The 5th IEEE International Conference on E-Health and Bioengineering - EHB 2015
Grigore T. Popa University of Medicine and Pharmacy, Iaşi, Romania, November 19-21, 2015

A Healthy Nutrition Expert System for Children

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Abstract-*Healthy food is one of the most critical aspects for the family, especially for their children as healthy diet for children results in better life including the increase of their ability to learn, exercise, and even behaving. Therefore, a need for a full support for providing the children with healthy food is a vital target to reach. In this paper, we propose a prototype for a children nutrition expert system which aim is to provide its users with the nutrition expertise. It generates healthy meals for children in different ages according to different criteria including their growth stage, gender, and their health status. A web application is developed and two case studies are applied to demonstrate how the proposed prototype can be applied for determining child's nutrition.*

Keywords: Expert system, Knowledge base system, children nutrition, E-Health.

I. INTRODUCTION

Nutrition plays an important role in maintaining human health. It provides persons by energy needed to perform different activities, and helps the body to prevent diseases. Healthy food is essential for children as it helps them to form their body in a healthy way which in turn supports them in resisting different risks that threaten their health. Therefore, having healthy food supports the children to be able to have the enough energy for their daily life [1]. As information Technology is one of the vital fields that can support providing the children with the recommended health diet which preserve the required goal. Applying different information technology methodologies usually provide a trust and exciting output for the children.

Different plans for healthy nutrition for children have been proposed [2, 3], however, a need to support these plans with the new technology is now an essential step. In [4], an expert system prototype for nutrition is proposed, however, the proposed prototype did not focus on a determined age stage. Other systems are built for elderly people nutrition such as in [5] an ontology-driven personalized food and nutrition planning system is introduced for the elderly. They aimed to help the hospital staff in planning suitable diet and provide nutrition advices for the elderly with considering their physical condition and favorite food. Also in [6], a meal planning system for elderly is proposed to overcome the malnutrition problem. According to the special needs for observing the child growth, we believe that nutrition systems with more focus on children is more beneficial.

The rest of this paper is organized as follows. Section 2, describes the main idea of the proposed expert system. Section 3,4, and 5 presents the domain knowledge layer, the inference layer, and how the inference steps are controlled which is presented by the task knowledge respectively. Case study for the proposed expert system can be found in section 6. And the final section presents the conclusion.

II. MAIN IDEA OF CHILDREN NUTRITION EXPERT SYSTEM

Expert systems can provide its user with an efficient nutrition plan in a very simple method which ensures the required satisfaction and interestingness [7]. This research presents a nutrition expert system for children that aims to support its users to determine the suitable nutrition plan for their children. This plan takes into consideration the variation of needed calories for different gender, age, and activity level. Also, it considers the child health status which affects the meals' selection.

Expert systems are usually divided into three main knowledge layers [8], they are knowledge base, inference knowledge, and task knowledge. This methodology in representing the expert system components follows the CommonKADS methodology [9]. CommonKADS is the main methodology that supports structured knowledge engineering. We also need to clarify that the knowledge that are considered in the proposed system is based on different nutrition resources such as [10, 11, and 12].

The domain knowledge layer consists of two main parts, they are: nutrition ontology and domain models. Nutrition ontology identifies the terminologies that are used in a children nutrition domain. The domain model is the expert's expressions about the domain which defines particular relations between ontology items. Inference knowledge defines the used inference steps in solving the nutrition problem. Finally, the task knowledge defines the inference steps control sequence needed to achieve the system objective. The following sections describe these three layers.

III. DOMAIN KNOWLEDGE LAYER

A. Domain Ontology

The nutrition ontology presents the main concepts of the proposed prototype which classifies the concepts and its sub-concepts. This representation preserves the main aspects of

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object oriented paradigms such as inheritance. All concepts are characterized and described with a set of attributes with all the details that describe each attribute. For example, Child concept has birthdate, growth stage, gender, and disorders attributes which are used to describe a child status.

- *Domain Model*

Domain model represents the relations between concepts separated from the control of the expert system. In the proposed system, nutrition domain models are represented in many formats which including rules, functions, and tables.

Children nutrition problem solving contains three domain models. These models are: "Age Stage Model", "Calculate Needed Calories", and "Determine Meals Schedule".

- *Age Stage Model*

This model includes *Calculate Age* and *Calculate Age Stage* relations. Calculate age is represented as a function which calculates the age of the child as a pre-step to determine his/her growth stage. Calculate age stage is represented as a relation which determines the growth stage of the child according to his/her age. The growth stages included in the prototype is: Toddler, Preschool, Gradeschool, and Teen.

- *Calculate Needed Calories*

Calculate Needed Calories is represented as a table which presents the relation between the age stage of the child and the required amount of daily needed calories according to the child's activity and gender. The used calculate needed calories knowledge is shown in table 1.

TABLE I
CALORIES NEEDED EACH DAY

gend	Age stage	Activity		
		Sedentary (calories)	Moderately (calories)	Very Active (calories)
male	Toddler	1,000–1,200	1,000–1,400	1,000–1,400
	Preschool	1,200–1,400	1,400–1,600	1,600–2,000
	Grashool1	1,200–1,400	1,400–1,600	1,600–2,000
	Grashool2	1,600–2,000	1,800–2,200	2,000–2,600
	Teen	2,000–2,400	2,400–2,800	2,800–3,200
female	Toddler	1,000	1,000–1,200	1,000–1,400
	Preschool	1,200–1,400	1,400–1,600	1,400–1,800
	Grashool1	1,200–1,400	1,400–1,600	1,400–1,800
	Grashool2	1,400–1,600	1,600–2,000	1,800–2,200
	Teen	1,800	2,000	2,400

- *Determined Meals Schedule*

Determine *Meals Schedule* model is considered the main step as its output is the main system output. This model presents a healthy diet schedule for the child according to the calculated calories amount, gender, and the required amount of each food group for the child. One of the main criteria to determine the suitable meal for the child is his/her healthy status such as diabetic children who needs special diet to avoid any consequences for the disease. It includes four relations: Determine Food Group, Food Unit Calories, Needed Food Group Unit, and Meals schedule. The Determine Food Group is represented as a set of rules which defines each food group items. There are six food groups namely: Milk, Protein, Fruit, Vegetable, Bread and cereal, and Sugar and Oil. The Food Unit Calories relation is represented as table which determines each food item calories. Needed Food Group Unit is represented as a set of rules which drives the suitable needed daily food group unites according to the child growth stage. Meals schedule is represented as a set of rules which defines each meal contains according to the child needed calories and its healthy statues.

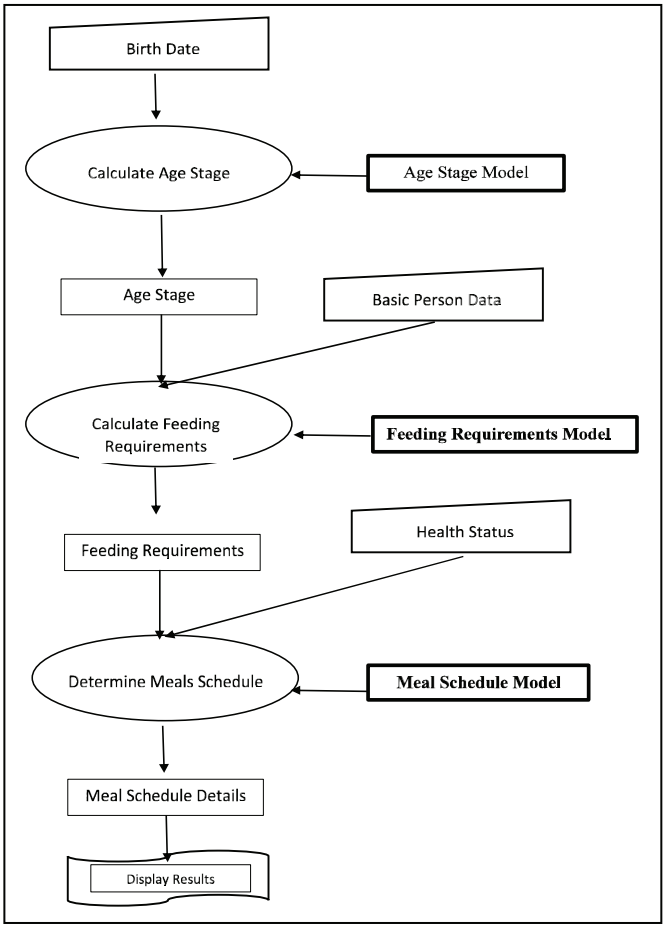

Fig. 1: Children Nutrition Inference Structure

IV. INFERENCE KNOWLEDGE

Inference Knowledge layer presents the steps for the problem-solving which applies the rules of the relations, functions, and tables which are describes in the domain model section.

As shown in Fig. 1, the inference structure contains three inference steps. These steps are: Calculate growth stage, Calculate feeding requirement and, Determine meal schedule. The following subsections describe the details of each inference role in Fig. 1 including its input parameters, output parameters, with mapping the applied part of the domain knowledge.

- *Calculate Age Stage*

The objective of the *Calculate Age Stage* inference is to determine the age stage of the child according to his birth date. This age stage is then taken into consideration in the next inference step as each age stage has its determined nutrition requirements. In addition, other personal

specifications are also considered such as the gender of the child. *Calculate Age Stage inference* derives its goal by applying the *Calculate Age* function which calculates the age of the child and a set of *Calculate Age Stage* rules that are defined in the *Age Stage Model*.

- *Calculate Feeding Requirements*

The objective of *Calculate Feeding Requirements* inference is to determine the main feeding requirements for a specific child according to the determined age stage driven in the previous inference step with the support of a number of specifications such as gender, and activity status. The main feeding requirements are defined by driven the required amount of calories. These determined requirements are then taken into consideration in producing the meals schedule for the child. *Calculate Feeding Requirements inference* derives its goal by applying the *Calculate Needed Calories* table that is defined in the *Feeding Requirements Model*.

- *Determine Meals Schedule*

The objective of *Determine Meals Schedule* inference is to determine the main goal of the system which is presenting the suitable meals schedule for the child according to the child's feeding requirements with considering the child's health status of the child is considered as well as the food unites requirements. The output of *Determine Meals Schedule* inference also depends on the knowledge demonstrating the existing description for each food group that can be part of the meal. *Determine Meals Schedule* inference derives its goal by applying a set of rules in Needed Food Group Unit and meal schedule that are defined in the *Determine Meals Schedule Model.*

V. TASK KNOWLEDGE

The goal of Task Knowledge layer is to present the control over all described inferences steps to reach the determined goal. The task includes three subtasks which are: Calculate Child Growth Stage, Calculate Child Feeding Requirements, and Determine Child Meals Schedule. The following presents the Children Nutrition Task structure.

Task: Child Nutrition,
Task-Definition:
Goal: determine the suitable meals for the child according to his/her specifications.
Input: Birth Date, Basic Person Data, Health Status
Output: Meals Schedule Details
Task-Body
Type: Composite
Subtasks: Calculate Child Age Stage, Calculate Child Feeding Requirements, Determine Child Meals Schedule
Additional-Roles:
Age Stage {Child: Age_Stage}
Feeding Requirements {Child: F_Requirements }
Control-Structure:
OBTAIN (BD: Child: Birth_Date) % from user
Calculate Child Age Stage (BD → AS: Child: Age_Stage)
OBTAIN (BPD: Child: BasicPDate) % from user
Calculate Child Feeding Requirements (AS, BPD → FR: Child: Feeding Requirements)
OBTAIN (HS: Child: HealthStatus) % from user
Determine Meals Schedule (HS, FR, FUC: Food Units calories, FGU: Food Groups Units amount → MSD: Child: Meals Schedule Details)
Display Results (BD, BPD, HS, MSD)

VI. CASE STUDY

A web application has been developed for the proposed system. The knowledge base of the proposed children nutrition expert system is implemented using the Mini Knowledge Share and Reuse tool (MiniKSR) [13], while the control of the system and the user interface were implemented by Visual Basic.Net (Microsoft Visual Studio 2010). We have applied two case studies on the developed system to determine the system accuracy in generating the suitable meal. We changed the values of the required parameters, for example in the health status parameter, one experiment was applied for a healthy child while the second was applied for a diabetic child. We then measured the accuracy of the system by reviewing the output with experts in the nutrition field who approved the generated nutrition schedule.

In this section, we will present the steps applied in the developed system showing the steps of these experiments with demonstrating the developed user interface in the presented figures.

In fig. 3, the user enters the required information for the child, they are the birth day, gender, and activity level, and the health status (if exists) such as diabetic.

In the first case, the child is a male, was born in 21/3/2010, and his activity level is moderately, with no health status that should be considered. According to this inputs, *Calculate Child Growth Stage* subtask will call *Calculate Age Stage* inference step to drive the child growth stage which is determined to be ***preschool***. Then, *Calculate Child Feeding Requirements* subtask will use the output of the previous inference step to call *Calculate Feeding Requirements* inference step which drives the needed calories based on the child age stage, gender and activity level. The minimum need calories is determined by the system to be 1400 and the maximum is 1600. Now, the *Determine Child Meals Schedule* subtask is ready to generate the suitable meal schedule.

The system determines the generated needed food unit from each food category for the presented case. Then it determines the daily food items for ***preschool*** child as shown in Table 2.

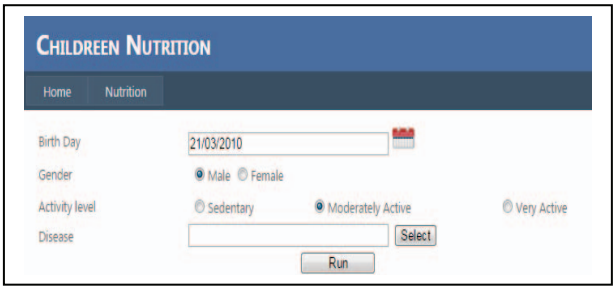

Fig. 3: Child Nutrition Interface

TABLE 2
NEEDED FOOD ITEM FOR A DAY

Food Group	Food item
Milk	cup of milk , cup of yogurt , 43 grams of cheese
Protein	57 grams of meat, cup of cooked cereal
Fruit	3/4 cup juice, a single grain of fruits quarter cup dried fruits
Vegetable	half a cup of vegetables, cup of leafy vegetables half a cup of vegetables
Bread and cereal	one slice of bread (a quarter of a loaf of Black), one slice of bread (a quarter of a loaf of Black), one slice of bread (a quarter of a loaf of Black), one slice of bread (a quarter of a loaf of Black), one slice of bread (a quarter of a loaf of Black), 30 grams beans ready to eat

Finally the system determines the meals schedule and present it to the user, as shown in Fig. 4.

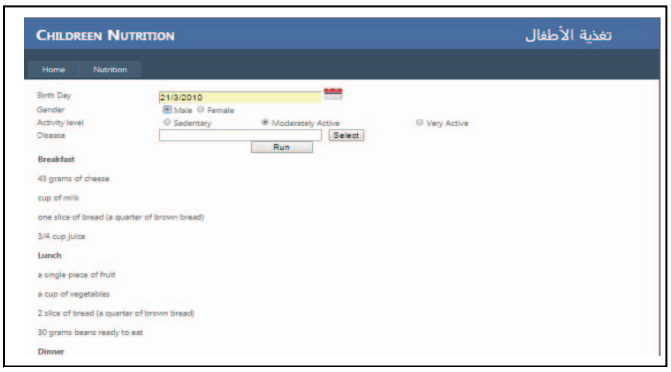

Fig 4: the meals schedule for a healthy preschool child

In the second case, the healthy status of the child is changed to be diabetic, consequently the meals schedule changed as shown in fig. 5. The meals schedule is changed to be suitable for a diabetic person. It includes three main meals and three snacks meals.

Fig 5: the meals schedule for a diabetic preschool child

In this paper, we proposed a prototype for a healthy nutrition expert system for children. The proposed system considers all age stages of the child with the target of providing a suitable daily diet. This daily diet is given according to determined criteria such as gender, age, health status. A case study is presented to prove the accuracy and applicability of the system. However, validating the knowledge for the proposed system and completing the knowledge base are two of the main future directions. Since, the proposed prototype is a first step towards a complete expert system for a broader target which is providing a whole nutrition plan for children with explanation facilities and different varieties of food based on their preferences. We also aim to include more than one plan for the child status to provide more varieties considering different situations such as the family financial level. Moreover, we aim to provide bilingual interface (English and Arabic) for more population to the presented system to serve different levels of families including education level and financial level.

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