Multi-Version Ontology-Based Personalization of Clinical Guidelines for Patient-Centric Healthcare

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ABSTRACT

When dealing with a specific patient case, physicians are often interested in retrieving a personalized version of a clinical guideline, that is a version tailored to their use needs. In a patient-centric scenario, empowered patients make up another class of users interested in retrieving personalized care plans from a guideline repository. In their previous work, the authors proposed techniques to efficiently provide ontology-based personalized access to very large collections of multi-version clinical guidelines. In this paper, they address the problem of also dealing with a multi-version ontology used to support personalized access to clinical guidelines. The authors’ approach allows the semantic indexing of guideline contents with respect to multi-version ontology classes and exploits the IS-A relationship among such classes for granting personalized access. Efficiency is ensured by a newly introduced annotation scheme for guidelines and solutions to cope with the evolution of ontology structure. The tests performed on a prototype implementation confirm the goodness of the approach.

KEYWORDS
Multi-Version Clinical Guidelines, Multi-Version Ontologies, Personalized Access, Semantic Indexing, Temporal Indexing, XML Repositories

INTRODUCTION

The adoption of reference ontologies and their deployment for the personalization of multi-version resources has been recently proposed by several authors in the medical informatics domain (Grandi et al., 2012; Riaño et al., 2012; Tu et al., 2011, Wang et al. 2013) (but also in other application fields, e.g., e-Government (Grandi et al., 2009)). In this work, as resources we consider clinical guidelines (Field & Lohr, 1990), that is “best practices” encoding and standardizing health care procedures, either in textual or in executable format, and their personalization with respect to an ontology of diseases, patients or available hospital facilities they are applicable to. In practice, references to ontology classes are added to the computer encoding of resources (e.g., for which an XML (W3C, 2015a) format can conveniently be used) to introduce a sort of semantic indexing of contents representing their applicability, relevance or eligibility with respect to ontology classes. For instance, a given guideline (e.g., involving treatment of heart diseases) may contain different recommendations which are not uniformly applicable to the same classes of patients: one general therapy may be non-applicable to persons who suffer from some metabolic disorders (e.g., diabetes mellitus) or chronic diseases (e.g., kidney failure) or present some addictions (e.g., cocaine); one first-choice drug may not be administered
to patients who are already under treatment with possibly interacting drugs (e.g., anticoagulants),
or show genetic or acquired hypersensitivity or intolerance to some substances (e.g., patients with enzymatic defects or documented allergies), and so on. Hence, when dealing with a specific patient care case, a physician may be interested in retrieving a personalized version of a clinical guideline, that is a version tailored to his/her use needs by means of all the available personalization coordinates involving the patient’s health state, anamnesis and characteristics (e.g., genetic, demographic or preferential) and local settings (including available hospital resources, diagnostic facilities and physicians’ skills). Therefore, the personalized version will only contain recommendations which are safely and effectively applicable by the user to the patient’s specific case. Furthermore, the emergence of patient-centered healthcare (Australian Commission on Safety and Quality in Health Care, 2010) and the development of patient-centered decision support systems (González-Ferrer et al., 2013; Sacchi et al., 2013), with the involvement of empowered patients as final users, requires the adoption of also non-strictly medical characteristics and individual preferences as further personalization coordinates (e.g., level of education, meal schedule and sleep habits).

To this purpose, we introduced in (Grandi et al., 2009; Grandi et al., 2012) a personalization query engine that, starting from a user-supplied list of ontology classes representing values of the semantic personalization coordinates, can exploit semantic indexing to retrieve the relevant contents only and produce a guideline version tailored to a specific use case. Notice that, coherently with ontology-based personalization solutions also proposed in other application fields (Callan et al., 2003; Cantador et al., 2008; Gauch et al., 2003; Middleton et al., 2004; Moreno et al., 2013; Pretschner, 1998; Riecken, 2000; Sieg et al., 2007), we use the term “personalized” as referred to the user of the computer system, that is either the medical care provider or the empowered patient who follows the guideline.

However, in a dynamic environment, the management of this kind of semantic versioning is interleaved with temporal aspects. The fast evolution of medical knowledge and the dynamics involved in clinical practice imply the coexistence of multiple temporal versions of the clinical guidelines stored in a repository, which are continually subject to amendments and modifications. Therefore, it is crucial to reconstruct the consolidated version of a guideline as produced by the application of all the modifications it underwent so far, that is the form in which it currently belongs to the state-of-the-art of clinical practice and, thus, must be applied to patients today. However, also past versions are still important, not only for historical reasons: for example, a physician might be called upon to justify his/her actions for a given patient at a past time on the basis of the clinical guideline versions applicable to the pathology of patient and which were valid at that time.

Moreover, in a dynamic environment, the definition of domain ontologies themselves is also subject to modification as the medical knowledge, clinical environments and viable technologies evolve and, thus, also ontologies come out versioned as a consequence of updates periodically effected by domain experts and knowledge engineers or even standardization committees. As we will exemplify in Section “Motivating Example”, personalization of a guideline with respect to a past point in time must be effected by taking into account, in order to consider semantic indexing, the version of the reference ontology which was valid at the same time point. In other words, the selected guideline version and the ontology version used for personalization must be mutually temporally consistent. Since clinical guidelines have also been recently proposed to be used as evidence of the legal standard of care in medical malpractice litigation (Mackey & Liang, 2011; Mello, 2001), enforcement of temporal consistency is crucial to assess the responsibility of physicians having followed the guidelines in the past (e.g., for an insurance controversy involving some damage due to treatment). In a patient-centric personalization scenario, where different responsibility levels might be ascribed either to the physicians and to the empowered patients, it is also crucial to reconstruct a temporally consistent historical perspective for both type of users.
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