November-December 2019
ISSN: 0193-4120 Page No. 666 - 671

Semantic Knowledge Management for Herbal Medicines Used in Primary Health Care

Nattapong Kaewboonma[1], Wirapong Chansanam[2], Panupong Puttarak[3], Thanakorn Damsud[4]

[1] Faculty of Management Technology, Rajamangala University of Technology Srivijaya, nattapong.k@rmutsv.ac.th
[2] Faculty of Humanities and Social Sciences, KhonKaen University, wirach@kku.ac.th
[3] Faculty of Pharmaceutical Sciences, Prince of Songkla University, panupong.p@psu.ac.th
[4] Faculty of Science and Technology, Rajamangala University of Technology Srivijaya, thanakorn.d@rmutsv.ac.th

Article Info
Volume 81
Page Number: 666 - 671
Publication Issue:
November-December 2019

Article History
Article Received: *3 January 2019*
Revised: *25 March 2019*
Accepted: *28 July 2019*
Publication: *25 November 2019*

Abstract

The use of medicinal plants or herbal medicines for the treatment of common and minor diseases and symptoms has been a part of culture and way of life. Semantic Web technologies enable people to create data stores on the Web, build vocabularies, and write rules for handling data. Ontologies provide a shared and common understanding of a domain that can be communicated across people and application. In this study, we propose the herbal medicines used in primary health care ontology. The ontology was developed by using the Hozo, which is an ontology editor environment. The process of ontology development of this research are 2 phases. Phases 1: Domain analysis for knowledge organization approach and Phase 2: Ontology life cycle for an evolutionary approach. The Concepts of Herbal Medicines classes can be divided into 6 concepts. These include Habit, UseTheRightParts, Taste, HealthProblem, MethodForPreparation, and PartsUsed. The consequently developed ontology will serve to be highly useful for the development of ontology-based recommendation system.

Keywords: *Semantic Web, Ontology, Knowledge Management, Herbal Medicines, Health Care*

1. Introduction

Nowadays, herbal medicines are increasingly popular among consumers. This is because they are cheaper and have less side effects than modern drugs which are made from chemical synthesis. As a result, pharmaceutical companies in many countries are becoming interested in herbs study and research in order to produce medicines and health supplements [1].In the area of primary health care, Ministry of Public Health use herbs as single herbs for medical treatment and food. People in various communities and in remote areas can effectively apply the knowledge of the use of herbs in their daily lives based on the principle of "Primary health care belongs to the people, service by the people for the people".

Herbs used for primary health care are selected to promote health and treat diseases with basic symptoms. The selection is based on the efficiency and safety corresponding to the knowledge and resources as well as the local environment of the community. The herbs must be well known and easy for people to make their own medicines. However, the utmost caution is required since negligence may lead to life-threatening consequences which may affect the effectiveness of the treatment or become toxic or cause unpleasant symptoms [2].The use of herbs in primary health care is promoted and published to treat common diseases or basic symptoms since many herbs are vegetables regularly consumed in most households. Herbs are used to treat the following diseases; 1) gastrointestinal tract disease, 2) respiratory tract disease, 3) urinary tract infection, 4) skin diseases, and 5) other diseases [3].In order to alleviate illnesses and

strengthen health conditions, it is essential to consider the safety of consumers and the right usage of herbs. Therefore, knowledge is required to be able to use herbs properly which will help people to take care of themselves and others.

Today, knowledge management is very important. It helps to transfer and use knowledge efficiently. Web technology plays a key role in knowledge management by enabling knowledge sharing and transfer. Semantic Knowledge Management is a form of deep knowledge management which aims to apply domain knowledge in computer programs for automatic intelligent processing. This form of knowledge management is crucial for the development of Semantic Web Technology which will be the web technology form in the next generation or Web 3.0. It sets the direction and standard of semantic knowledge to develop and store knowledge in the form of ontology. This will allow knowledge exchange and sharing via automatic web processing for further useful application [4].

According to the importance described above, the research team will apply the concept of semantic knowledge management for the use of herbs in primary health care in order to develop an ontology. However, this research has different scope of research and development of ontologies than other previous research. Its objective is to develop an ontologies based on the idea of herbal usage recommendation such as using the right herbal for the right disease with the right dose and dosage instructions as well as indicating herbs' properties, dose and dosage instructions step by step. In the future, this study aspires that the consequently developed ontology will serve to be useful for the development of ontology-based recommender system for herbal medicines used in primary health care in the subsequent research.

2. Related Work

According to the related study and literature review, there are the studies of herbs used in the primary health care such as the research on herbs used in the primary health care on the website [5] is the research and development aiming to develop herbs database for the primary health care on the website. The development processes are conducted by collecting data and pictures of herbs used in the primary health care in a total of 62 types and designing the database search into 4 channels which are 1) search from herbs reports, 2) search from pictures or names of herbs, 3) search from diseases or symptoms and 4) search from key words.

The study of knowledge base development for computer programs or ontologies, it is found that there is the development of Thai herbs knowledge base by using ontology technique [6]. This study aims to develop Thai Herbal Medicine Ontology (THMO) and Semantic Search System. The findings show that THMO consists of 323 concepts. The 10 main concepts are Formulation, Indication, Adverse Reaction, Finished Product Form, Herb Material, Clinical Warning, Taste, Tri-That, Health Problem and Use Methods. The validity of THMO was evaluated by eight professional experts. The experts' opinions in general strongly agreed with THMO regarding 4 evaluation items: Scope identification, Classes identification, Properties identification, and Correctness and Reusability of the ontology. The semantic search THMO application was found to improve the efficiency of information query by excluding non-relevant information items during query answering process.

Furthermore, Izumi *et al*. [7] proposed an ontology-based advice system for health and exercise. To provide an advice to the user who has a goal accomplished by an exercise, He used an ontology about health and exercise in two basic rules to recommend an appropriate exercise based on the goal and not to recommend an exercise based on the health condition. In this ontology, his findings defined 6 main concepts: Person, Goal, Health Data, Health Advice, Exercise, and Effect of Exercise. In the inference for advice, he presented 2 basic IF-THEN type of inference rules. One is for the recommendation of an appropriate exercise based on the user's goal, and the other is for the non-recommendation of a harmful exercise based on the user's health condition.

The research on an ontology based knowledge preservation model for Traditional Unani Medicines by Amjad et al. [8] focused on conceptual structure of Unani medicines by presenting domain ontology which includes core principles and philosophy of Unani medicines, diseases, symptoms, diagnosis, drugs, and treatment. Knowledge about fundamentals is captured from expert interviews and books and then this knowledge is converted into ontologies using Protégé.

3. Materials and Methods

Material: Hozo ontology editor, developed by the Institute of Scientific and Industrial Research, Osaka University, Japan [9]; Ontology Application Management (OAM), developed by the Language and Semantic Technology Laboratory, National Electrics and Computer Technology Center (NECTEC) [10].

Methods: The ontology development for herbal medicines used in primary health care used an ontology editing tool, Hozo. Hozo is java-based graphical editor especially created to produce heavy-weight and well thought out ontologies, from Osaka University. The features of Hozo support the role representation and visualization of ontology schema based on knowledge domain. Ontology can be exported from Hozo to the OWL (Web Ontology Language) format, which is the standard language for creating ontology. The process of ontology development of this research are 2 phases.

Phases 1: Domain analysis for knowledge organization approach [11].

Concerting:1.1) Survey and selection of existing resources on herbal medicine for primary health care.1.2) Content analysis of the herbal medicine for primary health care. 1.3) Organizing of the herbal medicine for

November-December 2019
ISSN: 0193-4120 Page No. 666 - 671

primary health care using the domain analytic approach. 1.4) Clarification and modification of herbal medicine for primary health care by consulting with domain experts.

Phase 2: Ontology life cycle for an evolutionary approach [12].

Developing: Setting the scope, Enumerate terms, Defining the class and class Hierarchy, Creating instances, and implementation and Evaluation of ontologies.

Manipulating: After being built, the ontology could be browsed, searched, or operated, which are the activities supported in the manipulating stage.

Maintaining: Finally, in the maintenance stage, ontology engineers should be able to analyze syntactically and lexically the ontology and add, remove, or modify the ontology definitions.

4. Results

In the study, the herbal medicines used in primary health care ontology was developed using Hozo, which is an ontology editor environment. Congruently, the scope of the ontology development was focused on the idea of herb usage recommendation such as using the right herb for the right disease with the right dose and dosage instructions as well as indicating herbs' properties, dose and dosage instructions step by step.

The Concepts of Herbal Medicines classes can be divided into 6 concepts. These include "Habit", "UseTheRightParts", "Taste", "HealthProblem", "MethodForPreparation", and "PartsUsed". Also, one interesting aspect of the Herbal Medicines class hierarchy is the *is-a* relation of 5 important sub-class ("DigestiveSystem", "RespiratorySystem", "UrinarySystem", "SkinDisease", and "OtherProblems" (Figure 1).

The ontology was revealed in the study to consist of classes and properties that describe:

1. Use the right plants: Some herbs have several local names or one local name may represent different kinds of herbs in different regions. To ensure that the right plants are used, herbs are referred by their scientific names.
2. Use the right parts: Different parts of plants such as root, rhizome, leaf, flower, fruit, trunk, or bark have different efficacy.
3. Use the right dose: This is about the proper preparation and the correct amount of herbs used.
4. Method for preparation: It is important to know how to prepare each herbal medicines; for example, whether they must be fresh or dehydrated, taken by eating or applying to skin, prepared by boiling or soaking in alcohol or mixing with water.
5. Warnings and precautions: Users need to know the precautions concerning their health conditions and side effects which may occur.

The relations are found to consist of several types, including hierarchical relations such as, '*is-a'*, '*part-of*' and '*attribute-of*'. We specifically address these three formal relations in the study to indicate the specialization of the concept and sub-concept. For example, The *Part-of* relation: UseTheRightPlant,UseTheRightParts,UseTheRightDose, MethodForPreparation, WarningAndPrecautions, and HealthTips are sub-classes of the Recommendations class (Figure 2) and the *Part-of* relation: "Recommendations", "HerbalMedicinesInformation" are sub-classes of the HealthProblem class (Figure 3).

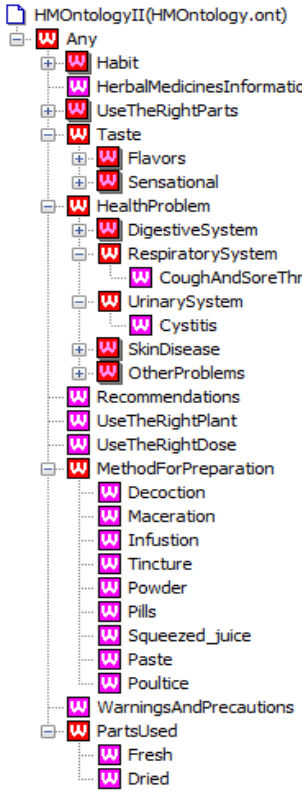

Figure 1. Class hierarchy of 'Herbal Medicines' class.

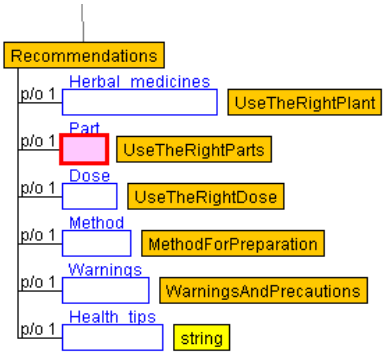

Figure 2. The hierarchical relations of the 'UseTheRightParts' class.

November-December 2019
ISSN: 0193-4120 Page No. 666 - 671

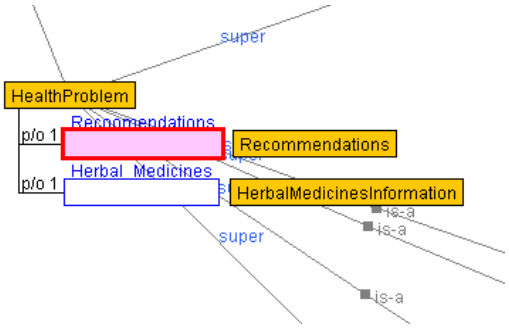

Figure 3. The hierarchical relations of the 'HealthProblem' class.

The relations are found to consist of several types, including hierarchical relations such as, '*is-a'*, '*part-of*' and '*attribute-of*'. We specifically address these three formal relations in the study to indicate the specialization of the concept and sub-concept. For example, The *Part-of* relation: UseTheRightPlant, UseTheRightParts, UseTheRightDose, MethodForPreparation, WarningAndPrecautions, and HealthTips are sub-classes of the Recommendations class (Figure 2) and the *Part-of* relation: "Recommendations", "HerbalMedicinesInformation" are sub-classes of the HealthProblem class (Figure 3).The *is-a* relation: Roots are sub-class of Root and Subterranean stem and also sub-class of UseTheRightParts concept (Figure 4).

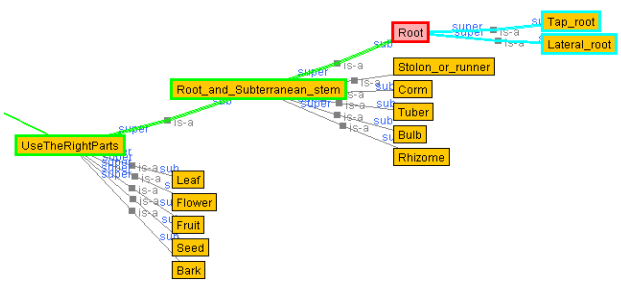

Figure 4: Class hierarchy of the 'UseTheRightParts' class

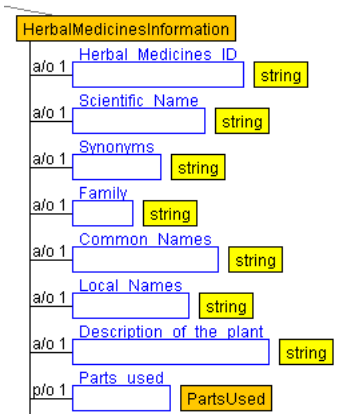

Figure 5:Properties of HerbalMedicinesInformation class

In addition, a class of "HerbalMedicines Information" is defined as a main class in the ontology with defined properties, i.e., HerbalMedicinesID, ScientificName, Synonyms, Family, CommonNames, LocalNames, and so on. Other main classes, as revealed in the study include the PartsUsed, Habit, Taste, HealthProblem, and Recommendations class, which show an association with the HerbalMedicinesInformation class as shown in properties of ontology: In OWL there are two kinds of properties. ObjectProperty, which related an object to other objects (Figure 5).

5. Thai Herbal Medicine Ontology Evaluation

All evaluation methods described above were applied to evaluate Thai Herbal Medicine Ontology. Evaluation results are showed below.

Verification

Ontology Taxonomy Evaluation.The method gave following results:

• Inconsistency : Circularity errors – no errors;Partition errors – no errors during final evaluation, classes Roots, initially subclasses of Root, were transferred to be subclasses of UseTheRightParts after the model was developed and classified because Thai Herbal Medicine can have concrete individuals; Semantic errors – no errors.

• Incompleteness: Incomplete concept classification – all concepts from knowledge sources were included into ontology;Partition errors – no errors.

• Redundancy: Grammatical redundancy – no errors;Identical formal definition of some classes (with a different name) – no errors;Identical formal definition of some instances (with a different name) – in domain ontology there are no instances.

Heuristics: *OntOlogy Pitfall Scanner OOPS![13]:*

Besides the theoretical guidance, there are other glitches in ontology developing. Rector *et al*. [14] described early works aimed at identifying typical modeling mistakes in OWL, which moved onward to the notion of "anti-patterns" of the 'don't do this' variation, and a developing catalog of pitfalls of which 41 can be scanned automatically online with the OntOlogy Pitfall Scanner! (OOPS!). All restrictions that have to be complied, except the last one, were checked automatically. They can also be checked manually, as was necessary for the last restriction. Both checks showed that all restrictions were satisfied, which was expected after taxonomy evaluation. Figure 6 shows obtained results.

November-December 2019
ISSN: 0193-4120 Page No. 666 - 671

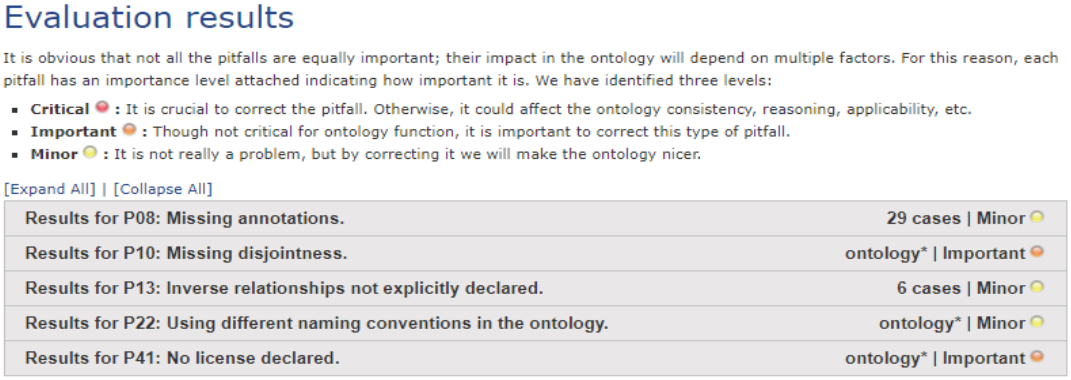

Figure 6: Deriving common pitfalls appearing with the OntOlogy Pitfall Scanner! (OOPS!)

An evaluation of the presence of those 5 pitfalls showed that it does not make much difference. It may well be that the notion of a good quality ontology is not tightly related to absence of pitfalls, or maybe the modeling pitfalls are propagated from the well-known ones by knowledge engineers; it is productive ground for research. However, the ontology can be scanned quickly with OOPS! and the results provides indicators where the ontology may be enhanced.

Validation

Since validation refers to the real world, it requires ontology content evaluation. But this also means that it should be checked on the real world example, with concrete application ontology. Therefore, authors suggest two, also independent, methods for validation: an application ontology building and Ontology content evaluation [15, 16, and 17].

Application Ontology

Since the original ontology represented domain ontology without instances, concrete ontology for herbal medicines at primary health care center in Songkhla, Ministry of Public Health was created. For that purpose several adjustments through the whole ontology had to be made both to the:Formal model: 6 new definitions for 6 new main classes were created;5 existing definitions were altered in a way that new classes are added into definitions where necessary; Ontology: 11 new classes with attributes were added to the taxonomy at the lowest hierarchy level;23 new attributes were added to existing classes;1 class changed from concrete (can have individuals) to abstract (cannot have individuals) because of new classes;3 new axioms were added. Into adjusted ontology concrete instances were successfully added. Domain experts, members of Faculty of Pharmaceutical Sciences, Prince of Songkla University, Songkla, Thailand, most involved in new studies concept design helped during the construction and approved obtained results.

Ontology Content Evaluation

Content evaluation was performed both on domain and application ontology, with the following results:Consistency –ontology is reliable individually (regarding informal and formal definitions) and no opposing knowledge can be inferred from all axioms and definitions:Completeness –as regards information from knowledge sources, ontology is complete, but since legal documents possibly have unclearness, there is a possibility that even application ontology is not complete.Conciseness –any unnecessary concepts does not contain into ontology. On the other side, complete and detailed definition of a formal model has caused implicit redundancies (some concept definitions can be inferred from others). Consequently ontology is not compact.Expandability –application ontology development showed that concept hierarchy does not have to be significantly changed. Reformation of model definitions did not influence on their meaning nor did new axioms not influence on other axioms and classes. Most of new restrictions are made very simply with new attributes. As a result ontology is simply expandable.Sensitiveness –as already stated in expandability, small changes in definitions of several concepts did not change the set of well-defined concepts, so ontology is not sensitive.

6. Discussion and Conclusions

This paper presents the study on herbal medicines used in primary health care that organized semantic knowledge in the herbal medicines by using domain analysis for knowledge organization approach and ontology life cycle for an evolutionary approach. The main concepts of the ontology are comprised of 6 concepts. These include ‘Habit’, ‘UseTheRightParts’, ‘Taste’, ‘HealthProblem’, ‘MethodForPreparation’, and ‘PartsUsed’. Therefore, the results may not be similar to the existing ontologies such as Thai Herbal Medicine Ontology (THMO) based on the practices and theories of Thai traditional medicine as well as the local communities. This study finding is also different, this study focuses on using the right herbal for the right disease with the right dose and dosage instructions as well as indicating herbs’ properties, dose and dosage instructions step by step.

November-December 2019
ISSN: 0193-4120 Page No. 666 - 671

In future work, we plan to implement this ontology for applying semantic knowledge of herbal medicines used in primary health care on recommendation system.

Acknowledgement

This work was supported by Faculty of Management Technology, Rajamangala University of Technology Srivijaya, Thailand.

References

[1] Food and Drug Administration. Sustainable Development for Thai Herb. *Med. & Herb*, 2(5), pp. 6-9, 2015.

[2] Khaokham, S., Taneeruttana, T., and Payogo, P. (2017). The Use of Herbal Medicine by the Buddha's Permission for Primary Health Care. *Journal of MCU Peace Studies*, 5(2), pp. 237-249, May-August, 2017.

[3] Faculty of Medicine Siriraj Hospital. *Herbal Medicines Used in Primary Health Care*. Available from: http://www1.si.mahidol.ac.th/km/sites/default/files/82_1.pdf , 2006.

[4] Buranarach, M., and Supnithi, T. *Semantic-based Knowledge Management*. Available from: http://text.hlt.nectec.or.th/ontology/content/what-is-semantic-km, 2010.

[5] Jatuporn, P., Thaipakdee, S., and Muanmalai, S. Thai Herb for Primary Health Care on Website. *Sripatum Chonburi Journal*, 11(2), pp. 83-91, 2015.

[6] Tungkwampian, W., Theerarungchaisri, A., and Buranarach, M. (2015). Development of Thai herbal medicine knowledge base using ontology technique. *The Thai Journal of Pharmaceutical Sciences*, 39(3), pp. 102-109, July-September, 2015.

[7] Izumi, S., Kuriyama, D., Itabashi, G., Togashi, A., Kato, Y., and Takahashi, K. An Ontology-based Advice System for Health and Exercise. *Proceedings of the 10th IASTED International Conference on Internet and Multimedia Systems and Applications*, pp. 95-100, 2006.

[8] Amjad, S., Waheed, T., Enriquez, A.M.M., Aslam, M., Syed, A. An Ontology Based Knowledge Preservation Model for Traditional Unani Medicines. Brain Informatics and Health, BIH 2014.*Lecture Notes in Computer Science*, 8609, pp. 278-289, 2014.

[9] Kozaki, K., Sunagawa, E., Kitamura, Y., and Mizoguchi, R. *Distributed Construction of Ontologies Using Hozo*. Available from: http://www2007.org/workshops/paper-19.pdf , 2007.

[10] Buranarach M., Thein Y.M., Supnithi T. A Community-Driven Approach to Development of an Ontology-Based Application Management Framework. Semantic Technology, JIST 2012. *Lecture Notes in Computer Science*, 7774, pp. 306-312, 2012.

[11] Smiraglia, R. *Domain Analysis for Knowledge Organization: Tools for Ontology Extraction*. Chandos Publishing, 2015.

[12] Kayed, A., Robert M., and Colomb, R.M. Extracting ontological concepts for tendering conceptual structures. *Data & Knowledge Engineering*, 40(1), pp. 71-89, 2002.

[13] Poveda-Villalón M., Suárez-Figueroa M.C., Gómez-Pérez A. Did You Validate Your Ontology? OOPS!. The Semantic Web: ESWC 2012 Satellite Events. ESWC 2012. *Lecture Notes in Computer Science*, 7540, pp. 402-407, 2015.

[14] Rector A. et al. OWL Pizzas: Practical Experience of Teaching OWL-DL: Common Errors & Common Patterns. Engineering Knowledge in the Age of the Semantic Web. EKAW 2004. *Lecture Notes in Computer Science*, 3257, pp.63-81, 2004.

[15] Gómez-Pérez, A. Guidelines to Verify Completeness and Consistency in Ontologies. *Proceedings of the 3rd world congress on expert systems*, Seoul, South Korea, pp. 901-908, 1996.

[16] Gómez-Pérez, A. Evaluation of Ontologies, *International Journal of Intelligent Systems*, 16, Chichester, UK, pp. 391-409, 2001.

[17] Staab, S., & Studer, R. Handbook on Ontologies, Springer-Verlag, pp. 293-313, 2009. Berlin, Germany.