Dynamic *is-a* Hierarchy Generation from a Clinical Medical Ontology

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Abstract

This article discusses an ontology-handling technology to provide on-demand reorganization of is-a hierarchy of diseases instead of one fixed hierarchy to cope with various viewpoints which physicians might have. It is one of the important benefits of our medical ontology which is developed as a Japanese national project. This technology tackles with the multi-perspective issues of medical knowledge.

Introduction

We discussed fundamental issues of medical ontology based on ontological theory as an intermediate report on the ontology development conducted in a project supported Japanese ministry of health, labour and welfare. In our medical ontology, we built the most fundamental *is-a* hierarchy of diseases based on “state”. Other *is-a* hierarchies according to the viewpoint specified are dynamically generated from the ontology. It resolves multi-perspective issues that there are many ways of categorization of diseases and different taxonomies are used depending on the purpose and situation. Especially, on a clinical site in which many specialists with varied backgrounds cooperate, it is significant for accurately processing medical information. In this article, we discuss development of a dynamic generation function of *is-a* hierarchy from the medical ontology.

Requirement for the on-demand reorganization of *is-a* hierarchy

Tabel.1, column (a) shows examples of viewpoints which we often see in the clinical practice. For instance, as diabetes, a certain clinical technologists may pay attention to the body part where the main pathological condition occurred. As a result, they may classify diabetes as an abnormal blood sugar level. On the other hand, a certain specialist may pay attention to the main pathological condition and may classify diabetes as an abnormality in metabolism, and another specialist may classify diabetes as a lifestyle disease for his purpose. To support these categorizations appropriately, we adopt the strategy as follows: (1) the conceptual structure of medical ontology is fixed based on ontological theories and (2) reorganizing some *is-a* hierarchy from the ontology as visualizations to cope with various viewpoints. It allows us to discuss both of conceptual classifications of diseases and manual mappings to existing taxonomies, such as ICD-10 and ICPC2, on the same level. .

Table 1. Some hierarchical classifications

(a) Viewpoints for classification of diseases		(b) Aspects for dynamic generation of is-e hierarchies of diseases from ontology
finding site (organs)	(m)	organs of the human body (part-of), main pathological condition information (slot)
	(s)	organs of the human body (part-of), symptoms information(slot)
finding site (organ systems)	(m)	organ systems(part-of), main pathological condition information (slot)
	(s)	organ systems, symptoms information(slot)
types of pathogenic abnormality		pathogenic abnormality information (is-a), main pathological condition information (slot)
types of symptoms		symptoms of abnormality hierarchy information(is-a),
first choice for diagnosis and treatment department		diagnosis and treatment department information, symptoms information(slot)
ICPC2		Mapping
ICD10		Mapping

* (m): main pathological condition occurred

* (s): symptoms

Dynamic generation of *is-a* hierarchies of diseases

To develop a function for dynamic generation of *is-a* hierarchy, we need to classify plausible viewpoints of the hierarchical classifications and relate these viewpoints to the conceptual structures of diseases. In our medical ontology, diseases are defined by specifying typical *disorder roles*, such as *pathological state, symptom,* played by *abnormal state*. For example, Fig.1 shows the framework to define diseases. Its *disorder roles* are represented as slots with classes for constraining slot values. These slots are used as the aspects to generate *is-a* hierarchies. The system traverses the ontology according to the aspect and collects information related to the slot. A new *is-a* hierarchy is then generated using this information.

For instance, to generate an *is-a* hierarchy from the viewpoint of the *pathological condition,* the *main* *pathological condition* of *metabolic disorders* is an *abnormal state* consisting of a *metabolic abnormality*, and the sub-class of a *metabolic disorder* is generated using *is-a* hierarchy information about the metabolic abnormality, which is the disorder's main pathological condition. The sub-class of a metabolic disorder is similar to an is-a hierarchy of metabolic abnormalities. The diabetes's main pathological condition is carbohydrate metabolism abnormality, which is a particular type of metabolic abnormality. Therefore, the disease of carbohydrate metabolism is subordinate to metabolic disease, and diabetes is one of the diseases of carbohydrate metabolism. (Figure.2 Aspect 1).

Moreover, to generate an *is-a* hierarchy with focus on the finding site of main pathological condition as aspect, the *part-of* relationships information of the human body are used. The partonomy of the human body is converted into *is-a* hierarchy using "p-" operator technology. The system traces it and generates an *is-a* hierarchy of disease which is similar to the part–whole relationship of the human body. For example, the diabetes's the main pathological condition is diabetic hyperglycemia, that is abnormality of blood sugar level. As a result, the diabetes is classified to diseases which have abnormality in blood. (Figure.2 Aspect 2)

Thus, the dynamic generation of an *is-a* hierarchy enables us to switch some classification hierarchies using collected information. To collect necessary information, we should trace not only *is-a* and *part-of* relationships but also the relationships based on the role played by a particular concept. Column (b) on Tabel.1 shows aspects for dynamic generation of *is-a* hierarchies of diseases from medical ontology. Some existing classifications, such as ICD10 and ICPC2, are manually mapped to our ontology for interoperability.

Implementation and Conclusion

We implemented the technology for on-demand reorganization of *is-a* hierarchy of diseases, and built a prototype of medical information service system using them. The *is-a* hierarchy of diseases, which is generated from ontology based on selected viewpoints, is used as indexes for navigation. The system switches them according to the user's intentions. When a concept in the index is clicked here, the detailed explanation is displayed. The system can switch the medium used for expressing content, such as a table, natural language or graphical expression. These contents also are dynamically generated from the ontology.

We conducted an informal evaluation of the system in a workshop and received favorable comments from medical experts. They liked the dynamic classification reorganization, which is a first solution to the multi-perspective issues of medical knowledge. The demonstration of the prototype is available at the URL: http://www.ei.sanken.osaka-u.ac.jp/MedOnto/ .

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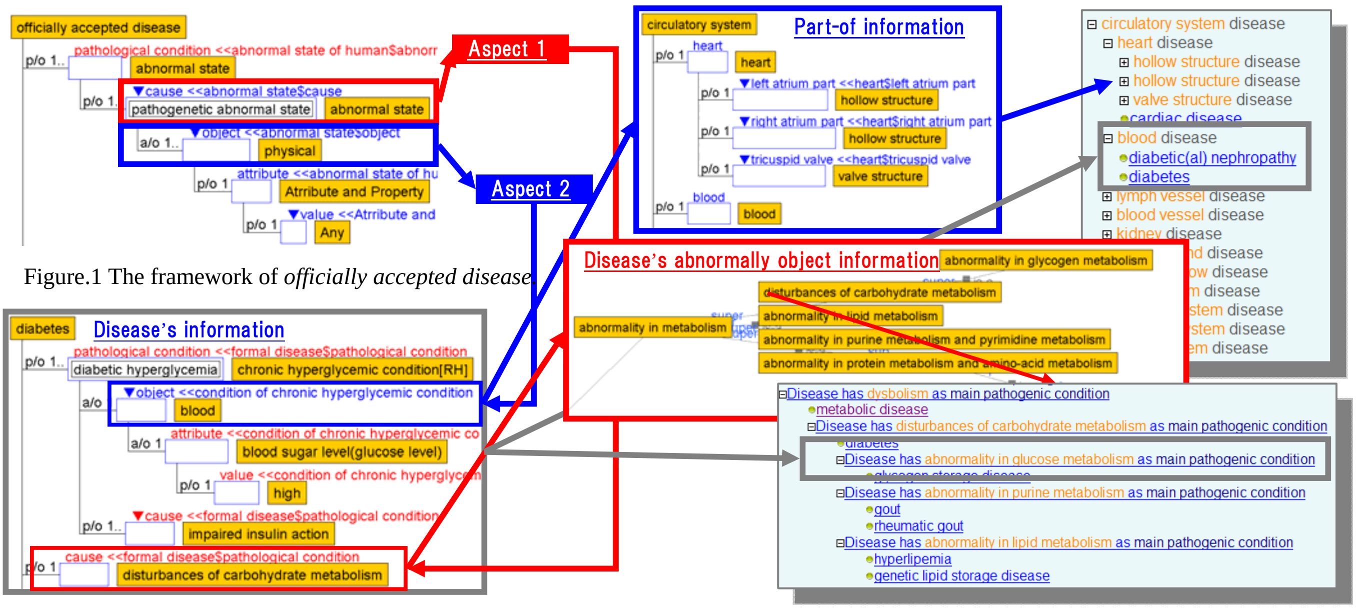

Figure.1 The framework of *officially accepted disease*

Figure.2 generated classification hierarchies of diabetics using knowledge described on ontology