Ontology-Driven Personalized Food and Nutrition Planning System for the Elderly

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ABSTRACT
Life expectancy for the Thai population has increased in recent decades, and at the same time the birth is decreasing steadily. This creates problems for health care and treatment of the elderly, since there are not as many younger people around to take care of them. The Thai Government is initiating campaigns for the dissemination of knowledge and practices of appropriate nutrition and life style, e.g. physical exercise, for the elderly.

In this paper, we describe the development and design of a personalized nutrition and food planning system for older people that uses a food-oriented ontology together with an expert system. The expert system harnesses the food ontology to derive meals that are suitable according to the personal conditions of the old age user.

Key Words: Elderly, Personalized, Food and Nutrition, Ontology, Expert System

1. Introduction
The world population is rapidly increasing, and due to growing health and medical care this is also the case for the elderly. Old people have limited regenerative abilities and are more prone to disease, syndromes, and sickness than other adults. In addition, their bodies also produce less sex hormone which results in the accumulation of body fat or not eating a full nutritional benefit, which also may cause nutritional based diseases. Among the diseases that older people often suffer from are hypertension, diabetes, osteoarthritis, osteoporosis, heart disease, and enlarged prostate.

Geriatrics is a sub-specialty of internal medicine and family medicine that focuses on health care of elderly people. It aims to promote health by preventing and treating diseases and disabilities in older adults. To prevent diseases among older people several government-sponsored measures have been discussed and recommended: vaccination, annual health checks, especially of typical medical conditions that affect the elderly, and medical preventative treatment, of course. Moreover, older people can also affect their health in a positive way by such activities as physical exercises, use of appropriate (healthy) food with the right amount, and avoidance of overstrain of their bodies.

Using good nutrition can cause the body to function normally and can help fit the body weight. It also prevents and mitigates diseases, especially when they have to recover from an illness. If the body is good nutrition can reduce the negative effects of the illness causes the body to recover faster. In general, the elderly need less power than younger people. Therefore, they have to take into account the foods that contain nutrients appropriate to their physical condition of the elderly should avoid certain foods that do not appropriate.

To help old people use appropriate nutrition, we have developed a personalized food and nutrition planning system for the elderly on the basis of a food-oriented ontology for the management of knowledge about food and nutrition. Moreover, we make use of an expert systems for food and nutrition planning for the elderly, which takes into account the physical condition and needs of the older people accurately and efficiently. The system has been developed for the use as a hospital service to provide food and nutrition plan for the older patients.

2. Related Work
The study's research ontology that is associated with the introduction of food and nutrition can be summarized as follows. (Snae, & Brueckner, 2008) Design and development of recommended food menu for restaurants, clinic, hospital or home. This research was led by the principles of expert systems, combined with ontology food and nutrition to help in selecting food menu for customers or consumers considering their physical and medical condition as well as their tastes related to food. The system applies the food ontology in supporting the user to search for food menu. The food classes were defined with nine major aspects including Ingredients, Availability, Nutrients, Utensils, Preparation methods, Regional cuisine, Dishes, Possibly nutrition and Price.
(Lee, Wang, Li, & Chen, 2008) Designed a food ontology for diabetes control from a nutrition support health care of diabetes patients. The ontology was developed based on some referenced nutrition guides for diabetes patients. For the food ontology 13 major classes of food types were defined including beverages, egg products, fruits, grain products, meat, milk products, etc. Some defined properties included the amount of nutrition, e.g. protein, carbohydrate, fat, vitamin, mineral, fiber, etc.

(Napat, Marut, Ye, Thepchai, & Ponrudee, 2010) Was developed to provide advice on nutrition and personalized eating properly. The food ontology and the recommender system was developed using a knowledge-based framework. The main components of the system are personal profile, food and nutrition ontology integrated with a rule-base for providing food recommendations.

Reviewing the research mentioned above no system provides suggestions for food for the elderly in particular. Also missing is a daily or weekly plan that suits older people in their favorite food and condition. This research has led to the design concept ontology food and nutrition counseling on food to appropriate physical condition and favorite food and from (Snae, & Brueckner, 2008) to adjustment to the older people appropriately. It also has a plan for nutrition per meal, day and week to appropriately control the physical condition and favorite food for the elderly in a proper and efficient way.

3. System Framework

The system framework is shown in Figure 1. The framework comprises a (1) User Interface; a (2) Food Planning System; the (3) Personal Health Record; a (4) Knowledge Base; and a (5) Database. In the following these components are described in more detail and outlined according to the intended use in system.

(1) User Interface serves to receive and display information to the user and consists of:
- Getting information from the patient or hospital staff consist patient profile (patient id or name) and food favorite (regional cuisine, favorite ingredients and disliked ingredients).
- Shown results are displayed to the user and consist of an appropriate food menu per meal, day, week and other details associated with the consumption of food to suit the patient.

(2) The Food Planning System is a sub system for planning the food menu. It starts by reading information from the food and nutrition ontology plus the personal health record (PHR) and food favorites. Then, the inference generates the food menu that is appropriate for the condition and needs of the patient. After that it processes the plan for food menu per meal, day and week appropriate for the patient.

(3) The Personal Health Record (PHR) comprises the medical data of a single patient of the hospital, with such data such name, gender, age, weight, height, blood pressure, pulse rate, chronic diseases, etc., which these information is derived from the diagnosis of a doctor.

(4) In the Knowledge Base is information of knowledge stored that is related to food and nutrition gathered from food and nutrition experts, books and other sources of reference to knowledge that can be used for the recommendation of a food menu. It consists of:
- Food and Nutrition Ontology is part of the knowledge of food and nutrition to form the ontology categories and relationships.
- Rule-Base as part of the knowledge of experts to create rules or conditions to obtain a menu of foods that appropriate the patient.

(5) Database as part to record detailed information about food and nutrition, personal profile, food favorite and health planning history.

Figure 1. System Framework
4. Design and Implementation

4.1 Ontology
Ontologies have become recognized and widely used in state-of-the-art gathering of information and intelligence, information retrieval, knowledge representation, and database management systems (Thomas, 1993). This paper uses the concept ontology from (Snae & Brueckner, 2008) in Figure 2 adapted to suit the aims of this research. We employed RDF (RDF, 2004), RDF Schema (RDF Schema, 2004) and OWL (OWL, 2004) to describe food and nutrition knowledge. These languages are proposed by W3C. We have used the Protégé ontology editor (Protégé, 1987) in order to create, expand and edit the ontology.

The ontology makes use of food specifics, such as animal-based or plant-based food, flavors, added by nutritional facts, such as vitamins, proteins, fats, carbohydrates, and so on. This information can be used to recommend food and nutrition an appropriate to the physical condition and personalized to the patient likes and dislikes.

![Figure 2. Food and Nutrition Ontology](image)

4.2 Rule-Base
The rule-based knowledge for recommending food menu appropriate to the physical condition and favorite food for patients has been gathered from food and nutrition experts and books about food and nutrition for the elderly. The rule-based system part works with the food and nutrition ontology. The rules created are formatted as IF-THEN follows IF (antecedent) THEN (Consequent).

Let us consider a scenario for the use of rules for recommending food and nutrition, as shown in Table 1.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Recommendation Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Mr. First name Last name</td>
<td>IF Patient.ChronicDisease=Hypertension</td>
</tr>
<tr>
<td>Chronic Disease: Hypertension</td>
<td>THEN Patient.RecommendedIngredientNutrition=(Low-Fat AND No-Sodium) AND</td>
</tr>
<tr>
<td>Regional Cuisine: Thai</td>
<td>Patient.RecommendedFoodFlavor=Low-Salty</td>
</tr>
<tr>
<td>Favorite Ingredient: Pork</td>
<td></td>
</tr>
</tbody>
</table>
IF Patient.RecommendedIngredientNutrition=(Low-Fat AND No-Sodium) THEN Patient.RecommendedIngredient=(Kale OR Ivy gourd OR Bitter melon OR White cabbage OR Straw mushroom)

IF Patient.RegionalCuisine=Thai AND Patient.FavoriteIngredient=Pork AND Patient.RecommendedIngredient=(Kale OR Ivy gourd OR Bitter melon OR White cabbage OR Straw mushroom) AND Patient.RecommendedFoodFlavor= Low-Salty THEN Patient.RecommendedFoodMenu=(Fried kale and pork OR Clear soup with ivy gourd and minced pork OR Clear soup of bitter gourd stuffed with pork OR Fried vegetable combination and pork OR Fried white cabbage and pork OR Sour and spicy soup straw mushroom and pork)

Table 1. Show an examples of patient situation consisting of the patient's physical condition, food favorite and the recommendation rules that applied

4.3 Food Planning System
In this section the planning process for the recommended food menu is described. It starts by reading the information from the food and nutrition ontology by JENA API (Jena, 2000). Then, using personal health records and tastes of foods the system makes inferences using JESS (JESS, 2008) with rules that have been created before. For querying the data for the food menu we use SPARQL (SPARQL, 2008) query to get the food menu appropriate to the patient's needs. Then the system builds up a plan food menu appropriate to patient for a meal, day and week and then displays the results to the user using JSP and Servlet.

The example situation for the patient in our scenario of Table 1 results in plan for food menu in Table 2 below.

Table 2. Show an example of planning food menu to appropriate the patient

5. Experimental Results
This section presents the results of the implemented Ontology-Driven Personalized Food and Nutrition Planning System for the Elderly. Figure 3 shows the screen for displaying the patient profile, health information and favorite food of the patient. In this example, a patient suffering from Hypertension, favorites Thai regional cuisine and has pork as favorite ingredient. Then the user selects the button “Show Menu” for food menu planning that creates an appropriate menu according to the physical conditions and favorite food
Figure 3. Show a screen for displaying patient profile, health information and food favorite

Then, the system displays an overview of the plan for food that is appropriate for the physical condition and food favorite (as in Figure 4). The system can plan the food menu per meal, day and week, depending on the patient. Furthermore, the user can access details about the food menu, for example energy, nutrient, ingredient, and preparation process.

Figure 4. Show the results of food planning

6. Conclusions and Future Work

This paper has shown an Ontology-Driven Personalized Food and Nutrition Planning System for the Elderly. The objective is to assist the hospital staff in planning suitable food and nutrition for older individuals by providing advice and planning on eating foods that are appropriate for the physical condition and favorite food of the elderly. The system uses a food-oriented ontology (including nutritional data) and an expert systems that accesses the ontology structure and a knowledge-base on foods and diseases.
To achieve the goals of recommending a healthier lifestyle more information on physical exercise and other activities are needed. A further area that has not been studied in this research is the automation of purchasing and inventory of food supplies for the hospital. Solving this problem would further improve the situation hospital administration.

REFERENCES


