Web Application for Data Exchange and Follow-up in Heart Rate Turbulence

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Abstract

Cardiovascular risk stratification is widely used in clinical practice. Heart Rate Turbulence (HRT) is an example of a sudden cardiac death prediction index with clear and concise guidelines.

We developed a web application based on a previously built HRT archetype for data exchange and follow-up for the HRT domain. The goal was to build a web tool to collect HRT related data from different HIS to clinical decision support. CEN/ISO EN13606 standard aims to define an information architecture for communicating EHR between heterogeneous systems. It is based on a dual model that defines separation between information and knowledge. The information is supported by a Reference Model containing the basic entities for representing any information of a specific domain. The knowledge is supported by an Archetype Model, a structured and constrained combination of entities from a Reference Model that represents a particular clinical concept. The nodes (clinical terms) and constraints (such as ranges of allowed values) of the built HRT archetype are used to define this domain in the web application. This web application not only allows to collect and manage HRT data, but also it provides functionalities like editing or viewing the information related to a patient. HRT follow-up to be used by the clinical community independently of technical limitations is obtained by combining web technologies and archetypes.

1. Introduction

Medical informatics provides to healthcare community with a large variety of resources to improve many issues of their clinical daily practice [1]. In this setting, Electronic Health Record (EHR) [2], 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, specially in public health systems [3].

We proposed the standardization of clinical data from the EHR to infer Cardiovascular Risk Stratification (CVRS) from long-term electrocardiogram (ECG) signal processing in previous works [4–6]. To this aim, an ontology based on the conceptual model of SNOMED-CT for CVRS using ECG-derived indices was built. The ontology was focused on the current knowledge of Heart Rate Turbulence (HRT), since it represents a low complexity model domain. A practical development of a clinical form based on the HRT ontology was implemented in the HIS of University Hospital of Fuenlabrada (Madrid, Spain). We found two main drawbacks in these practical implementations. On the one hand, the implementation of the HRT form in different HIS was very difficult to reach, because changes in commercial systems require a political consensus. On the other hand, the HRT form based on the ontology did not achieve semantic interoperability in the EHR because it was created with no clinical standard to represent the relevant health information. For the latter, a CVRS archetype was subsequently built in [6], following the CEN/ISO EN13606 standard to achieve the interoperability among heterogeneous HIS.

The goal of the present work was to yield a standard and semantic interoperability structured database for CVRS, based on HRT indices, allowing their sharing among heterogeneous EHR systems. For this aim, and based on the HRT ontology and on the archetypes described in Section 2, we built an EHR web prototype called *HRT Archetype Proto*. This prototype provides three main functionalities: (1) the creation and management of EHR extracts from Patient Summary and HRT archetypes; (2) a binding process based on the HRT ontology; and (3) the clinical data export in xml format for semantic interoperability among different systems.

Concept	Description	Constraints	Values
Patient Data	Patient summary	*Cluster* 0..1	
Age	Patient age	*Count* 0..1	0..120
Gender	Patien gender	*Text* 0..1	Internal; 'Male', 'Female', 'Unknown'
Tobacco	Tobacco usage	*Cluster* 0..1	

Figure 1. Example of concepts, descriptions, constraints and values from the Patient Summary archetype in HTML format.

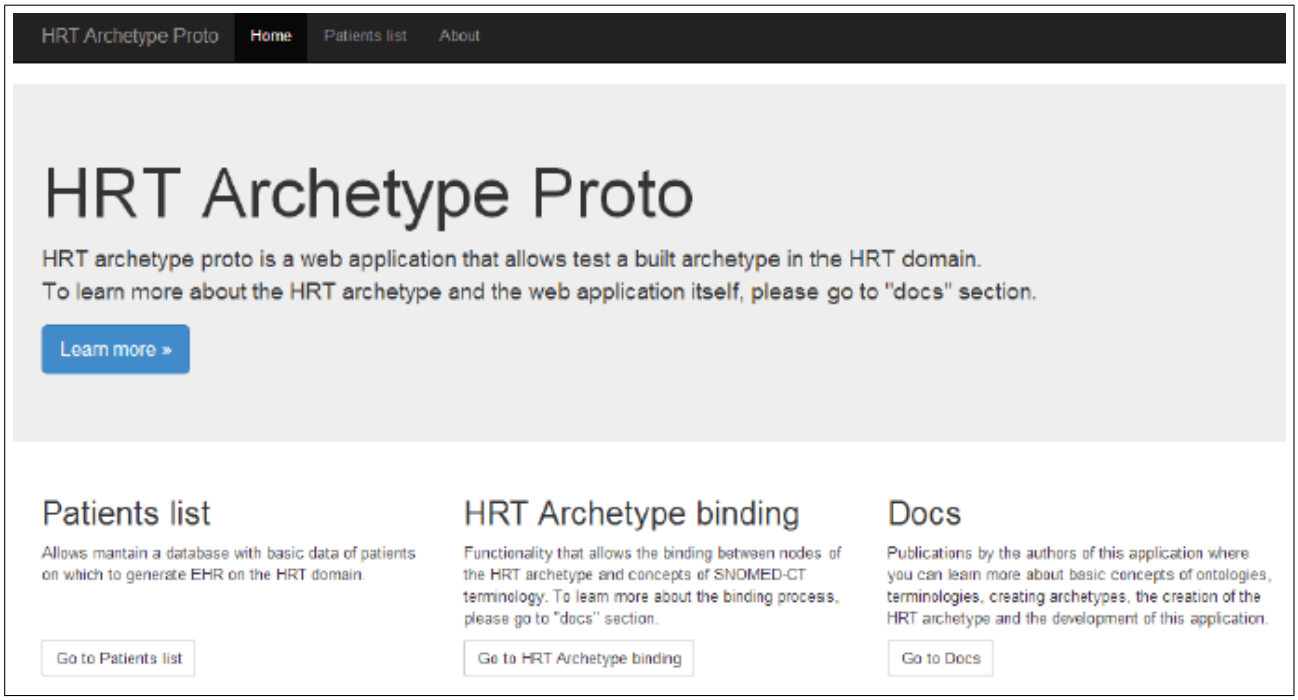

Figure 2. Home page in *HRT Archetype Proto* web application.

The paper is organized as follows. Section 2 summarizes the main concepts related to the development and use of ontologies and archetypes in HRT domain. In Section 3, the web Application for Data Exchange and Follow-up in HRT is described with detail. Conclusions are finally stated in Section 4.

2. Background

This section summarizes the ontology and the CVRS archetype for HRT domain previously created in [5, 6].

Heart Rate Turbulence is the phenomenon of short-term fluctuation in sinus cycle length over about 20 beats following a Ventricular Premature Complex (VPC) [7]. HRT is usually assessed from 24-h ECG signals. From such recordings, a VPC tachogram is constructed by aligning and averaging the RR interval sequences around isolated VPCs, according to the guidelines [7]. HRT is quantified using two parameters, namely turbulence onset (TO) and turbulence slope (TS). TO reflects the amount of sinus acceleration following a VPC, whereas TS reflects the rate of sinus decelerations after sinus acceleration.

The concepts of the HRT domain were defined following SNOMED-CT, which is the most comprehensive, multilingual clinical healthcare terminology in the world (`www.ihtsdo.org`). SNOMED-CT consists of a structured collection of health care terms, which are attached to concept codes with multiple definitions per code. A concept is a clinical meaning identified by a unique identifier (ConceptID) that never changes. SNOMED-CT facilities the communication within diversified health teams and in searching health information.

On the other hand, the **CEN/ISO EN13606 standard** (`www.en13606.org`) is an ISO standard used to define an information architecture for communicating EHR between heterogeneous systems. It is based on a dual

model that defines separation between information and knowledge. The information is supported by a Reference Model containing the basic entities for representing any information of a specific domain. The knowledge is supported by an Archetype Model, a structured and constrained combination of entities of a Reference Model that represents a particular clinical concept. The main advantage of this dual approach is that knowledge is upgraded when it changes, whereas the Reference Model (information) remains unaltered.

The ontology based on SNOMED-CT enables a consistent representation of the HRT concepts, whereas the archetype provides a formal definition of this clinical domain. Both the HRT ontology and archetype were previously created (see [5, 6]), and jointly they allow to achieve semantic interoperability among heterogeneous systems.

3. HRT Archetype Proto

In this section, we describe the design of the web prototype called *HRT Archetype Proto* based on the built ontology and archetypes, as well as its main functionalities.

3.1. From Archetypes to Web Prototype

In order to obtain semantic interoperability, we separated knowledge and information by following a twofold schema. On the one hand, knowledge is provided by clinical experts by defining the domain elements directly using an archetype editor software, which was Archetype Editor Ocean Informatics in our implementation. On the other hand, information is managed and supported by the web prototype *HRT Archetype Proto*.

Firstly, the information related to nodes of the archetypes are their constraints were exported into a csv file. In particular, we considered constraints such as ranges of allowed values and coded text options, as shown in Fig. 1. Secondly, this csv file was used to generate a clinical standard table in a MySQL database, hence allowing the development of *HRT Archetype Proto*. The *Home page* in *HRT Archetype Proto* web application is shown in Fig. 2.

3.2. Functionalities

The *HRT Archetype Proto* provides three main functionalities: (1) the creation and management of EHR extracts from archetypes; (2) a binding process based on the HRT ontology; and (3) the clinical data export in xml format for semantic interoperability among systems with different technical requirements. The web prototype allows the management of patient data and EHR (add, edit, view, delete) taking into account the constraints of the archetypes to have complete data sets (see Fig. 3).

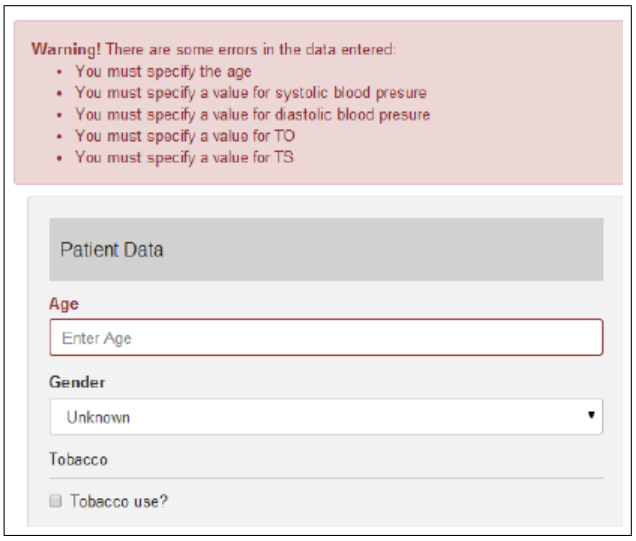

Figure 3. Patient data form following the archetype constraints in the *HRT Archetype Proto* web application.

The binding process consists on the structural relationship between the archetypes nodes and the terminology concepts. We propose in this work a solution to help clinicians to use the previously defined ontology without requiring either a terminology server or a specific software. Specifically, we built a simple system to bind SNOMED-CT concepts from the HRT ontology with the nodes of the HRT archetype. The *HRT Archetype Proto* web prototype automatically writes the SNOMED-CT code into the portion corresponding to the binding code (see Fig. 4), hence completing the binding process.

Exporting clinical data in xml was pursued in this work to share EHR data with fully meaning among different systems, and a schema of the process is shown in Fig. 5. The path of each archetype node and its datatype and classtype (knowledge in the dual model) were merged with all data generated when a new EHR extract was created. The web prototype generates xml files in the form of EHR extracts, by combining the data from the nodes of the archetype and the EHR data entered by the clinicians. These extracts have the same structure and constraints as the built archetypes, so they provide semantic interoperability.

4. Discussion and Conclusion

The interoperability among different health care systems was pursued in this work by: (1) creating a structured database based on the standard CEN/ISO EN136066; (2) using SNOMED-CT, since it guaranteed the standardization and interoperability with emerging EHR; and (3) exporting clinical data in xml to be shared with fully meaning among different systems.

Overall, the *HRT Archetype Proto* allows a new web sys-

```
            ["at0084"] = <
                text = <"*Gender(es)">
                description = <"*Patient gender (es)">
            >
            ["at0085"] = <
                text = <"*Male(es)">
                description = <"*The patient is a male (es)">
            >
            ["at0086"] = <
                text = <"*Female(es)">
                description = <"*The patient is a female (es)">
            >
            ["at0087"] = <
                text = <"*Unknow(es)">
                description = <"*Patient's gender unknown (es)">
            >
        >
    >
>
term_bindings = <
    ["SNOMED-CT"] = <
        items = <
            ["at0084"] = <[SNOMED-CT::263495000]>
            ["at0085"] = <[SNOMED-CT::248153007]>
            ["at0086"] = <[SNOMED-CT::248152002]>
            ["at0087"] = <[SNOMED-CT::394743007]>
        >
    >
>
```

Figure 4. Screenshot of the binding process integrated in the *HRT Archetype Proto* Web prototype.

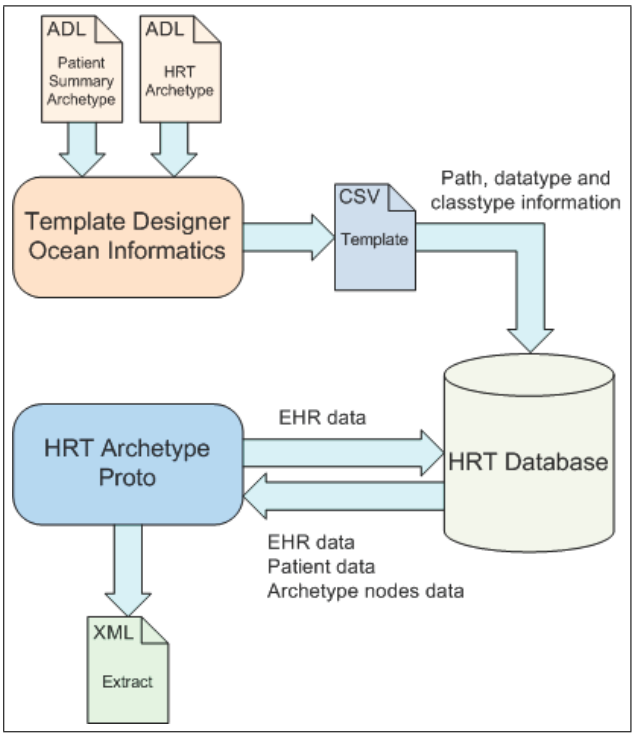

Figure 5. Schema for exporting clinical data in xml for semantic interoperability.

tem for HRT CVRS decision support based on clinical data standards and on the SNOMED-CT conceptual model.

The proposed prototype provides a multi-centric system to access to EHR information. Oncoming work is devoted to apply it in the daily practice for automating and streamlining the clinicians workflow, with the long-term ability to generate a complete record of a clinical patient encounter directly from the information of the EHR.

Acknowledgements

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