Sci. J. Fac. Sci. Minufia Univ., 2007, Vol. XXI, 57-64

AN INTELLIGENT SYSTEM FOR DESIGNING HEALTHY MEALS

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ABSTRACT

This paper concerns with a system acts as dietitian for designing healthy meals. The work of the dietitian is very hard, complicated and takes a lot of time and effort. The problem is how to build a system that can solve the diet problem. So our system will save a lot of time and effort such that the result will be near or exact the Dietary Reference Intake (DRI). We applied our system on a case study for example under supervision of experts in nutrition, and the designed meal is accepted by them.

INTRODUCTION

At the beginning we have to explain the meaning of designing healthy meals, which is *"designing a meal such that its components are suitable for the need of a certain person with least cost"*. The food consists of primary components (for example Carbohydrate, Protein, Iron and Vitamins...etc) and every person has different needs of these components, moreover these needs differ from one person to another. For example, the needs of builders differ from the needs of employees and also differ from the needs of the children. These needs are constant factors, and depend on the age, height, sex, and the kind of activity that the person is doing. With these needs we have a suitable DRI for what the person will take?

Thus we want to put the suitable quantities of food (such as boiled rice, boiled red meat and green salad.... etc), which with its analysis meets the most favorable DRI for this person. With these constrains we designed a system that acts as dietitian for designing healthy meals.

This paper is organized as follows: section two introduces the problem statement. Section three summaries a survey of the previous work in the field of designing dietitian systems. Section four concerns with our system for designing healthy meals and the used techniques to find the solution. Section five presents a result of the designed meal. Finally, we demonstrate the conclusion and future work in section six.

Problem statement

To build a system that solves diet problem and find the cheapest combination of foods that will satisfy all the daily nutritional requirements of a person. The problem can be formulated as a programming problem where the objective function is to minimize the cost and meet the constraints, which require that nutritional needs must be satisfied. We include constraints that regulate the number of calories and amounts of vitamins, minerals, fats, sodium, and cholesterol in the diet.

PREVIOUS WORK

There are many techniques used in designing meals. After our analysis, we found that the best three traditional tools are NutriBase IV Clinical v.4.71. [6], Food Processor VII v.7. [3] and Nutritionist Pro v.1.2. [4]. Also, there are an artificial intelligent tools that can stated as follows CAse-based Menu Planner (CAMP) [7], Pattern Regulator for the Intelligent Selection of Menus (PRISM) [2] and CAMP Enhanced by Rules (CAMPER) [5].

SYSTEM FOR DESIGNING HEALTHY MEALS.

We designed a system for designing healthy meals, consists of three phases and uses a combination between linear programming and AI techniques. Section 4.1 describes the three phases and the techniques used. To fiend a solution is demonstrated in section 4.2.

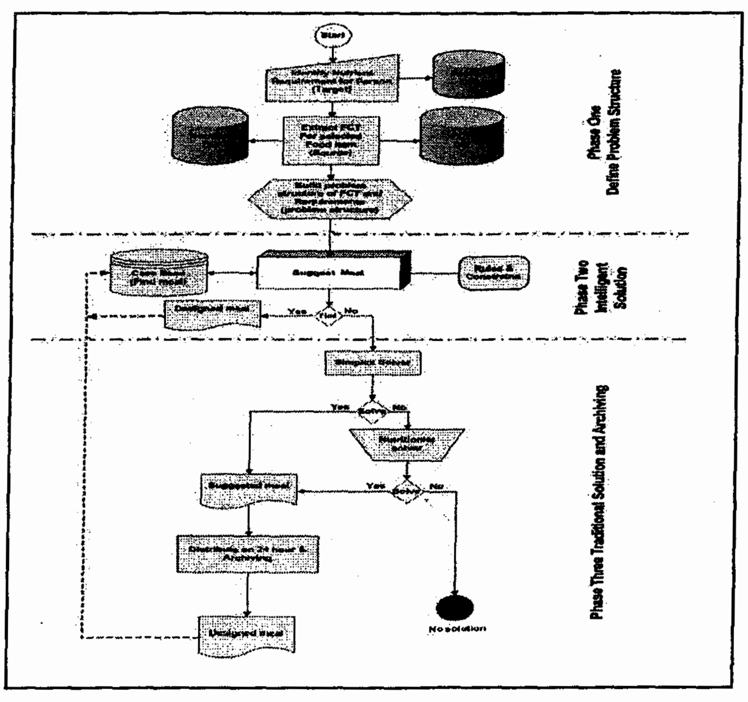


FIG 1 SYSTEM ARCHITECTURE

1. System architecture.

We build a system that acts as dietitian for designing healthy meals. The developed system consists of three phases. Phase one defines the problem structure, phase two is to find an intelligent solution and phase three is to find the traditional solutions and archiving as shown in figure 1.

1.1. Phase one, define the problem structure.

Phase one is to define the problem structure as follows: - first dietitian enters the person data (sex, weight, height, activity and anthropometric data of the person) to find and calculate the required nutrient, second dietitian asks his person about what he likes from food table taking in consideration to select from food groups, healthy meals and healthy conditions to extract food composition table of selected food items, then our system builds the problem structure to be solved. The problem structure [9] consists of nutrient requirement (Target), food composition table of selected food items (source), and minimum costs.

1.2. Phase two, intelligent solution.

Phase two starts after defining the problem structure and tries to find a solution of our problem using AI technique (CBR) a person's calorie level, any optional nutrition, and personal preference criteria are inputs first. Nutrition criteria added to ensure that the DRI requirements are met. We put an indicator for each constraint to be used for this purpose. The best menu matches the criteria are retrieved from the case base database.

1.3. Phase three, traditional solutions and archiving.

Phase three is the last phase in designing meal and we use it if there is no solution in phase two, i.e., there is no case in database can satisfy minimum criteria. We use simplex trying to find a solution and it is a linear programming technique to solve diet problem. Entering our problem to simplex solver, the solver either finds a solution or finds no solution. If the result is no solution, we can try nutritionist solver, and it is a tool for designing healthy meal. The dietitian can change quantities of food items selected, and see the changes of nutrient intake compared with the standard at the same time; but if simplex solver finds a solution, we can archive this designed meal.

The designed meal is only food items quantities intake during 24 hours. In the last phase we have to distribute food items on breakfast, morning snack, lunch, afternoon snack, dinner and Evening snack.

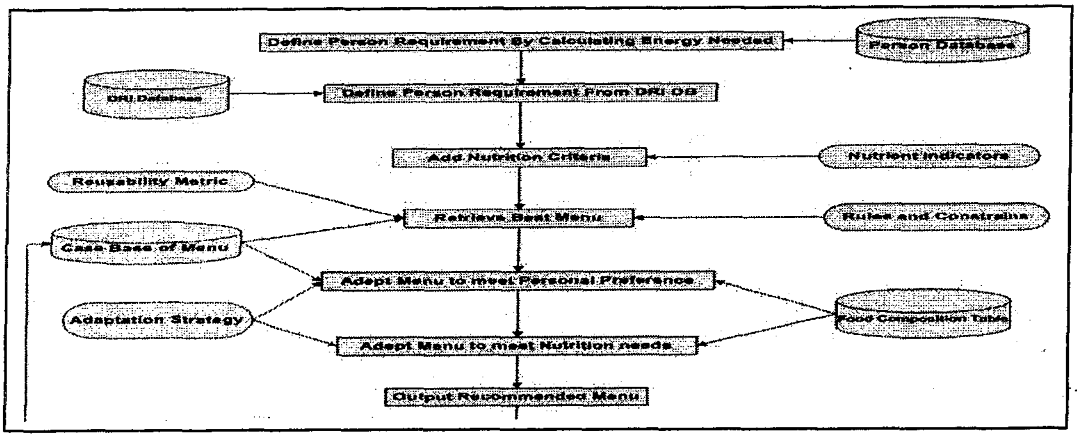
2. Techniques used to find the solution.

In the proposed system we used the traditional technique and AI techinque to find a solution

2.1 Case-based reasoning.

First defining person requirement of nutrient by calculating energy needed and finding suitable requirement of nutrients depended on person data (such age, sex, weight and height … etc) by selecting from DRI database, adding nutrient criteria to ensure that the requirements are met. Using nutrient indicator for this purpose. The best menu suiting the criteria is retrieved from the case base.

Reusability metric is used to select and retrieve a case based on the ease of adapting it to meet nutrient requirements. Before a case can be reused, it must be adapted until it meets all user-specified constraints (e.g. such meal must contain boiled rice not macaroni), and additional constraints imposed as minimum DRI. To find the best case, the system checks each case against all constraints. Any case meeting all constraints constitutes an exact match is retrieved. When a case does not comply with a constraint, a penalty score is assigned based on how difficult it would be to bring the case into compliance. After the menu is designed we add it to the case-base data-base to be used later on as shown in figure 2. [8]



2.2 Simplex.

Simplex is a linear programming technique to solve many problems such as the diet problem. We can formulate the diet problem into a mathematical model that can be solved by the simplex algorithm, the object function will be minimizing the cost of designed meal subject to constrains consists of food composition table of selected food items on the left hand side and standard intake of the person on the right hand side. By passing this mathematical model to simplex solver the result will be the amounts of food items required for that person, moreover the minimum costs. We can use simplex, after defining the person data, the nutrient requirements (goal), and defining the food composition table of preferred food items (source). [1]

	Food Items											
	Decision Variables					Slack Variables					Right Hand Side	
	X1	X2	X3	......	Xn	Xn+1	Xn+2	Xn+3	......	Xn+m		
Nutrients Intake	a11	+ a12	+ a13	......	+ a1n	1	0	0	......	0	= B1	Standard Intake
	a21	+ a22	+ a23	......	+ a2n	0	1	0	......	0	= B2	
	a31	+ a32	+ a33	......	+ a3n	0	0	1	......	0	= B3	
	:	:	:	......	:	:	:	:	......	:	:	
	am1	+ am2	+ am3	......	+ amn	0	0	0	......	1	= Bm	
	- C1	- C2	- C3	......	- Cn	0	0	0	......	0	0	

Where

X = Food Item Weight
a = Analysis of nutrient per food item
B = Standard intake during the day
C = Cost of each food item
n = Maximum number of food items (Food Items)
m = Maximum number of standard nutrient intake (consti

2.3 Nutritionist Solver.

Nutritionist solver is a tool for designing healthy meals. After fixing dietitian input person data, calculate energy, nutrient required, and select suitable food items for that person, nutritionist input suitable quantities for selected food items. Nutritionist solver analyzes the meal and compares this analysis with the standard requirements. Sorting the difference between analysis and standard intake. The dietitian check if this meal is acceptable or not. If the meal is not acceptable because there is, a nutrient analysis does not match with the standard, the nutritionist solver will allow the dietitian replace that food item with another food item within the same group of old food items. For example if we use salted or smoked meat, or fish in our meal, nutritionist solver will find that, the amount of sodium is too high. So we want to reduce it, nutritionist solver will find that the salted or smoked meat, or fish gives too much amount of sodium and will suggest to replace this food item with another gives amount of sodium less than the amount of sodium of salted or smoked meat, or fish. By replacing salted or smoked meat, or fish from our meal by another one gives fewer amounts of sodium and recalculating from the beginning until the meal becomes an accepted one.

When replacing a food item, nutritionist solver will sort the food group which food item exists in, sorting on the selected nutrient analysis. Selecting another food item with, in the same group contain the old food item, with nutrient analysis greater or less than old food item if the nutrient analysis is less than the standard. If the nutrient analysis is greater than the standard, nutritionist solver will select another food item with nutrient analysis less than the old food item as shown in figure 3

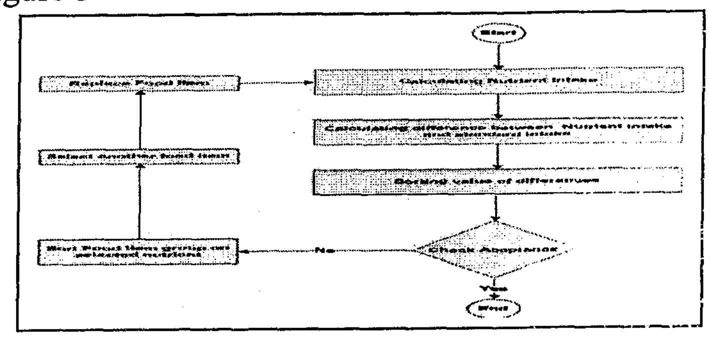


Fig 3 Nutritionist Solver Flow Chart

5 - EXPERIMENTED RESULTS.

We developed an intelligent system for designing healthy meals. Using this system we designed healthy meals after defining nutrition facts from the dietitian taste and the prices from the Egyptian market.

The designed meals consist of breakfast, lunch and dinner and designed for adult person. The informations of a person are, e.g:-

Sex: Male	Age: 31 years
Weight: 79.0 kgm.	Height: 178 cm
Physical Activity: Sedentary.	Activity Type: Low.

Giving these informations we defined the standard requirements from dietary reference intake calculated by the proposed system as shown in figure 4

Person Information Report for ex, adult

Estimated Daily Calorie Requirement Summary:

Basic Calorie Requirement:			2750.17	
Nutrient		**Perc**	**Grams**	
	Calories			
Protein (g)		21%	120.93	483.72
Carbohydrates (g)	65%	378.13	1512.52	
Fat (g)		14%	83.77	753.93
Nutrient			**Goal Value**	
Est. Net Carbs (g)			353.13	
Saturated Fat (g)			30.56	
Cholesterol (mg)			275.00	
Vit-A (mcg_RAE)			900.00	
Calcium (mg)			1000.00	
Phosphorus (mg)			700.00	
Sodium (mg)			2400.00	

The designed meal designed and reviewed by experts and professionals from the nutrition and food science department, home economics faculty, Menoufia University and the designed meal for that person is shown in figure 5

Breakfast	bread	110	0.1
	cheese romi	60	1.4
	cold cut	30	0.5
	cup of tea(20-suger,5-tea)	250	0.25
Lunch	fish	300	3.9
	white rice	200	0.5
	green salad	100	0.25
	banana	220	0.66
Dinner	arabic cheese	75	0.53
	green salad	100	0.25
	boiled eggs	110	1
	cup of milk	250	0.75
	bread	110	0.1
	Total Price in EGP		10.19

Analysis

Nutrient	Total	Standard	%
Energy (kcal)	2727.50	2,750.00	99.18
Protein (g)	149.28	120.93	123.44
Carbohydrates (g)	266.92	378.13	70.59
Total Fat (g)	118.08	83.77	140.96
Cholesterol (mg)	253.35	275.00	92.13
Fiber (g)	26.97	25.00	107.88
Sodium (mg)	2,417.70	2,400.00	100.74
Calcium (mg)	1,111.05	1,000.00	111.11

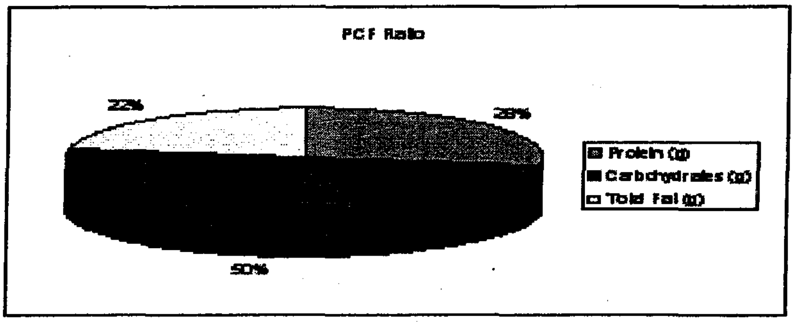


Fig 5 Designed Meal

6 - CONCLUSION AND FUTURE WORK.

The main goal of this work is to design and implement a system to design healthy meals in a short time and in an efficient manner with minimum effort and minimum costs. In this paper we build a model for a system that act as dietitian for designing healthy meals. The developed system solves the diet problem and finds a combination of foods that will satisfy all the daily nutritional requirements of a person using a computer system with minimum cost..

The future work is to increase the usage of AI in creating and adapting healthy meals. And upgrading our system to be more scalable (i.e. contains more parameters in the meal construction such as social, financial, geographical and seasonal parameters)

REFERENCES

A. M. Anderson, M. D. Earle;"Diet Planning in the Third World by Linear and Goal Programming"; Journal of the Operational Research Society; USA; Volume. 34; Issue 1; pp 9-16; 1983.

C. R. Marling, G. J. Petot & L. S. Sterling;"Integrating Case-Based and Rule-Based Reasoning to Meet Multiple Design Constraints ";Computational Intelligence; England; Volume 15; Issue 3; pp 308; 1999.

Esha Research Web Site **(http://www.esha.com).**

First DataBank Web Site **(http://www.firstdatabank.com).**

Marling CR, Petot GJ, Sterling L. "Integrating case-based and rule-based reasoning to meet multiple design constraints." Computational Intelligence; Volume 5; Issue 3; pp 308-332; 1999.

NutriBase Web Site **(http://www.nutribase.com/homepages.html).**

SMYTH, B., and M. T. KEANE. "Experiments on adaptation-guided retrieval in case-based design." In Case Based Reasoning Research and Development: First International Conference, Proceedings ICCBR-95. Edited by M. Veloso and A. Aamodt. Springer-Verlag, Berlin, pp. 313–324.; 1995.

Sterling L, Petot GJ, Marling CR, Kovacic K, Ernst G. "The role of common sense knowledge in menu planning"; Expert Systems with Applications ; Volume 11; Issue 3 ;pp.301-308; 1996.

Ursula Arens BSc RD;" Dietary Reference Intakes. Applications in Dietary Planning "; Journal of Human Nutrition and Dietetics; England; Volume. 17; Issue 3; pp 269; 2004.