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Ontological Model for EHR interoperability

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Abstract. The main purpose of this paper is to design a data model for Electronic Health Records which main goal is to enable cooperation of various heterogeneous health information systems. We investigate the interest of the meta-ontologies proposed in [1] by instantiating it with real data. We tested the feasibility of our model on real anonymous medical data provided by the Médibase Systèmes company.

Keywords. Electronic Health Record (EHR), Medical Ontologies, Interoperability

Introduction

Health information systems (HIS) are complex, heterogeneous, ambiguous (semantically) and rarely interoperable. As part of our research, we are particularly interested in one of the most common tools used in the field of health informatics: Electronic Health Records (EHRs). According to [2], EHRs universally comprises medical history, clinical examinations, laboratory results and para-clinical examinations. We propose to design a data model for EHRs in order to enable cooperation of various heterogeneous health information systems and reduce the cognitive overload of physicians treating numerous and various medical data.

Despite the large number of works on medical data structuring and design, data exchange between healthcare professionals remain inefficient. Among the works dedicated to this problem, an interesting approach has been proposed by [1] whose main contribution is to make cooperating heterogeneous information systems together based on a semantic mediation architecture. We propose an instantiation and adaptation of this work.

In this article we firstly briefly describe Sassi's work [1] and secondly, our instantiation and adaptation of this model applied to the patient health record from a French company, Médibase Systèmes. We have illustrated features of our work on a "trajectory of care" representation in regard to a chronic disease (diabetes) on a real anonymous medical database.

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1. Modeling and representation of medical data

In this work, we are interested in modeling, structuring and representing medical data as well as their interoperability. Among the works on modeling and representing medical data, some propose medical terminologies as UMLF [3] and SNOMED CT [4]. These works propose a semantic representation of data but their use does not necessarily provide semantic interoperability. According to [5] the use of knowledge bases and formal ontologies for the structuring and the reorganization of data and medical knowledge are widely used. We can cite [6] and [7], which proposed an ontological framework to represent information and medical events.

"OntoUrgences" [8] is an ontology of emergency acts, and in [9], the authors designed an ontology based on a medical decision support system to enhance patient's lifestyle. Ontologies are widely used to model knowledge in the medical domain because of their ability to represent data semantics. But the fact is here: the increase of more and more complex, distributed medical data lead to a continuous difficulty to have a synoptic view of the patient health record. We propose in this work a standard model to represent any EHR independently of its own design.

2. Overview of the ICOP approach

The Iconic Project Management (ICOP) mediation systems transforms data coming from different medical databases into a synoptic health records on which medical data are chronologically represented, annotated, contextualized and "iconized". The system uses two meta-ontologies, the Meta-Ontology of Domain (MOD) and the Meta-Ontology of Tasks (MOT) in order to unify the different data from heterogeneous systems. The MOD describes and classifies medical objects and represents the concepts used in the different EHRs. The MOT is used to unify the medical vocabulary and the actions reflecting the medical professions.

Let us consider the following medical scenario: "A patient P1 (who has a NIDDM²) consults a diabetes specialist HP1. HP1 draws a report that can be communicated to all health professionals whatever their specialties and a biological laboratory test that must be read only by other diabetes specialists. Every legacy system, represents each concept with their own terminology. The ICOP system extracts these concepts, generates the meta data and adapts these concepts to the MOD and MOT. In our example, the report is considered as a simple object (text), communicated to all HP, a biological lab test is a complex object (<attribute, value, lower/upper bound>) only communicated to diabetes specialists. The concepts are then unified, annotated and contextualized. The figure 1 describes the meta model of the MOD.

² NIDDM: Non-Insulin Dependent Diabetes Mellitus.

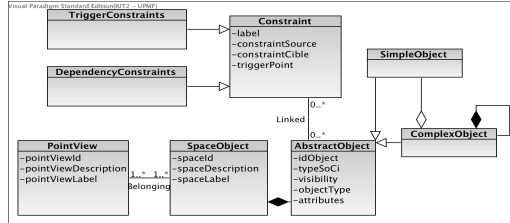


Figure 1. Meta-Ontology of Domain(MOD).

3. Data model of patient health records

In our work, we propose an instantiation of the Icop mediation system adapted to the Médibase Systèmes company databases. We created an EHRs model (based on the company medical databases) containing anonymous real medical data. The model mainly contains data related to patients, doctors, medical prescription, drugs and biological examinations. (For more visibility of our model in figure 2, we retrieved all attributes of objects). The prescriptions are made according to Vidal database [10]. Diseases are coded according to the International Classification of Diseases (ICD10) [11].

Every medical data is then seen as a medical event, that represents the treatment of each clinical problem (e.g. allergies, diagnoses, complaints, labs, imaging, medications, immunizations and communication). We add a date (a time stamp) for each medical event.

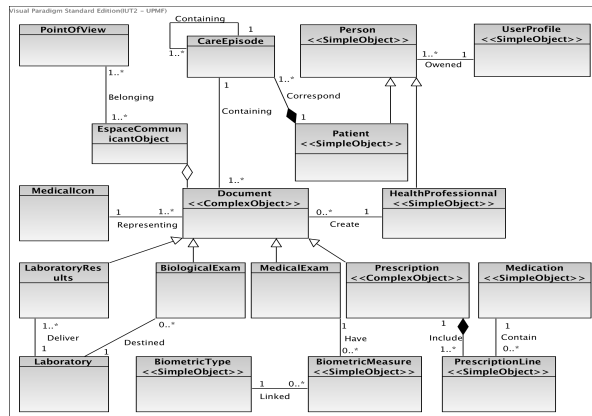


Figure 2. Medical Data Model.

All medical events related to a same health problem are gathered in a care episode represented by a start-date, an end-date, a label (extracted from ICD-10 or any else classification like ICPC [12] in primary care), an identification, and all medical events related to this care episode like prescription, medical exam or biological exam. In the previous example, the care episode is type 2 diabetes, (labelled E11 in ICD-10) that contains two medical events, the report, and the biological laboratory test.

To represent the transition between two consecutive care episodes, we defined a new concept, the trigger event that represents a dynamic point of view³ which trigs the creation of a new care episode linked to the previous one. In the above example, the trigger event is the result of the laboratory examination. We pass a care episode (E11: NIDDM) to another (E10: IDDM⁴)

The graphical representation of medical events is supported by a concept vector generated from the EHR and representing all medical events related to a care episode. The concept vector is described below: VC_{CE} : CareEpisode (Att: IdCareEpisode, Att: label, Att: label, Att: start-date, Att: end-date, P: Person, D: Document, MI: MedicalIcon, Pr: Prescription, ME: MedicalExam, BE: BiologicalExam, BM: BiometricMeasurement). For each significant table in the database, we instantiate the concrete objects and define the attributes of the concept vector. The graphical interface of the application (viewer) is provided with a chronological timeline. Care episodes are linked to the timeline, and contain icons representing each medical event.

4. Conclusion and perspectives

In this article, we have presented an original instantiation of a mediation system, which allows heterogeneous EHR to cooperate. We used some real anonymous medical patient and obtained very good feedbacks. Our perspectives are to design the patient's context, the physician's behaviors and improving the medical knowledge with machine learning methods. The final goal is to perform recommendations and diagnosis help.

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³ Dynamic diagram transition state is developed to present the different sequences of "episodes of care".

⁴ IDDM: Insulin Dependent Diabetes Mellitus.