Ontology Development for Type II Diabetes Mellitus Clinical Support System

Nopphadol Chalortham¹, Marut Buranarach² and Thepchai Supnithi²

¹Department of Health-Related Informatics of Pharmacy, Silpakorn University
Amphoe Mueang, Nakorn Pathom, Thailand 73000
{nopphadol}@su.ac.th

²Nation Electrics and Computer Technology Center (NECTEC)
112 Thailand Science Park, Phahon Yothin Rd, Klong Luang, Pathumthani, Thailand 12120
{marut.bur,thepchai.sup}@nectec.or.th

Abstract

Diabetes mellitus becomes a serious problem in most countries. A continuous plan and management for DM patients to control the blood glucose level and to monitor progress of DM’s complications becomes an important issue. We proposed an ontology-based development for clinical information system which enables health providers who are non-experts in Diabetes disease can suggest patients the essential activities for improving life quality and achieving goals of DM treatment. In this paper, we mainly focus on the ontology development process for Type II DM. There are three main steps, 1) domain and scope setting, 2) important terms acquisition, classes and class hierarchy conceptualization and 3) instances instantiation. We show an example of using reminding system which developed based on our ontology.

1 Introduction

Diabetes mellitus (DM) has been a serious health problem in Thailand for many years. It is a chronic disorder characterized by hyperglycemia and associated with major abnormalities in the metabolism of carbohydrate, fat, and protein. Moreover, it is accompanied by a marked propensity to develop relatively specific forms of renal, ocular, neurologic, and premature cardiovascular disease. DM therapy requires a continuous plan and management for DM patients to control the blood glucose level and to monitor progress of DM’s complications.

DMS DD system is clinical information developed by the endocrine Society of Thailand and Institute of Medical Research and Technology Assessment, Department of Medical Services, Ministry of Public Health. Most of users are health providers, non-experts in Diabetes disease, who can not apply information to suggest patients the essential activities for improving life quality and achieving goals of DM treatment. Clinical support system is the information system that supports decision-making activities. It is aimed to assist health providers compile useful information to remind activities for achieving diabetes treatment plan.

Since it is necessary to bridge gaps between Diabetes expert and providers, defining knowledge explicitly is the important part of clinical support system. Ontology, a knowledge systematization, is suitable to conceptual knowledge because it shares common understanding of the structure of information among people or software agents. In addition, it is reusable for domain knowledge, able to make domain assumptions explicit, and to separate domain knowledge from operation knowledge and analyze domain knowledge. (Noy, N.F., Mcguinnes, D.L., 2001)

In this paper, we present Diabetes Mellitus Ontology based on Diabetes Mellitus Clinical Practice Guideline 2008 and suggestion of medical experts. This is the most crucial part in our developed clinical support system. DM ontology covers four main tasks: risk assessment/screening, diagnosis and complications, treatment, and follow-up. We analyze the step-by-step process to develop DM ontology and show some examples on using the ontology.

2 Review Literatures

There are several attempts to develop Diabetes related ontology. Yuval Shahar et al. develop a general method called knowledge-based temporal-abstraction (KBTA) and focused on representation for reuse and share knowledge. (Y. Shahar, A.K. Das, S.W. Tu, F.M. Kraemer and M.A. Musen, 1994) Gajun et al. developed an ontology-driven for multi-agent system and apply to diabetes management as a case study. They provided
communication among three agents, specialist agent, patient agent and WWW agent. (Gajun Ganendrun, Quynh-Nhu Tran, Pronab Ganguly, Predeep Ray and Graham Low, 2002)

Yu Lin defined the ontology of glucose metabolism disorder (OGMD) in 2008. (Yu Lin and Norihiro sakamoto, 2008) It is applied with the ontology of Geographical regions (OGR) and the Ontology of Genetic Susceptibility Factor (OGSF) for describing the genetic susceptibility factors to Diabetes Mellitus. Ontology of glucose metabolism disorder includes the disease names, phenotype and their classifications involved in glucose metabolism disorder. Diabetes Mellitus is a concept in this ontology as shown in figure 1.

Marut et al. introduced the overview of chronic disease healthcare framework. They pointed out the important on applying ontology for healthcare knowledge management system. (Marut Buranarach, Thepchai Supnithi, Nopphadol Chalotham, Patcharee Varasai, Khunthong and Asanee Kawtrakul, 2009) However, existing ontology did not pay attention to important concepts in reminding activities, such as assessment, diagnosis, treatment and follow-up activities. Therefore, we define a new DM ontology including above concepts for implementing clinical support system.

3 System Architecture

Figure 2 shows architecture of clinical support system. It consists of two subsystems: clinical information system and reminding system. Clinical information systems are built for manipulating the information of patient records and cooperate with reminding system for suggesting activities to enable patients to take care of their DM treatment plan. The main objective of this system is to help patients control their blood glucose level and to keep close watch on progress of DM’s complications such as retinopathy, nephropathy, neuropathy and foot diabetes. Knowledge base in reminding system is represented in model instances that mapped patient database to DM ontology. It was built based on Diabetes Mellitus Clinical Practice Guideline 2008 and suggestion of medical experts. Reminding system is alerted when a patient can not follow the treatment, such as overdue complication examination period, risk blood glucose level, etc. Moreover reminding system can provide the suitable information based on the reminded condition.
4 Ontology Development

DM ontology is developed from the perspective of activities for health providers. DM ontology is designed based on 1) Diabetes Mellitus Clinical Practice Guideline 2008 (CPG) of the Endocrine Society of Thailand (Endocrine Society of Thailand, 2008) which is a document with the aim of guiding decisions and criteria regarding diagnosis, management, and treatment in Diabetes Mellitus and 2) discussions with physicians to verify correctness. As Natalya F. Noy and Deborah L. McGuinness said “there is no correct way or methodology for developing Ontologies and ontology development is necessarily an iterative process”. (Noy, N.F., McGuinness, D.L., 2001) In our framework, the development process of DM ontology is based on the following steps.

4.1 Step1: Setting the Scope of DM Ontology

There are mainly two approaches to define scope of DM ontology, bottom up approach and top-down approach. Bottom-up approach starts from investigating patient’s record, such as OPD card. This method is powerful in terms of implicit knowledge acquisition, but it consumes heavy workload. Moreover, the evidence of information is not significant. Top-down approach applies existing information based on expert which enable us to easily gather all concepts. However it might not be covered all specific concepts. We decide to use top-down approaches by using CPG as a reference. Our scope is limited to Type II DM and four main related complications, which are, retinopathy, neuropathy, nephropathy and foot diabetes.

4.2 Step2: Enumeration Important Terms, Defining the Classes and Class Hierarchy

In this step, we list up all important terms from CPG guideline and then conceptualize into concepts and relations among concepts to define related classes and class hierarchy. Hozo-ontology editor (Kouji Kozaki, Yoshinobu Kitamura, Mitsuru Ikeda, and Riichiro Mizoguchi., 2002) is a tool for developing DM ontology. Figure 3 illustrates an example of defining class and class hierarchy. Class is defined based on basic relations, part-of relation and attribute-of relation. Patient card class which contains patient record is defined by three concepts, Person class, Status class and VisitingActivity class. Surname, firstname, birthday, gender and family history are attributes defined in the Person class. Status class is a class that shows the DM and complications diagnosing results for all visiting. VisitingActivity class contains activities of each visiting as follow:

- Sign and symptom from patient.
- Treatment activities such as medication, procedure (e.g. amputation).
- Assessment activities which are verified by a physician such as examinations, sign and symptoms.
- Follow-up activities such as eye examination within next three months.
• Status that shows DM and complications diagnosis of each visiting.
• Date attribute

We apply is-a relation to define class hierarchy as shown in figure 4. In this Figure, class hierarchy of examination is explained. We divide examination class into four groups: physical examination, radiograph, electrograph and clinical laboratory examinations. Physical examination is the process that a health care provider inquires signs of disease from patient’s body, such as temperature, blood pressure and heart rate.
Radiography applies X-rays to capture image of internal organs. Electrophograph uses electromagnetic to monitor organ mechanisms into wave form such as Electrocardiogram (ECG) which is used to monitor heart rhythm. Clinical laboratory examination is a human specimen examination in laboratory room. Currently, DM ontology has approximately 220 concepts that have been defined.

4.3 Step3: Creating instances

There are two methods in creating instances. First method is to use model editor (instance editor) which is an engine provided by Hozo environment, especially for model instantiation.

Figure 5 shows example on using model editor to develop instance. Figure 6 represents a framework for applying database information based on ontology. The second method is mapping the existing information to ontology, normally mapping the existing date in database into model. This is suitable for organization where database are possibly provided. Since our collaborative hospital collect patients’ data into database. We apply the second method in creating model instances. The patient database and DM ontology are mapped to create model instances. Several ontology applications apply programming interface, such as Jena and Jastor API, in this step.
5 Application based on DM ontology: Reminding system

We developed an ontology-based clinical support system to remind and recommend the useful information for hospital providers. Providers are able to search each patient’s treatment history. Figure 7 shows all patients’ remind, regarding to blood glucose level, blood pressure, retinopathy, neuropathy and foot diabetes. Fig 8 illustrates patient’s individual information. Remind information is displayed in red and yellow.

Figure 7 All Patients’ Remind

Figure 8 Pop-up for Reminding

Figure 9 Parent’s individual information

Figure 10 Reminding Information

10, reminded information is displayed at the top rightmost in red area.

6 Conclusion and Future works

In this paper, we presented our ontology-based clinical support system, especially focused on ontology development process. We give an example to apply ontology into reminding system. Ontology can be developed based on three main steps, 1) domain and scope setting, 2) important terms acquisition classes and class hierarchy conceptualization and 2) instances instantiation. In the future, we plan to develop a feedback framework to acquire implicit know-
knowledge from physician, nurse, pharmacist and providers to develop suitable criteria for reminding and recommending useful information to patient.

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