論文の内容の要旨

論文題目　Development of an Ontological Model for Mappings between Computer-Interpretable Guidelines and a Virtual Standardized Clinical Information System

和訳　電子的診療ガイドラインと仮想的な標準化された臨床情報システムのマッピングのためのオントロジカルモデルの構築

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I.　Introduction

Based on rigorous clinical evidence, clinical practice guidelines are developed with the aim of improving the quality of healthcare. Computer-Interpretable Guidelines (CIGs), which are encoded using guideline representation models, promise to enable guideline knowledge be usable at the point of care and so promote guideline-recommended clinical practices. In order to accomplish sharing of CIGs between diverse Clinical Information Systems (CISs), generic concepts independent of specific CIS, especially those highly abstract and familiar to most healthcare professionals, are recommended to be used for guideline encoding. On the other hand, any data representation is dependent on the CIS where the data exists because CISs are institution specific. Therefore, it is necessary to map a CIG's abstract concepts to an institutional CIS's corresponding data when it comes to retrieving the data from the CIS and executing the CIG. We call this the *concept mapping approach*.

With this background, this study aims at developing a framework for representing mappings between concepts in CIGs and corresponding data in CISs based on the concept mapping approach. Since CIS varies among many clinical institutions, we defined our ‘ontological model’ and ‘primitive concepts’ as an intermediate layer between them.

II. Methods

(A) An overview of our framework

Our approach to mapping CIG’s abstract concepts to CIS’s data uses definitions of abstract concepts based on primitive concepts. For that purpose, a set of primitive concepts is firstly determined. We used ‘Japanese Standard Terminologies and Codes for Clinical Uses’ (Japanese Standard Terminologies) and ‘CEN13606 Reference Model’ (CEN13606 RM) to determine the granularity of the concepts in the ‘Primitive Concept Layer’, as shown in Fig.1. Then, we separated the mapping process into the following two phases: (1) mapping CIG’s abstract concepts to primitive concepts; (2) mapping primitive concepts to institutional CIS’s data elements which vary among CISs. After that, we developed the ontological model for the first phase.

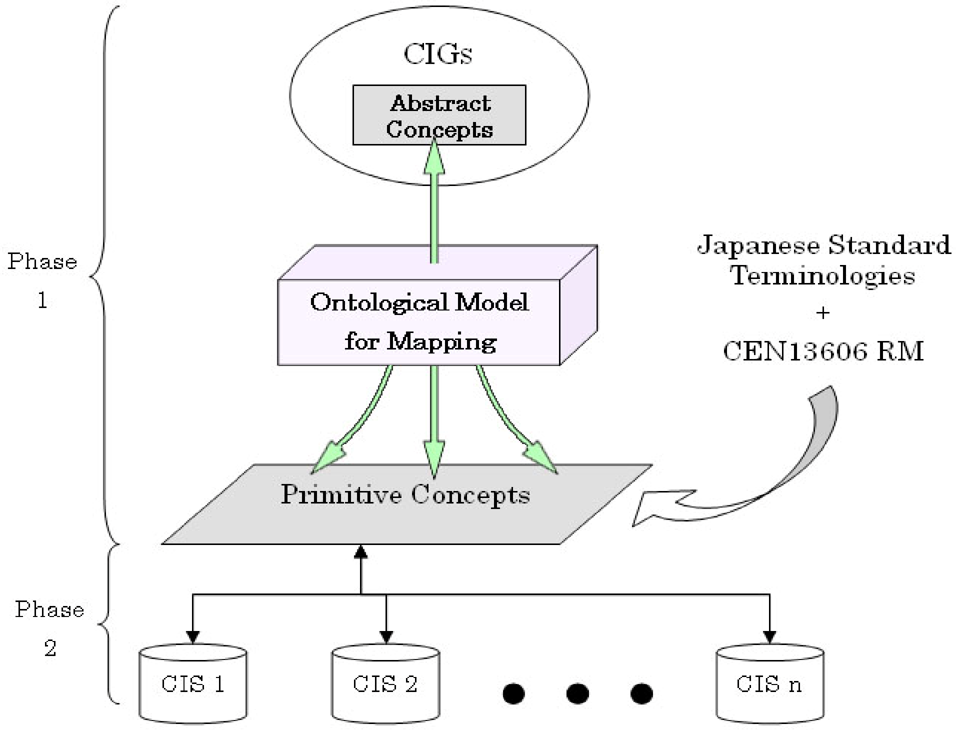

Fig. 1: The outline sketch of our work. The ontological model is used to map abstract concepts in CIGs to primitive concepts which are determined by Japanese Standard Terminologies and CEN13606 RM. Then CIGs can be shared among institutional CISs using mappings between the primitive concepts and CIS data.

(NOTE) CIGs: computer interpretable guidelines; CIS: clinical information systems; Japanese Standard Terminologies: Japanese Standard Terminologies and Codes for Clinical Uses; CEN13606 RM: CEN13606 Reference Model.

(B) Development of primitive / abstract concept layer and the ontological model

First, we defined the basic entity classes, as shown in Table1, which are necessary to describe the primitive concept layer and the abstract concept layer.

[Entity]	[Examples]
Primitive Element	Systolic Blood Pressure (SBP) Diastolic Blood Pressure (DBP)
Primitive Element-Value	SBP > 180mmHg DBP > 110mmHg
Abstract Element	Severity of High Blood Pressure
Abstract Element-Value	Severity of High Blood Pressure is 'severe'

Table1: Four main entity types and examples

The granularity of 'Primitive Element's is determined based on the minimal unit of data in EHR defined by CEN13606 RM and concepts existent in Japanese Standard Terminologies. The definition of an 'Abstract Element' depends on 'Primitive Element's (e.g. 'Severity of High Blood Pressure' depends on 'SBP' and 'DBP') and other 'Abstract Element's, if necessary. For both 'Primitive' and 'Abstract' entities above, the meaning of 'Element-Value' is expressed as a combination of 'Element' and 'Value'. An 'Abstract Element-Value' is defined by 'Primitive Element-Value's (e.g. 'Severity of High Blood Pressure is severe' is defined as 'SBP > 180mmHg $\vee$ DBP > 110mmHg') and other 'Abstract Element-Value's, if necessary.

Second, we developed an ontological model to map 'Abstract Element's and 'Abstract Element-Value's to 'Primitive Element's and 'Primitive Element-Value's. We investigated five guidelines to determine the minimal set of both relationships between classes such as 'Is-A', and logical operators such as 'AND', 'OR', 'At Least', etc. To develop our model, we used the Protégé 3.3.1 environment which is an ontology and knowledge-base editor developed by Stanford Center for Biomedical Informatics Research.

(C) Evaluation studies

Then we performed two evaluation studies as follows: (E-1) validating the ontological model using two guideline cases; (E-2) evaluating the suitability of the model for mappings used in multiple CIGs from a variety of medical domains. In the first study (E-1), we prepared a virtual CIS for a test purpose, including the primitive elements used for the implementation of the two guideline cases, and the clinical data for those primitive elements which were created manually by different healthcare professionals.

Then, the execution system output the recommendations for clinical practices according to the guidelines we had encoded, our ontological mapping model, and the clinical data in the virtual CIS. Finally, the output and the recommendations manually annotated by healthcare professionals were compared. In the second study (E-2), five guidelines from four different medical domains were analyzed; and we confirmed whether the abstract concepts in those guidelines were successfully represented in our ontological model.

III. Results

(A) The ontological model

Fig.2 shows our ontological model for mapping between abstract concepts necessary to execute CIGs and primitive concepts determined by Japanese Standard Terminologies and CEN13606 RM. The "Mapping" classes, playing the most important roles in the model, were developed for both element mappings and element-value mappings, which used different mapping relationships we introduced in II-(B).

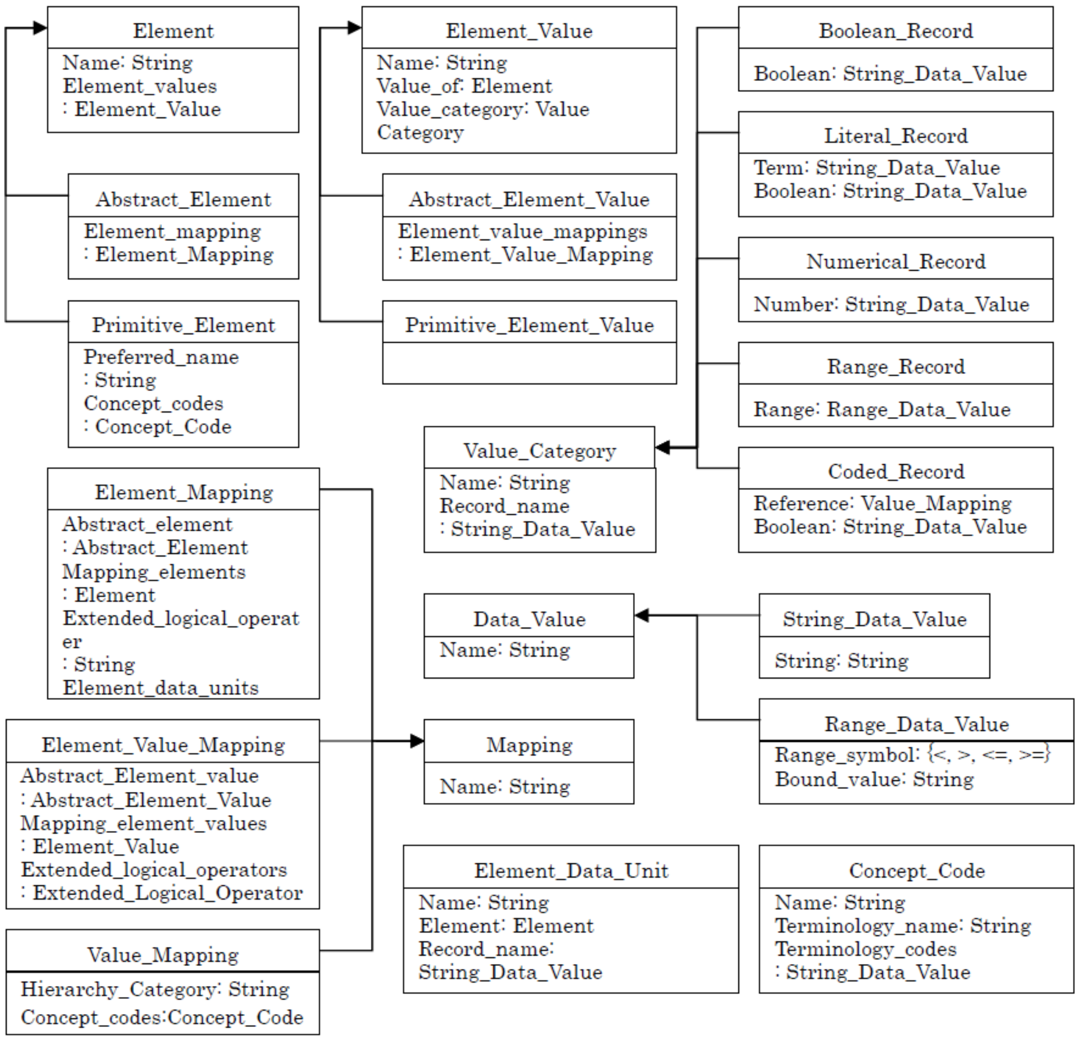

Fig. 2: The main classes of the ontological model.

(B) Results of evaluation studies

The runtime functions of the integrated system were illustrated in Fig. 3. The results of the validation study (E-1) were: (1) we succeeded retrieving clinical data from the CIS and implementing two guideline cases ('Hypertension' and 'Acute Pancreatitis') via mappings represented in the ontological model; (2) we found that recommendations derived from the integrated system were totally identical to those acquired from the healthcare professionals.

As for the evaluation study (E-2), we confirmed that our framework is efficient to represent mappings of other guidelines, and some abstract concepts and mappings can be shared among multiple guidelines. The sharing of guideline knowledge clearly indicates that these concepts and mappings can be reused and ease the guideline encoding process.

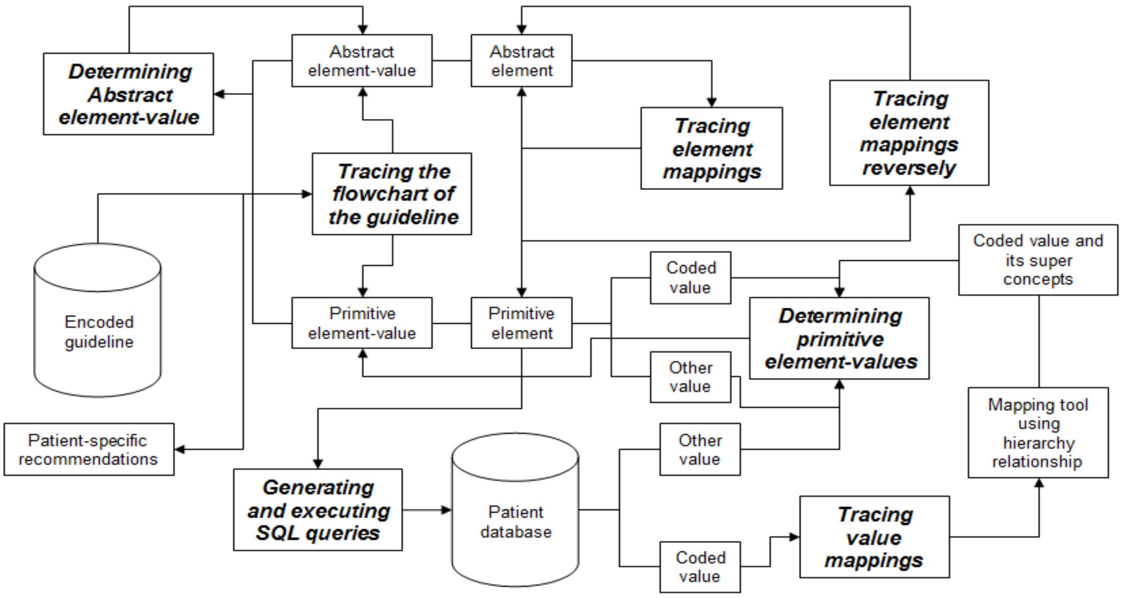

Fig. 3: The functions needed for runtime execution of the ontological model.

IV. Discussion

With development of the ontological model, the concept mapping is separated from guideline encoding and definition of institutional CIS data fields. Hence, guideline encoders can use more concepts, especially those highly readable and close to the language that healthcare professionals widely use in their routine practices; it becomes possible for the specialist who is familiar with medical expertise but is not familiar with architecture of institutional CISs, such as a medical doctor or a biomedical scientist, to accomplish the mapping task.

Substantial efforts have been made for mapping between CIG concepts and CIS data so far; however, our framework has advanced by now more than any other related works.

For example, the SAGE project, developed mainly by Stanford University, provides a methodology and infrastructure for guideline representation and implementation. It uses some standard information model (HL7 RIM, a standard reference information model in the U.S.) and reference terminologies (SNOMED-CT, etc.) to determine its virtual standard medical record; however, they did not provide any mapping function via definitions of abstract concepts, so the guideline encoders have to use syntactic notation (e.g. Arden Syntax) in order to represent abstract concepts using reference terminologies, which sometimes causes redundant expressions and much burden on encoders. In our project, we can use our ontological model to define abstract concepts in CIGs even if they are not included in the reference terminologies, and can also reuse them for encoding other guidelines.

There are also several researches that tried to fulfill the mapping capabilities, but most of them did not support definitions of abstract concepts. Exceptionally, Knowledge-Data Ontological Mapper (KDOM), developed by Peleg et al in 2008, is a mapping ontology representing definitions of abstract concepts for mappings between CIG concepts and CIS data, almost in the same way as our framework; however, compared to HL7 RIM and its recommended database schema adopted by KDOM, Japanese Standard Terminologies and CEN13606 RM we used to determine the primitive concepts can define concepts more widely from most medical domains. Additionally, Japanese Standard Terminologies are considered to be linked to extended ontologies that will define concepts in a simple way in the near future. Therefore, our approach has the advantages of expressiveness and expandability of required medical primitive concepts.

There are several limitations in our work. For example, we investigated only five guidelines to evaluate our model. With more guidelines are to be encoded and more abstract concepts are to be mapped, more mapping patterns will be identified and represented. Another limitation is that Japanese Standard Terminologies are still under development. At the present time, they are not sufficient for encoding CIG abstract concepts. Moreover, this study did not include the mapping between primitive concepts and institutional data; however, our mapping framework would simplify the mapping work that system engineers in each institution should do.

V. Conclusion

Separation of mapping process and determination of primitive elements enable CIGs independent of institutional CISs and shared between them. Our ontological model's capability for definitions of abstract concepts and necessary relationships simplifies guideline encoding and improves CIG sharing. The evaluation studies for validation of the model and confirmation of its suitability were performed successfully.