International Journal of Engineering & Technology, 7 (4.19) (2018) 476-480

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

The Ontology of Food and Nutrition System for Pre-School

PuriwatLertkrai[1], NattapongKaewboonma[2], JutapornLertkrai[3]

Department of Information Systems, Faculty of Management Technology,
Rajamangala University of Technology Srivijaya
**Corresponding Author Email: [1]puriwat.l@rmutsv.ac.th*

Abstract

Nutrition is very important for pre-school children age 1-5 years. At this age, they grow too fast both with body and brain. Structural damages in the body and brain may result if children are underweight or obese. In this research, we propose an ontology development of food and nutrition for ore-school that aims to assist pre-school in daily diet selections based on Thai foods menus and nutrition guidelines. This research reused existing ontologies and resources to present the ontology modeling and rules-based that focus on Thai pre-school. The methodology of this research can be summarized into four major states; data collection, ontology development, rules-based development, and evaluation. The eight main classes of this ontology are Body Mass Index (BMI) levels, Thai foods menus, Food energy levels, and knowledge base for providing the recommendation based on BMI level for Thai pre-school. In addition, the evaluation result from domain experts ensured that this ontology and rules-based can be used in Thai food menu recommendation system for Thai pre-school.

Keywords*: *Pre-School; Thai Food Menu; BMI; Ontology Development.

1. Introduction

One of the domain ontology is the foods and nutrition. It is one of the main world's problems, also in Thailand. Nutrition is very important for pre-school children aged 1-5 years, because in this span of age the children are growing too fast with both brain and body [1, 2]. Underweight or Obesity can be caused by several factors such as; Parenting, Gastrointestinal disease, Neuropathy, Heart disease, Lung disease, Kidney disease and so on [3]. So, children who have underweight or obesity problems acquire direct structural damage in their brain and body. In Thailand, approximately 10% of children under 5 years of age have mild to moderate undernutrition, and it is a group of children whose mother is not educated. There will be 20% of children. Meanwhile, 10% of children under 5 years of age have obesity and are highly likely among children over the age of 18 months. In addition, Children in the south tend to lack nutrients over children in other parts of Thailand [3]. Normally, foods are prepared by the parents. Thus, if the foods are suitable for children it can improve children's health status.

The Semantic Web is a mesh of information linked up in such a way as to be easily processed by machines, on a global scale that can give a value added to application content. Semantic Web can help the knowledge sharing process to get easier than traditional ways because the knowledge-based has resided within the head of the expert [4]. So, the semantic web is the solution that can solve this problem by maintaining the content of knowledge-based.

Ontology is the one of technologies for semantic web technology development. Ontology is a model to represent Resource Description Framework (RDF) and OWL in The WWW Consortium (W3C) standard.

The reason for the popularity of ontology is being used widely that they provide researcher who wants to share information in a specific knowledge domain and common understanding of some domain which can be communicated between people and computer [5]. Researchers also built ontology in food and nutrition domain [4], [6]-[8], the majority was aimed to nutrition, foods, foods calorie.

In this research, we propose a new ontology modeling and rules-based focus on Thai foods menus energy levels that is divided into 3 groups [9]; Low calories, Medium calories and High calories including BMI levels for Thai children [10] to children's health status classification and recommend Thai foods menus that are suitable for Thai Pre-School [11].

2. Related Work

Currently, several researchers have been a widespread interest in the ontology development and ontology-based recommendation system that developed and implemented in foods and nutrition domain. Suksom et al. [6] was developed the ontology for personalized and nutrition recommendation system that aims to assist the users in a daily diet based on some nutrition guidelines. The main components of the system are: 1) User personal profiles with illnesses such as: obesity, diabetes, high blood pressure, and so on, 2) Food with nutrition, and 3) Nutrition database and knowledge base. This recommendation system use inferred rules for recommending food items specifically for different illness and ages. Therefore, this system is good comparing to human experts. In a prototype of nutrition expert system, Hazman&Idrees [7] was developed a prototype healthy nutrition expert system for children that aim to provide its user to determine the suitable nutrition plan with healthy meals for children in different ages, according to different criteria including their growth state, gender, health status and activity level. The expert system follows the Common KASD methodology to classify that knowledge are considered in the proposed system is based on different nutrition resources. Children nutrition problem solving by three models, these are "Age

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stage Model" that determines growth state including Toddler, Preschool, and Grade school, "Calculate Needed Calories" determine gender and activity, and "Determine Meals Schedule" determine food group, Food unit calories, Needed Food Group Unit and Meal schedule. The other ontology model based on fact according to Sari et al. [4] was developed pediatric nutrition ontology based on the fact. Generally, one in four children aged under 5 years in the worldwide has poor nutritional status and under nutrition. This pediatric nutrition ontology has six main classes. They are Nutrient, Nutrient Function, Malnutrition, Malnutrition Caution, Food, and Person. This prototype application in this research was built to evaluate the ontology model and has two main querying features, which are SPARQL Mode and Quick Search Mode. The validation result of expert indicates that this ontology model can be used in an application in conformity with the pediatric nutrition science. Lastly, the study of Arwan et al. [8] proposed diabetic food recommendation using ontology and semantic matching called Weight Tree Similarity to increase the sense of semantic search in the system. This system using the Body Mass Index (BMI), patient activities, and calorie intake per day to classify patient's health status and daily calorie needs. In ontology domain build using Protégé including patient data, foods with information from nutrition experts, and food calorie that consists of information of diabetic patients and the number of calories of foods. List of food menus could help patients with diabetes to control their blood sugar level depending on the number of daily calories needs that setting the menu list can be done by foods ontology.

3. Materials

In this study, we have reviewed existing resources on nutrition status and Thai food menu for pre-school children. The key resources were selection including: Pediatric outpatient (2nd Edition) [1] and Family Nutrition (4th Edition) [2] to design rules-based. The BMI Level for Thai Children [10], the nutrition status [9] and sample recipes for pre-schoolers [11] are shown in Tables 1 and 2.

Table 1: BMI Level for Classified Nutrition Status for Thai Children [10]

Nutrition Status	BMI
Underweight	
Mild degree	14.5-13.0
Moderate degree	13.0-11.5
Severe degree	<11.5
Normal	14.5-18.0
Overweight	18.0-19.5
Obesity	
Mild degree	19.5-21.0
Moderate degree	21.0-22.5
Severe degree	>22.5

Table 2: Example Thai Food Menu for Children [9], [11]

Thai Foods Menus	Kcal.	<٢٠٠ Kcal.	200-300 Kcal.	>300 Kcal.
		Low	*Medium*	*High*
Apple Fired Rice	357			●
Braised Fish Maw in Red Gravy	334			●
Canned Fish American Fried Rice	298		●	
Chicken Soup	202		●	
Crab Meat Fried Rice	229		●	
Deep Fried Tilapia with Tomato Sauce	113	●		
Egg Tofu Soup	121	●		
Ham Korokke	256		●	
Korokke	164	●		
Minced Fish Ball Fried	239		●	
Minced Pork and Winter Melon Soup	112	●		
Noodles with Fish Curry (KhanomJeenNamya)	229		●	
Pad Thai	298		●	
Pork stewed and Eggs Boiled in the gravy	163	●		
Soy Sauce Fired Rice	280		●	
Steamed Snapper with Soy Sauce	61	●		
Suki Dry Noodles	209		●	
Thai Chicken and Rice (Khao Man Gai)	296		●	
Tomyam Seafood Soup	40	●		

4. Methods

This section describes how ontology can be developed and interacted with knowledge management system. The methodology of this research can be summarized for developing ontologies around four major steps. They are data collection, ontology development, rules-based development, and evaluation as described below.

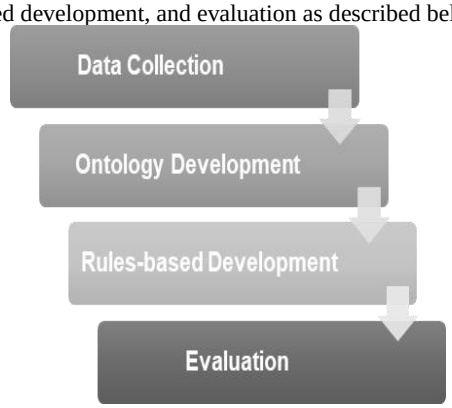


Fig. 1: Methodology

4.1. Data Collection

The first step, we have reviewed existing resources on pre-school, Thai foods menus, food calories level, nutrition, BMI level, and food ontologies, In addition we had interviewed domain experts who is a paediatrician and nutritionist working in a hospital developing ontology and rules-based.

4.2. Ontology Development

In this step, we have built the ontology with HOZO Ontology Editor [12]. The major steps for development ontology are: setting the scope, consider to reuse existing ontologies, enumerating important terms, defining the class, class hierarchy, instants creation, and implementation. The ontology was built to define classes, subclass, properties and hierarchical relations such as '*is-a'*, '*part-of*' and *'attribute-of'* [13].

1) Classes or Subclass of ontology: Class can be defined with OWL: Class element. For example, we can define a class BMI Level as follows:

```
<owl:Classrdf:ID="BMI_Level">
        <rdfs:label>BMI_Level</rdfs:label>
        <rdfs:subClassOfrdf:resource="#Any"/>
</owl:Class>
<owl:Classrdf:ID="Obesity">
        <rdfs:label>Obesity</rdfs:label>
        <rdfs:subClassOfrdf:resource="#BMI_Level" />
</owl:Class>
```

2) Properties of ontology: In OWL there are two kinds of properties. Object properties, which relate an object to other ob-

jects. Examples of Object properties with OWL are as follows:

```
<owl:ObjectPropertyrdf:ID="has_Energy_Level">
        <rdfs:subPropertyOfrdf:resource="#hasPart" />
        <rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
<owl:ObjectPropertyrdf:ID="has_process">
<rdfs:subPropertyOfrdf:resource="#hasPart" />
<rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
```

3) Data type properties relate objects to data type values. For example, we can define the Object data type properties as follows:

```
<owl:ObjectPropertyrdf:ID="has_fat_Amont">
        <rdfs:subPropertyOfrdf:resource="#hasAttribute" />
        <rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
<owl:ObjectPropertyrdf:ID="has_protein_Amont">
        <rdfs:subPropertyOfrdf:resource="#hasAttribute" />
        <rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
<owl:ObjectPropertyrdf:ID="has_carbohydrate_Amont">
        <rdfs:subPropertyOfrdf:resource="#hasAttribute" />
        <rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
<owl:ObjectPropertyrdf:ID="has_calories_Amont">
        <rdfs:subPropertyOfrdf:resource="#hasAttribute" />
        <rdfs:domainrdf:resource="#Food_Menu" />
</owl:ObjectProperty>
```

4.3. Rules Development

Rules in the ontology for recommending Thai foods menus appropriate to the physical condition and suitable foods for pre-school from domain experts and existing resources for pre-school[1], [2], [9], [11]. The rules created are formatted as IF-THEN follows IF (antecedent) THEN (consequent). In addition, a set of rule bases by Semantic Web Rule Language (SWRL) is designed to apply for knowledge inference (W3C).

4.4. Evaluation

The final step aims to ensure the ontology model created in this research has already been corrected [14]. This evaluation will be conducted by domain experts.

5. Result

5.1. Ontology Model

The Ontology model in this research was developed and focused on Thai Food menu and BMI levels with 8 main classes, there are person, food menu, BMI level, meal, food process, food energy level, complications, and goal recommend as shown in Figure 2.

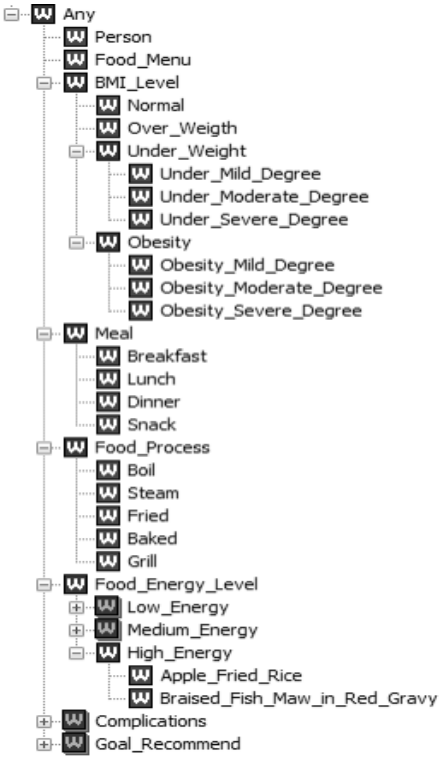


Fig. 2: Class Hierarchy of Ontology Model

This research suggests that Thai food menu suitable for Thai preschool should be based on the BMI level. In a class of "BMI_Level", we apply the 'is-a' relations to define class hierarchy of BMI Level that can be divided into ٤ levels [10]; normal, underweight, overweight, and obese as shown in Figure3.

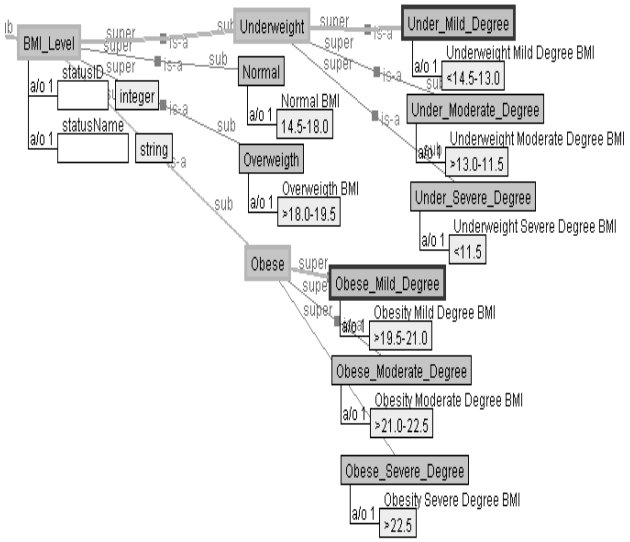


Fig. 3: Class Hierarchy of BMI Level

In a class of "Food_Menu" is defined as a main class in this ontology with defined properties, i.e., food_ID, food_Name, fat_Amont, protein_Amont, carbohydrate_Amont and calories_Amont with 'attribute-of' relation. In addition, a class of "Food_Menu" that is concerned about food energy level and food process, we applied the 'part-of' relation to define class properties linked with classes of "Meal", "Food_ Process", and "Food_Energy_Level" as shown in Figure 4.

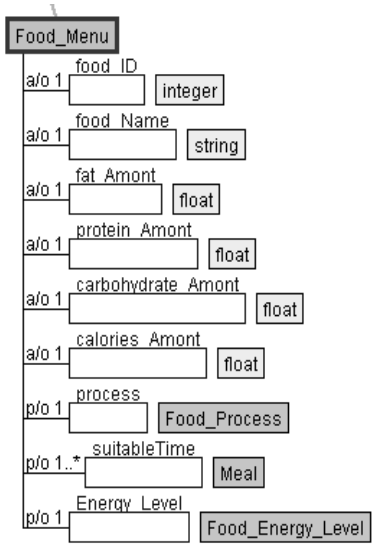


Fig. 4: Class Properties of Food Menu

In a class of "Food_Process", we applied the 'is-a' relation to define class hierarchy such as boil, steam, fried, baked and grill as show in Figure 5.

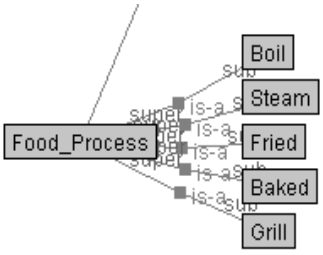


Fig. 5: Class Hierarchy of Food Process

According to a class of "Food Energy Level" can be divided into 3 levels [9] with 'is-a' relation including less than 200 kcal is a class of "Low Energy", 200 -300 kcal is a class of "Medium Energy" and more than 300 kcal is a class of "High_ Energy". For example, Apple Fired Rice and Braided Fish Maw in Red Gravy are Thai food menu high in calories as shown in Figure 6.

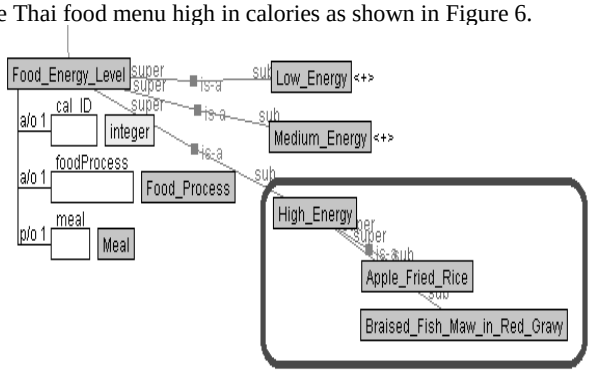


Fig. 6: Class Hierarchy of Food Energy Level

5.2 Rules-Based

In this section, we provided rules-based to automated data classification. Knowledge from existing resources and domain experts were used in building rules-based. The sample rules-based can be described as shown in Table 3.

Table 3: Example Rule-Based for Thai Foods Menu Recommendation

Natural Language : IF child has BMI = 20.0 (according to Obesity mild degree) THEN Thai food menu that suitable for child is Thai food menu that process by boil and has low energy
Rules: IF-THEN	IF Person(BMI) = "19.5-21.0" THEN Person(BMI_Level) = "Obesity_Mild_Degree" IF Person(BMI_Level) = "Obesity_Mild_Degree" THEN FoodMenu(Process) = "Boil" AND Food-Menu(Food_Energy_Level)= "Low energy IF FoodMenu(Process) = "Boil" AND Food-Menu(Food_Energy_Level) = "Low energy" THEN Food-Menu?
Rules: SWRL	Person(?x1) ^ float[>=19.5,<=21.0](?BMI) ^ hasBMI(?x1,?BMI) →hasBMI_Level(?x1, "Obesity Mild Degree") Person(?x1) ^ hasBMI_Level(?x1, "Obesity Mild Degree") →FoodProcess(?x,"Boil") ^ FoodEnergyLevel(?x, "Low energy") FoodMenu(?x) ^ hasFoodPorcess(?x, ?process) ^ swrlb:equal(?process, "Boil") ^ hasFoodEnergyLevel(?x, ?energylevel) ^ swrlb:equal(?energylevel,"Low energy") →sqwrl:select("Food name", ?x, "has food process", ?process, "has energy level", ?energylevel)
Natural Language : IF child has BMI = 13.5 (according to Underweight mild degree) THEN Thai food menu that suitable for child is Thai food menu that process by fried, grill and has High energy	
Rules: IF-THEN	IF Person(BMI) = "13.0-14.5" THEN Person(BMI_Level) = "Under_Mild_Degree" IF Person(BMI_Level) = "Under_Mild_Degree" THEN Food-Menu(Process) = "Fried, Grill" AND Food-Menu(Food_Energy_Level)= "High energy" IF FoodMenu(Process) = "Fried, Grill" AND Food-Menu(Food_Energy_Level) = "High energy" THEN Food-Menu?
Rules: SWRL	Person(?x1) ^ float[>=13.0,<=14.5](?BMI) ^ hasBMI(?x1,?BMI) → hasBMI_Level(?x1, "Underweight Mild Degree") Person(?x1) ^ hasBMI_Level(?x1, "Obesity Mild Degree") →FoodProcess(?x,"Boil") ^ FoodEnergyLevel(?x, "Low energy") FoodMenu(?x) ^ hasFoodPorcess(?x, ?process) ^ swrlb:equal(?process, "Boil") ^ swrlb:equal(?process, "Grill") ^ hasFoodEnergyLevel(?x, ?energylevel) ^ swrlb:equal(?energylevel,"Low energy") → sqwrl:select("Food name", ?x, "has food process", ?process, "has energy level", ?energylevel)

In addition, the health conditions of the children were also of main concern. Health status such as underweight and obese results to complications thus parents are advised to have their child/children be treated by a pediatrician specializing in nutrition. For example, rules-based can described as shown in Table 4.

Table 4: Example Rule-Based for recommendation with complication

Natural Language : IF the child has BMI less than 11.5 and with deep eyes or sunken cheeks, parents should consult with a Pediatrician and Nutritionist	
Rules: IF-THEN	IF Person(BMI) = "<11.5" THEN Person(BMI_Level) = "Underweight Severe Degree" IF Person(BMI_Level) = "Underweight Severe Degree" and Person(Complication) = "deep eye, sunken cheeks" THEN Person(goal Recommend) = "Consult with Pediatrician Special-

	ty and Nutritionist”
Rules: SWRL	Person(?x1) ^ hasBMI(?x1, ?x2) ^ swrlb:lessthan(?x2, 11.5) → hasBMI_Level(?x1, “Underweight Severe Degree”) Person(?x1) ^ hasBMI_Level(?x1, “Underweight Severe Degree”) ^ hasComplications(?x1, ?x2) ^ Complications(?x2) ^ swrl:equal(?x2, “deepe eye”) ^ swrl:equal(?x2, “sunken cheeks”) → hasGoal_Recommend(?x1, “Consult with Pediatrician Specialty and Nutritionist”)

5.3. Evaluation

The evaluation is conducted by three domain experts using criteria included the quality and appropriateness of the following items: defining the scope, objective, classes and sub-class, properties, instances, and future application. The evaluation result was high quality level at 89.25% and suitable for developing recommendation system.

6. Conclusion

Food and nutrition ontologies have been developed [4], [6]-[8]. However, food energy levels and BMI between adult and children are different [9]. Consequently, in this research we focused on Thai Pre-school with BMI to classify Thai children's health status [10] and selected Thai food menu that specify and suitable for preschool only [11] to guide parents in selecting Thai food menu for children with different level of BMI.

In conclusion, we present our Food and Nutrition ontology model, specifically focused on ontology development process. The ontology was developed by using HOZO Ontology Editor. In this ontology modeling, we reused classes from existing ontologies such as person, meal, process, and food [4], [6]-[8], and proposed new classes “BMI_Level” for class Children's health status [10] and “Food_Energy_Level” to energy levels classification of a class of “Foods_Menu”. This ontology was developed by applying “is-a” relation and “part-of” relation to define the class hierarchy and provide rules-based to data automated classification. For future work, we will use this ontology and rules-based to promote the future development of Food and Nutrition Recommendation System for Thai Pre-School by using Ontology Application Management Framework (OAM) [15].

Acknowledgement

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

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