Modeling a Classification Scheme of Epileptic Seizures Using Ontology Web Language

Bhaswati Ghosh, Cleveland State University, USA
Partha S. Ghosh, Cleveland Clinic Foundation, USA
Iftikhar U. Sikder, Cleveland State University, USA

ABSTRACT

Ontology-based disease classification offers a way to rigorously assign disease types and to reuse diagnostic knowledge. However, ontology itself is not sufficient for fully representing the complex knowledge needed in classification schemes which are continuously evolving. This article describes the application of SWRL/OWL-DL to the representation of knowledge intended for proper classification of a complex neurological condition, namely epilepsy. The authors present a rigorous and expandable approach to the ontological classification of epileptic seizures based on the 1981ILAE classification. It provides a classification knowledge base that can be extended with rules that describe constraints in SWRL. Moreover, by transforming an OWL classification scheme into JESS (rule engine in Java platform) facts and by transforming SWRL constraints into JESS, logical inferences and reasoning provide a mechanism to discover new knowledge and facts. The logic representation of epileptic classification amounts to greater community understanding among practitioners, knowledge reuse and interoperability.

Keywords: Epilepsy, Ontology, Ontology Web Language, Semantic Web

INTRODUCTION

In recent years there is a growing trend towards developing semantic interface for clinical diagnostic decision support systems (Asuman, 2006; Miller & Geissbuhler, 2007; Stephens, Morales, & Quinlan, 2006). As health practitioners are relying more and more on software systems for automating tasks such as electronic medical records maintenance and the implementation of treatment guidelines, there is increasing demand for knowledge integration in such systems. However, there are many issues involved including the complexity of knowledge representation and information encoding which includes (i) definition, (ii) composition, (iii) scale, and (iv) context (Lussier & Bodenreider, 2007). Due to multiple definitions of clinical phenotypes, diagnostic specifications often lack precision. Researchers have reported at least five differ-
ent definitions of phenotypes in the literature (Mahner & Kary, 1997). To enforce semantic specification, ontology has been widely used in many clinical diagnostic decision support systems (Yu, 2006). In particular, neurology, as a subspecialty, has many native built in semantics. Additionally, neurological conditions are unique and may not be very familiar to other medical specialists. The medications prescribed by neurologists and the investigations (e.g. Electroencephalogram (EEG), Magnetic Resonance Imaging (MRI), Nerve Conduction Study/Electromyography (NCS/EMG) etc) are often different from other medical subspecialties. Hence, having a specialty specific ontology is essential to integrate neurology with other medical software systems. It is particularly important when developing a specific ontology system for epilepsy, a subspeciality within neurology. Epilepsy is a condition which is frequently encountered by general practitioners before these patients get referred to a neurologist. Epilepsy is a chronic neurological condition with significant morbidity and increased risk of mortality compared to the general population. Proper diagnosis and management is of essential importance not only in the short term but also for long term prognosis.

In this article we present a rigorous and expandable approach to ontological classification of the epileptic seizures based on the 1981 ILAE classification. Section 2 identifies the role of ontology for developing knowledge specification of domain concept, particularly in the context of clinical decision support systems, by a literature review. Section 3 outlines the complexities involved in classification of epilepsy type and syndrome. Section 4 describes the development of epilepsy ontology for knowledge modeling and reasoning. Finally, we evaluate the ontology in the context of clinical decision making.

**ONTOLOGY FOR CRAFTING SPECIFICATIONS OF DOMAIN CONCEPTS**

Historically, expert systems have been used to assist in medical decision making involving diagnosis, prediction, evaluation, monitoring (Heathfield, 1999; Hernandez, Sancho, Belmonte, Sierra, & Sanz, 1994; Keles & Keles, 2008; Liebowitz, 1997; Tsumoto, 2003). By encapsulating domain knowledge into a set of rules, expert systems simulate the performance of one or more human experts with expert knowledge and experience in a specific problem domain. With the advent of Semantic Web movement, a growing interest in ontologies is being noticed as means of representing human knowledge and as critical components in knowledge management over the Web. Various research communities commonly assume that ontologies are the appropriate modeling structure for representing knowledge. While expert systems emphasize technology, ontologies emphasize knowledge. Ontologies make a domain specific knowledge base reusable, sharable and interoperable. Domain-specific questions can then be answered by reasoning over such highly specialized knowledge. Ontologies have evolved in computer science as computational artifacts to provide computer systems with a conceptual yet computational model of a particular domain of interest. While expert systems provide excellent tools for reasoning with domain rules, they often lack the means to resolve semantic ambiguities inherent in the predicates and related facts. Hence, a key requirement is to reason in a semantically consistent way is to exploit both the ontology and the rule-based knowledge to draw inferences.
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