoperable. The project publishes specifications, implementations and archetypes with that goal in mind. Archetypes are an expression of clinical concepts, created by domain specialists. In the modeling proposed by openEHR, that kind of information shall be separated from the stable reference model, leading to simpler and more maintainable systems and empowering clinicians by giving them the opportunity to work developing the standards they will use in a real clinical environment. The main objective of this work is to introduce the openEHR specifications and its main features, the concept of archetypes and show the possibility of creating an archetype from an initial clinical concept, using magnetic resonance clinical reports of the lumbar spine as an example.

Introduction

The openEHR Project (1) aims at establishing an open specification for managing, storing and exchanging clinical information through electronic health records (EHRs). Using electronic health records, it is possible to reduce medical costs, improve clinical care quality and increase the amount of information available for decision making from clinical professionals.

The openEHR specifications provide a powerful means to express clinical information, making perfect understanding and processing of information possible. Those definitions are done through the archetype concept, which defines formal models from clinical concepts.

This work discusses the modeling of clinical data using openEHR archetypes. Therefore, a clinical concept was chosen, which is the magnetic resonance imaging of the lumbar spine, and an archetype for modeling this concept was developed.

The rest of this text is structured as follows. Section "Methods" presents the basic concepts of openEHR specification, its objectives, principles and information structures, as well as archetypes, their main purposes, principles and structure and the Archetype Definition Language (ADL). Section "Results and Discussion" presents the structure of a magnetic resonance imaging of the lumbar spine and the methodology for development of archetypes and the tools used for this development. This section also comments some related work. Finally, Section "Conclusion concludes with a study on possible future work in this area.

Methods

OpenEHR (1) is an open standard specification describing management and storage of clinical data in electronic health records (EHRs). The objective of the openEHR initiative is to have all clinical data from one person in one single electronic health record, whose temporal scope would be a whole life. The openEHR specifications are maintained by the openEHR Foundation.

The specifications are published in a free and open manner, as are the implementation specifications (databases or XML structures corresponding to the specification models). From those, open-source implementations can be

created and validated in clinical environments, used for research or adopted in a real clinical environment. Besides publishing specifications and implementations, the openEHR project develops information and workflow models, known as archetypes.

One of the key paradigms of the openEHR architecture is two-level modeling. It consists on a first level based on a stable reference model, while clinical content definitions based on templates and archetypes form the second level. In this kind of modeling, only the reference model is implemented in software. This way, systems become considerably smaller and easier to maintain when compared to one-level models. They are also more adaptable by using archetypes and templates, structures that can be improved in the future.

This kind of modeling alters significantly the system development process. There are two system cores, the reference model and the archetypes. The domain semantics is, generally, delegated to specialists, who develop archetypes, templates and terminologies. This way, the information technology professionals can concentrate on the generic components of the system, and the domain specialists work outside the software development process to generate definitions to be used in runtime.

Archetypes (2) are created to allow clinical concepts to be modeled in a formal way by domain specialists. Using them, it is possible to create systems that can deal with knowledge and communicate with each other on the knowledge concept level. It also empowers clinicians, because they can help in the process of creating the informational concepts that they will use.

Every archetype is an instance of an archetype model (3), a common formalism to describe all archetypes. This model is strongly related to the openEHR reference model, once it defines restrictions on objects defined on this reference model. If any data is created or modified using archetypes, those will restrict the data instance configuration in a way to make these compliant to the archetype.

It is important to stress that archetypes are only useful if they define a complete and distinct clinical concept. They can have a composition relationship, that is, it is possible to group different archetypes to represent valid possibilities for bigger data structures. Also, an archetype can be a specialization of another one, defining concepts on different detail levels.

There is no native language to the archetypes, that is, they can be developed in any language and then translated. In addition to that, they are neutral in relation to terminologies. They can refer to external terminologies or even to multiple, different terminologies. Defining any term in an archetype is not based on its existence or usage in any given terminology.

The ADL (Archetype Definition Language) (4) is a formal language to define archetypes. It can be used to write archetypes for any domain where formal object models describing data instances exist. ADL documents can be analyzed in a parsing tree, showing objects defined by an abstract, formal model, AOM (Archetype Object Model). This model can be expressed in any concrete syntax (such as XML (5), e.g.).

Results and discussion

The chosen concept for this work was the report on a magnetic resonance imaging from the lumbar spine. The lumbar spine is a part of the lumbar column (6), between the thoracic and sacral regions. It consists on 5 vertebrae (L1 to L5) and their respective intervertebral discs. Sometimes, a lumbarization process occurs on the first sacral vertebra, leading to the existence of a L6 vertebra.

MRI (Magnetic Resonance Imaging) is a process to obtain high quality images from the inner human body. It is based on the physical principle of Nuclear Magnetic Resonance, aligning the hydrogen atoms in the body and bombarding them with hydrogen resonation radiofrequencies. With a tridimentional gradient on a magnetic field, it is possible to locate the hydrogen atoms and produce images based on these locations. Different body tissues have different hydrogen concentrations, leading to different colors on this image.

The MRI result consists on the images and a report, based on the captured images, to help diagnosis. There is no standardization on those reports but observing several report examples, generally, they contain (besides information about where the exam took place and who is making the report) information about clinical indication, technique, findings and diagnosis.

The clinical indication explains the motivation for the exam, the clinical history that made the clinician ask for this MRI. The technique indicates how the images were obtained. As different techniques for obtaining the images exist, it is important to explain which one was used. This section can also limit which part of the body was scanned.

Then, the findings section is where the clinician will indicate, in full detail, his observations about the images obtained. This section works as a transcription of the images, providing extra diagnostic support. Finally, the clinician shall present his impression on the exam, that is, based on the images and the motivation for the exam, he shall relate his findings to the context of that patient.

Based on the sections in several real lumbar column MRI reports, an archetype structure was developed. Any attributes a clinician would want to capture about this particular concept should be considered, and also other existing archetypes to be reused as a part of this concept had to be searched. From the collected information, it was possible to define the following steps on the archetype development.

First, it was clear it should be an "observation" archetype, as it is about an observation from a patient with diagnostic purposes. Then, primary sections named "technique", "diagnosis", "notes and comments", "findings" and "images" were defined. They correspond to their counterparts in a real report, being simple text fields, except for "findings". The "notes and comments" section is intended to contain any extra information the clinician feels important to add in the report. The "images" section is a multimedia field with free cardinality, and can contain any number of JPG or DICOM images from the exam.

The "findings" section will be examined in detail. It contains an internal structure, where the clinician describes his observations about the obtained images. Inside this section, we have many coded text fields (coded for binding with terminologies): general findings about the spine as a whole, observations on a thoracic section eventually covered in the exam, observations on each of the vertebrae and intervertebral disc and on the sacral section eventually covered in the exam. There is also a boolean variable to indicate if there is lumbarization, and thus the existence of an L6 vertebra. The final structure of the archetype is shown in Figure 1.
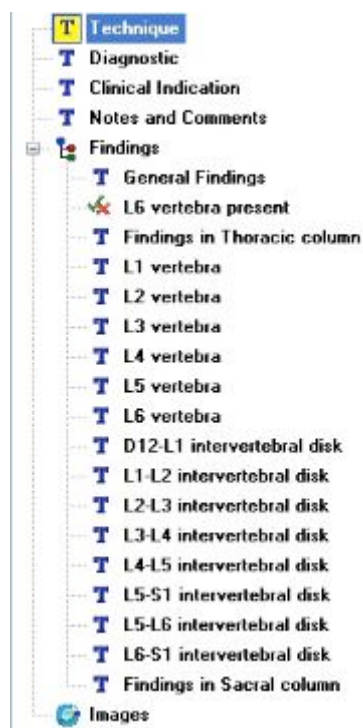
Figure 1 - Hierarchical Structure of the developed archetype

Finally, we see that, starting from a clinical concept, it is possible to develop an archetype just based on basic principles and collecting relevant information. Free tools for archetype creation and edition, such as the Ocean Archetype Editor (7) and Java Archetype Editor (8), are available on the Internet.

Other works about modeling of clinical data using archetypes exist. One example is the article of Bird, Goodchild and Tun (9), talking about a real implementation of EHRs using archetypes. Instead of openEHR, GEHR (Good Electronic Health Record) specifications were used. This article confirms that the two-level modeling approach taken by openEHR works in a real clinical environment.

Another similar work is the D.Sc. thesis from Koray Atalag (10), intending to develop a minimal terminology for endoscopies. To model this terminology, he used openEHR archetypes. Different concepts from an endoscopy were modeled using different kinds of archetypes, from evaluations to interventions.

Conclusion

The openEHR project aims at developing an open and interoperable health computational platform, and an important component in this effort is the development of EHRs that are clinically effective and interoperable. The project publishes specifications, implementations and archetypes with that goal in mind.

Besides that, the two-level modeling used with the archetype model brings the possibility of developing much smaller and simpler systems, besides making them more adaptable and flexible. In addition to that, the archetype model empowers who should have power to decide about domain content: the clinical specialists.

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For the future, the archetype developed in this work can be integrated into a real clinical environment, providing a valid model for the chosen clinical concept. Another possible work is to extend this archetype to contain metadata from the images, such as slice width. With that, an application that converts DICOM images to the format of the archetype, extracting the metadata from the header, would also be necessary.

Referênces

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