

A Cardiac Web Prototype for Semantic Interoperability and Decision Support

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Abstract

Clinical decision support systems can be improved if data exchange among different organizations with full and understandable clinical meaning is achieved. Towards this end, the development of new methodologies of information management is necessary. Among them, CEN/ISO EN13606 (archetypes) is the most promising approach.

According to World Health Organization, cardiovascular diseases are the leading causes of death worldwide. A good number of risk indices from electrocardiogram signal processing have been proposed for cardiovascular risk stratification. We have considered here the Heart Rate Turbulence (HRT) due to its clear and concise guidelines.

Based on previously built HRT ontology and archetype, a web prototype was created to achieve semantic interoperability among heterogeneous hospital systems; and to avoid technical limitations when different commercial tools are used. The web prototype was able to provide the user with the following functionalities: (1) binding the HRT ontology concepts to the HRT archetype nodes by using a designed archetype-ontology binding system; (2) compiling and maintaining database HRT records; and (3) exporting these records, while enabling semantic interoperability to allow data exchange among different systems.

Keywords: Semantic interoperability, SNOMED-CT, archetypes, web technologies, clinical decision support, cardiovascular risk stratification.

Introduction

Health care providers require rapid and reliable decision-making processes in patient diagnosis, treatment, and follow-up. In recent decades, it is undergoing a change from traditional medical approaches based on clinicians' experiences to innovative methods, which use signal and image processing for decision-making. In this context, the called Clinical Decision Support (CDS) systems have been widely studied in the literature [1,2,3]. Medical informatics provides a large variety of resources to healthcare community to improve many issues of their clinical daily practice [4]. In this setting, Electronic Health Record (EHR), a longitudinal record with patient health information, can be very useful to provide access to the vast amount of clinical information and to share data among heterogeneous Hospital Information Systems (HIS). However, the ability to exchange data and to understand clinical information from EHR with independence on the system (semantic interoperability) is a major challenge in this field, specifically in public health systems [4].

The aim of this work was to design an architecture for exchanging EHR data among heterogeneous HIS. To account for the technical requirements of different systems, a web prototype called *HRT Archetype Proto* was created. In order to get semantic interoperability, the CEN/ISO EN13606 standard was used to build the archetype (knowledge). We focused on the Heart Rate Turbulence (HRT) domain due to its concise guidelines and clear indices calculation procedures for cardiovascular risk stratification. Archetypes were saved as *ADL* files.

Materials and Methods

Semantic interoperability is an essential factor in achieving the benefits of EHR to improve the quality and safety of patient care, public health, clinical research, and health service management. European Commission encourages the use of standards to represent the relevant health information for a particular application using data structures (such as archetypes and templates), terminology systems and ontologies [6].

On the one hand, SNOMED-CT is the most comprehensive, multilingual clinical healthcare terminology in the world [8]. Following this terminology, this work considers the HRT ontology presented in [9].

On the other hand, we used CEN/ISO EN13606 to define a rigorous and stable information architecture [10]. CEN/ISO EN13606 follows Dual Model architecture, i.e., an architecture model that defines a clear separation between information and knowledge. The information is supported by a Reference Model (RM), which contains the basic entities for representing any information of a specific domain. The knowledge is based on archetypes, i.e., formal definitions of clinical concepts as a structured and constrained combination of RM entities. The RM is used to collect data, whereas the Archetype Model (knowledge) describes those data structures semantically. Hence, the main capability of this Dual Model is that knowledge could be modified in the future, whereas data will remain unaltered. Clinicians from different hospitals agreed the nodes and constraints of the HRT archetype developed in [7], providing an adequate knowledge representation from a clinical viewpoint.

A web prototype based on the HRT ontology/archetype was built to overcome the limitations of technical implementations among heterogeneous HIS. The prototype is a proof of concept of the schema shown in Figure 1. The HRT archetype nodes obtained from the *ADL* file were considered as fields in

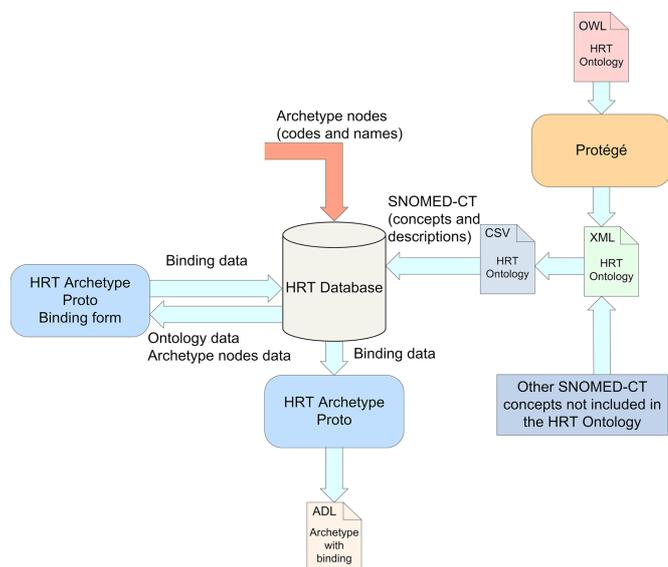


Figure 1- Schema for HRT web prototype.

a MySQL HRT database to collect data (information) from different HIS exactly in the same way. Thus, the archetype constraints such as ranges of allowed values and coded text options were also assessed.

Furthermore, a simple system to bind SNOMED-CT concepts from the HRT ontology with the nodes of the HRT archetype was developed following the schema shown in Figure 1. As the first step, Protégé software tool was used to export the HRT ontology into an xml file. This file was converted to csv format to be able to include more SNOMED-CT concepts potentially useful but not considered in the HRT ontology. The obtained csv file was imported into the HRT database. As a second step, the archetype nodes (codes and names) were also imported into the HRT database. With the mappings stored in the HRT database, the terminology section in the ADL file is completed, and it can be now readily shared among different systems.

Results

The web prototype, called *HRT Archetype Proto*, generates xml files in the form of EHR extracts, by combining data from the nodes of the archetype and the EHR data entered by the clinicians, both stored in the HRT database. These extracts have the same structure and constraints as the developed archetypes, so they provide the same advantages, i.e. semantic interoperability.

As a result, the prototype provides with: (1) a simple and helpful system for binding archetypes to the HRT ontology, and (2) a clinical data export approach based on semantic interoperability. Therefore, our web prototype supports the use of clinical standards for CDS, and the development of a structured database to scientifically assess and improve the knowledge of the HRT domain for wider and subsequent cardiac domain expansion.

Conclusions

The present work has demonstrated a web prototype for achieving semantic interoperability among heterogeneous EHRs by using ontologies and archetypes. *HRT Archetype Proto* provides the user with the following functionalities. First, the creation and maintenance of EHR extracts from the knowledge of the HRT archetype; and second, the export of

these extracts in xml files, hence allowing their exchange with fully semantic meaning among different systems, since these extracts are generated from archetypes.

Overall, *HRT Archetype Proto* enables building a new web system for HRT decision support based on clinical data standards and SNOMED-CT conceptual model. The proposed prototype provides a multi-centric system to access to EHR information. Oncoming work is devoted to apply the web prototype in the daily practice for automating and streamlining the clinicians' workflow for cardiovascular risk stratification. Specifically, our short-term research is focused on the extension of the prototype to take into account more indices for cardiovascular risk stratification (e.g., heart rate variability indices). It will allow the long-term ability to generate a complete patient record using information from different EHRs.

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