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Developing a Nutrition and Diet Expert System Prototype

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Abstract

This research paper aims to present the development of an expert system prototype on nutrition and diet domain using rules-based system technique. The knowledge engineering process started by eliciting knowledge from domain experts from nutrition department in a local university and experts' recommended websites. To build the logic for this expert system, the knowledge is organized as inputs – middle (through if-then statements and decision tables) and outputs. The system is then captured in machine language using e2go freeware rule-based shell. After the development of the nutrition and diet prototype expert system, the system has been verified by the experts. In addition, the system had been evaluated by potential users to assess its benefits and limitations. The users identified several benefits of the use of nutrition and diet the expert system prototype and provided some recommendations.

Keywords: Nutrition, Expert System, Benefits, Knowledge, Nutrition Expert System

Introduction

Nutrition is getting food into the body for growth and energy, and for keeping the body healthy and living (Nordqvist, 2009). It also includes the environmental, psychological and behavioral aspects of food and eating. Nutrition focuses on how to protect the body from disease by healthy diet. There are seven major classes of nutrients: carbohydrates, fats, minerals, protein, vitamins, fiber and water (Nordqvist, 2009; Wikipedia, 2013). These nutrient classes can be classified as either macronutrients, which needed in relatively large amounts, or micronutrients, which needed in smaller quantities. The macronutrients include carbohydrates, fats, protein, fiber, and water; whereas the micronutrients include minerals and vitamins. Carbohydrates and proteins supply 17 kJ approximately (4 kcal) of energy per gram, while fats provide 37 kJ (9 kcal) per gram. Vitamins, minerals, fiber, and water do not provide energy, but are vital for other reasons. Most food contains a mixture of all or some of the seven nutrient classes. Not enough or too much of a nutrient, or some nutrients may result in poor health (Nordqvist, 2009).

Most of people gain knowledge nowadays through the use of technology including artificial intelligence technologies. Artificial Intelligence (AI) aims to develop systems which exhibit 'intelligent' human-like behavior (Anjane, 1998; Becerra-Fernandez et al., 2004). Expert systems, a type of AI technologies, encode human expertise in specific domains by using If-Then rules, and accordingly advise and provide solutions to different problems (Becerra-Fernandez et al., 2004); the five components of expert system are user interface, working memory, knowledge base, inference engine and explanation system.

A nutrition expert system helps people to evaluate their nutrition status and conditions and accordingly provides them with nutrition and diet advises. Moreover, it will help people to save their time as they will not need to visit the doctor to evaluate their nutrition conditions. The general idea of the nutrition expert system is asking users many questions related to age, weight, height, gender, and exercise time and type, and accordingly advise them. Knowledge acquisition in any domain including nutrition is not an easy process. The process requires expertise and experience, and may inherent calculation errors (Horn et al., 2002). Also, experts are often unable to express explicitly their reasoning process (Becerra-Fernandez et al., 2004; Duan and Edwards, 2005; Khan and Hoffmann 2003). This difficulty is considered "a major challenge in developing an ES capable of providing accurate and timely diagnosis" (Duan and Edwards, 2005, p804). Another difficulty that

the system developers may face is the need to continuously update the knowledge base of the expert system.

Nevertheless, in domains where knowledge is well established, the development of an expert system offers many benefits to people such as increased timeliness, increased productivity of experts, improved consistency in decisions, improved understanding, and improved management of uncertainty and formalization of knowledge (Marakas, 2003). In nutrition support, the main benefits of expert system are substantial time savings for people and clinicians and an improved quality of care; an expert system's ease of use, robustness, integration, and the maintainability by the clinical experts are the main factors for its success (Horn et al., 2002). Also this kind of system is required particularly in view of large rural population with no access to medical help (Ramachandran et al., 1992).

There are a number of nutrition expert systems reported in the literature; the first one is called "The Nutrition Diet Program" (NDP) which is developed to help the rural population who can't find dietician or the medical doctor near them. This system provides a customized diet plan for patients; the system prepares this plan based on the many details provided by the user (Ramachandran et al., 1992). Another expert system is for "Nutrition Counseling and Menu Management"; this program makes menu planning and manages the eating habit (Hong and Kim, 2005). The third one is a "Nutrition Diagnosis Expert System" that utilizes "Nutritional Care Process and Model (NCPM)", which is "defined by American Dietetic Association (ADA) in 2008 and integrate the nutrition diagnosis knowledge from dietetics professionals to establish the basics of building the rule based expert system with its knowledge base" (Chen et al., 2012, p. 2132). The system is built using Microsoft Visual Studio 2008.

In Oman, as any other developing country, health and nutrition is a major challenge. People awareness of the importance of nutrition to avoid many health problems is still not high; thus, the objective of this developed prototype expert system is to improve people awareness about nutrition by consolidating knowledge from human experts and well established websites, and accordingly advise them. This developed expert system not only captures knowledge but also apply it.

Expert System Prototype Development

System Objective

The objective of this developed nutrition and diet expert system is to help people to evaluate their nutrition condition and to know their neediness of the type of food and required time to do exercising each day. Moreover, the system provides advices about healthy food and the rate of protein, vitamins, and calcium they have to eat. Also, the system provides advices about sport for different conditions. Accordingly the developed system improves people awareness about the importance of nutrition, reduces consultation time and makes people care more about their health. This developed prototype nutrition expert system provides advice only for healthy people, not for unhealthy people and pregnant and lactating women.

Knowledge Elicitation Process

There are many ways to elicit knowledge from experts. The performance of the expert systems depends upon the reliability, validity and accuracy of the elicited knowledge (Becerra-Fernandez et al., 2004). Many knowledge elicitation techniques have been used to obtain the required knowledge for the development of an expert system. The main technique that we apply is the interview. The most popular elicitation technique used for extracting knowledge from a human expert was structured interviews (Becerra-Fernandez et al, 2004; Tehrani, 1991). We interviewed an expert in nutrition from Food Science and Nutrition department in a local university. We asked her many questions about the nutrition and related topics; she provided us with many valued information and resources that helped us, the knowledge engineers, in our project. Although the interview is time consuming, it provides rich qualitative information. Furthermore, after the development of the system, we

presented the prototype expert system to other domain experts in the nutrition field and we handed them questionnaires to evaluate the system.

System Design

Inputs

The inputs are necessary for an expert system to give a diet advice for users. The developed nutrition and diet expert system advises people based on the following inputs:

- 1- What is your age "age"?
- 2- What is your gender "gender"?
- 3- What is your height "height"?
- 4- What is your weight "weight"?
- 5- Are you doing exercise "exercise"?
- 6- What is your waist circumference "waist"?

Outputs

The developed prototype nutrition and diet expert system provides the following outputs to the users :

- Body Mass Index(BMI)
- Body Status: obese, normal or under weight
- [Kcal] : Such as "you should eat 4000Kcal a day"
- [Protein] : Such as "you should eat 20-25g of protein"
- [carbohydrates] : Such as "you should eat 137-187g of"
- [fiber] : Such as "you should eat 8-20g of fiber"
- [vitamin A] : Such as "you should eat 350-500µg of vitamin A"
- [vitamin d] : Such as "you should eat 2.5-5 µg of vitamin d"
- [iron] : Such as "you should eat 5.5 mg of iron" and
- [folate] : Such as "you should eat 150-200 µg of folate"
- [Zinc] : Such as "you should eat 10 mg of Zinc"
- [calcium] : Such as "you should eat 250-400 mg of calcium"

The prototype system also provides advice on the recommended exercises and recommended food menu for:

- [Breakfast] : Such as "40 ml fruit juice ,1/4 cup oats porridge with 1 T honey,1/2 cup full cream milk"
- [Mid-morning snack] : Such as "1/2 cup yoghurt ,1/2 mashed, ripe banana"
- [Lunch]: Such as "1 boiled egg,1/2 - 1 slice whole wheat bread with 1 t polyunsaturated margarine,1/2 grated apple,1/2 cup full cream milk"
- [Mid-afternoon snack] : Such as "15 g sweet milk or Gouda cheese,1/2 slice whole wheat bread with 1 t polyunsaturated margarine,40 ml fruit juice" and
- [Supper]: Such as " 30 g cooked, mincemeat, Mashed potato 2 T,Cooked butternut 1 T,1/4 cup custard" and
- [Bed-time snack]: Such as "1/4 cup full cream milk with Ovaltine"

Middle

The expert system outputs(advice)s are different for people with different ages and genders. From a knowledge engineer perspective, a decision table is utilized to improve building the logic in the knowledge base of the expert system. A decision table is a good way to deal with combinations of

things (e.g. inputs). Decision tables provide a systematic way of stating complex business rules, which is useful for developers as well as for testers. Different decision tables are developed depending on age groups: young children (1-3 years) , 4-8 years children, adolescent male (9-13 years and 14-18 years), adolescent female (9-13 years and 14-18 years) , adults males (19-30 , 31-50 , 51-70 , and >70 years), and adults females(19-30 , 31-50 , 51-70 , and >70 years) . This categorization is recommended by the Omani guide to healthier eating by the Ministry of Health(2009). It is categorized in this way because every level of age need different requirement of nutrients . It differs from young to adults and from male to female as well .

The developed nutrition and diet expert system, first calculates the body mass index(BMI) based on this formula: $BMI = \text{weight}/\text{height}^2$. By calculating the BMI , the system concludes about the “body type”: whether the person is under weight , Normal weight , overweight or obese. Consequently, based on the concluded “Body type”, and other inputs, the expert system then advises the identified above nutrition and diet outputs.

System Development

The nutrition expert system is developed by using a freeware rule-based shell called eXpertise2Go. eXpertise2Go is a Web-based rules-based expert system. As indicated by eXpertise2Go website, the tool is goal oriented, efficient , adaptive , able to deal with uncertainty and able to explain their information requests and suggestions. The search strategy is to examine all rules that could determine the value of the current goal or sub goals . Figure 1, 2 and 3 illustrates snapshot of the developed expert system.

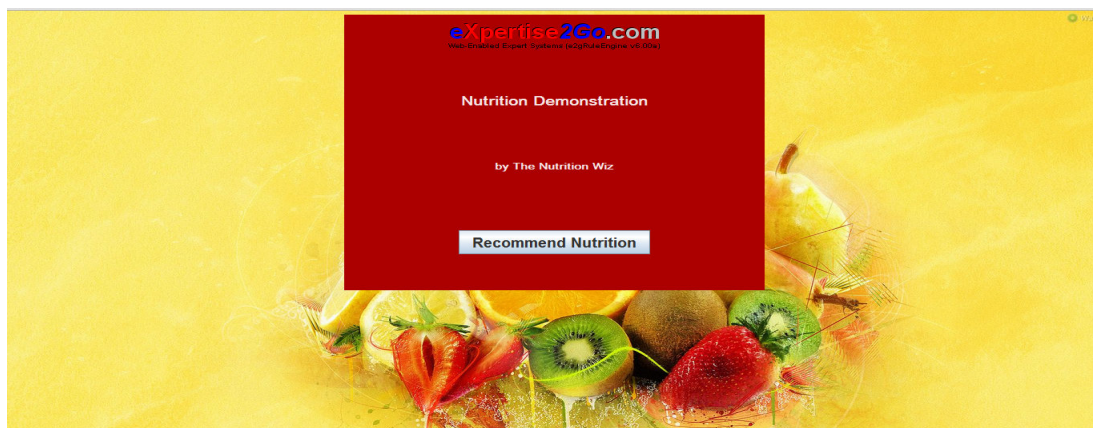


Fig 1. The main interface of the developed Nutrition and Diet Expert System

Fig2. A snapshot of requesting the weight input by the developed Expert System

Fig 3. A snapshot of the recommended outputs by developed Expert System

System Evaluation

Evaluation Method

To improve the interface and capability of the developed expert system, the system is evaluated by 15 college students, potential users; the aim of this evaluation is to identify the system's benefits and limitations. The participants are asked to try the developed nutrition and diet expert system and evaluate it by responding to a questionnaire. About 40% of those participants were male; whereas 60% were female.

Users Evaluation

About 93.33% of the participants agreed that the system is user friendly; about 86.66% of them agreed it is useful; about 86.66% of them agreed it is accurate; about 80% of them agreed it is

relevant, about 60% of them agreed it has fast response time, about 53% of them agreed it is complete, and 66.66% of them agreed that they are satisfied with it and will use it.

Table 1 illustrates the benefits of the developed nutrition and diet expert system. The users identified that the benefits of the developed nutrition and diet expert system were in order time saving (cited by 73% of respondents), helping identifying body type(46.66%), ease of use(40%), providing useful advices(33.33%), money saving(26.66%), providing quick solution(20%), more consistent services than human(20%), urges to interest the health (13.33%), direct and clear(6.66%), and availability (6.66%)

Table 1: The Benefits of the Developed Nutrition Expert System

Benefits	Percentage
save time	73.33%
help us to know the type of our body	46.66%
Easy to use	40%
Provide quicker solution	20%
Provide useful advices	33.3%
save money	26.66%
cheaper and more consistent than the services of a human expert	20%
Urges to interest the health	13.33%
Direct and clear	6.66%
expert advice available all the time	6.66%

Table 2 identifies the limitations of the developed nutrition and diet expert system based on the participating users. The finding shows that 40% of user said that the method of calculating waist circumference is unknown. About 26.66% of them indicated that the system lacks images. About 13.33% said that it is not covering everything and it's not good as having human expert in hand.

Table 2: The Limitations of the Developed Nutrition Expert System

Limitations	Percentage
The method of calculating waist circumference is unknown	40%
Boring style (no images)	26.66%
Unclear solutions	20%
Not cover everything related to nutrition	13.33%
Not as good as having human expert to hand	13.33%
Cannot be opened without Java	6.66%

Accordingly, as illustrated in Table 3, the participating users recommended the expert system to provide how the BMI is computed, make it more interesting with images, provide examples of food for each solution, and guide the users how to measure the waist circumference.

Table 3: The Recommendations for the Developed Nutrition Expert System

Recommendations	Percentage
Provide the function to how compute BMI	26.66%
Make it more interesting with images	20%
Provide example of food for each solution	20%%
Guide the user to how measure the waist circumference	13.33%

Conclusion

In conclusion, people these days are more aware of their health, they are always searching for ways to help them be healthier. The use of expert systems can improve people awareness and help them get a proper advice. Providing an expert system for Nutrition and diet advising adds value to people life

especially in developing countries. This rule-based system captures nutrition and diet knowledge from human expert and relevant websites and then presents it in if-then statements format , and provides solutions.

The developed expert system provides expertise in nutrition consulting. It offers a wide range of advices about nutrients quantity that meet the basic needs of the body; such nutrients as proteins, vitamins, fiber, and some kind of minerals. Also the system helps the users to make a decision to increase or decrease their weight by knowing their body type. Moreover nutrition system will provide you with meal plans and the foods you need to eat for your particular body type.

In addition, the system will save time instead of going to the human expert. Also the nutrition system is available all the time and can be used in any place. Our system integrates and captures the nutrition and diet knowledge and information in easy, clear, and understandable way for the users. However, the developed nutrition and diet expert system prototype had some technical and presentation limitations such as not covering everything about nutrition, some unclear solutions for average people, and lack of guidance how to measure waist circumferences . The revised expert system should fix these limitations and incorporate the several users' recommendations related to technical , knowledge, and presentation issues such as: Make it more interesting with images, provide the function to how compute BMI , provide examples of food for each solution, provide easy understandable advice for the user, identify health risk factors associated with obesity, and provide the system with other language (Arabic).

In conclusion, this paper illustrates the process of developing nutrition and diet expert system prototype and the potential benefits of developing such system.

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