Expert System Prototype to Monitor and Control the Proper Diet for Diabetics

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Abstract. Diabetes Mellitus is a disease that causes blood glucose level rise in human body. Treatment includes insulin, tablets, regular exercise and development of a meal plan. Medical care in diabetes remains severely limited in developing countries, this result in slow service, and patients end up waiting long hours without receiving any attention. Fortunately, diabetes can be managed very effectively through healthy lifestyle choices, primarily diet and exercise. Eating just ideal diet can prevent the onset of diabetes and keeps glucose within normal ranges. The paper aimed to develop an expert system prototype on healthy food to help diabetics to monitor and to control the proper diet. The expert system recommended maximum five meals and minimum three meals per day for every patient.

Keywords: expert systems, diabetic diet, Diabetic Informatics, Reasoning, Knowledge Acquisition.

1 INTRODUCTION

The development of an expert system on healthy food helps diabetes people of Type 2 to monitor and to control the proper diet

1.1 Diabetes Mellitus

Diabetes mellitus is a condition in which the pancreas no longer produces enough insulin or when cells stop responding to the insulin that is produced, so that glucose in the blood cannot be absorbed into the cells of the body [1]. Diabetes Mellitus is spreading expected to be 366 million in year 2030. It can affect nearly every organ system in the body [2].

Most medical resources reported that 90 to 95% of diabetic is diagnosed as type-2. Furthermore, in these cases the pancreas is not able to produce enough insulin to keep the blood sugar level within normal ranges. Over 80-90% of Type 2 diabetes is overweight, and this in turn contributes in many diabetes symptoms. Therefore, reducing daily carbohydrates and fats intake and the commitment to a healthy diet with a simple waling keeps your glucose within normal ranges and help dropping those extra pounds [3].

Diabetic diet for diabetics is simply a balanced healthy diet which is vital for diabetic treatment. The treatment of a diabetic requires a strict regimen that typically includes a carefully calculated and controlled diet [4]. Access to medical care is sometimes very difficult for people living in rural and underserved areas. Medical facilities are available in urban areas. Lack of time due to work schedule, time taken to go in for this comprehensive procedures of getting appointment and spending a whole day, discourage people to visit these facilities.

Therefore a doctor is considered the biggest authority facing the particular problem. He is the expert. He has to use his knowledge, knowledge of the expert each time when he intervenes (and he does it every day, quite often). But it happens very often that the problem he diagnosed by him is quite trivial, with identical diagnosis. He has to devote lots of time to mechanical deduction. Finally, improper management of diabetic diet can lead to severe complications [5].

On the other hand, the development of computer technology and tools has provided a valuable assistance for Medicare [6]. Recent work in Artificial Intelligence is exploring the use of expert systems (ESs) to provides expert advice as if a real person had been consulted where this advice can be decisions, recommendations or solutions.

1.2 Problem definition

In the domain of medical treatment by controlling patient food (healthy diet) there are numerous variables that affect the decision process of selecting interesting food list from the patient point of view and efficient list in treatment from the doctor's point of view. These numerous variables causing the differences in the opinions of the practitioners. Also, access to medical care is sometimes very difficult for people living in rural and underserved areas. Medical facilities are available in urban areas. Lack of time due to work schedule, time taken to go in for this comprehensive procedures of getting appointment and spending a whole day, discourage people to visit these facilities. Finally, improper management of diabetic diet can lead to severe complications.

1.3 Literature Review of Existing Diabetic Expert Systems

J.Cantais1 et. al (2005) [7] introduced building an environment for Health, and Knowledge Services Support. They create a dynamic knowledge environment that focus in managing heterogeneous knowledge from different sources. Also they proposed a Food Ontology which organizes foods in 13 main categories. They used hierarchical structure for designing the ontology. They suggest the size of the portion that allowed safely for diabetic type1.

P. M. Beulah et. al (2007) [8] introduced system allows the availability to detect and give early diagnosis of three types of diabetes namely type 1, 2, gestational diabetes for both adult and children.

M.Wiley et. al (2011) [9] presented diabetes management tool that monitors and controls blood glucose (BG) levels in order to avoid serious diabetic complications. They mentioned the difficult task for physicians, to manual large volumes of blood glucose data to tailor therapy of each patient

W.Szajnar and G.Setlak(2011)[10] proposed a concept of building an intelligence system of support diabetes diagnostics. The initial target of their system was to function as a medical expert diagnosing diabetes and replacing the doctor in the first phase of illness. The system find out whether the patient has diabetes and decides whether it is type1 or type2.

S. Kumar and B. Bhimrao (2012)[11] developed a natural therapy system for healing diabetic, they aim to help people's health and wellness, which don't cost the earth, they described the Natural Care (Herbal /Proper Nutrition) treatment solution of diabetes disease.

2 DIABETIC INFORMATICS

The field of medical informatics has been growing rapidly over the past two decades. Due to the advances in new molecular, genomic, and biomedical techniques and applications. The digitization of critical medical information such as lab reports, patient records, research papers, and anatomic images has also resulted in large amounts of patient care data.

New computational techniques and information technologies are needed to manage these large repositories of biomedical data and to discover useful patterns and knowledge from them [12]. Intelligent medical informatics consist of five main domains Medical Imaging, Medical Knowledge Engineering, robotic surgery, medical education/training and medical expert systems (Fig 1).

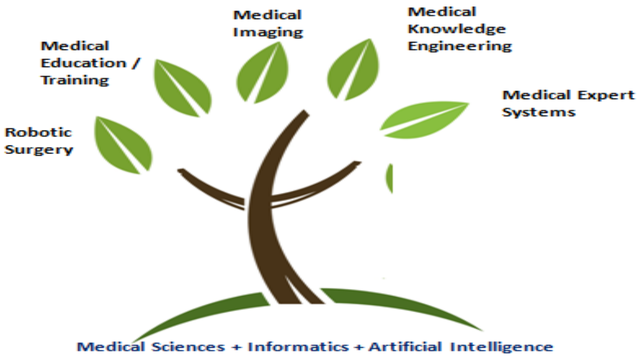

Fig. 1. Intelligent medical informatics tree

The most successful paradigm in medical domain are Symbolic reasoning approaches, decision theory approaches, Bayesian analysis approaches, statistical pattern recognition, mathematical models of physical processes, data bank analysis for prognosis and therapy selection and clinical reasoning. In summary, the trend increased use of knowledge engineering techniques for clinical decision programs stems from the dual goals of improving the performance and increasing the acceptance of such systems [13].

2.1 Medical Expert Systems

Expert system is a knowledge intensive computer program that captures the expertise of a human in domains of knowledge. Medical expert systems are the common type of artificial intelligence in medical in routine clinical use. They contain medical knowledge, usually about a very specifically defined task, and are able to reason with data from individual patients to come up with reasoned conclusions. Expert systems can be applied in various tasks of medical domains:

a) Diagnostic assistance.
b) Expert laboratory information systems.
c) Therapy critiquing and planning.
d) Agents for information retrieval.
e) Generating alerts and reminders.
f) Image recognition and interpretation [14].

2.2 Diabetes Mellitus

It is known that the normal blood glucose level (BGL) lies between (70-100) mg/100 ml when fasting and around 140 mg/100 ml otherwise. For a diabetic person, the blood glucose is around 126 mg/100 ml when fasting and 200 mg/100 ml otherwise. The most common symptoms observed in diabetic patients are: polyuria, weight loss, excessive thirst, continuous hunger, blurring and changes in vision, and fatigue. Late clinical manifestations of diabetes mellitus include a number of pathologic changes that involve small and large blood vessels, stroke, cranial and peripheral nerves, the skin, and the lens of the eye. These lesions lead to hypertension, renal failure, blindness, autonomic and peripheral neuropathy, amputations of the lower extremities, myocardial infarction, and cerebrovascular accidents [15]. The importance of regular tests for glucose on capillary blood specimens should be stressed and instructions on proper testing and recording of data provided [16].

2.2.1 Diagnostic Tests for Diabetes.

Diabetes may be diagnosed based on A1C criteria or plasma glucose criteria, either the fasting plasma glucose (FPG) or the 2-h plasma glucose (2-h PG) value after a 75-g oral glucose tolerance test (OGTT). The same tests are used to both screen for and diagnose diabetes. The same tests will also detect individuals with prediabetes [17]. The importance of regular tests for glucose on capillary blood specimens should be stressed and instructions on proper testing [16].

2.2.2 Calories

Calories should be tailored to the diabetic patient. The total amount of carbohydrate in the diet should provide 50-55% of the total calories, with fat approximately 30% and protein 15%.

- An overweight patient is started on a reducing diet of approximately 4-6 MJ (1000-1600 kcal) daily.
- A lean patient is put on an isocaloric diet.
- Patient who are underweight because of untreated diabetes require energy supplementation [16].

3 STUDY AND REASONING IN DIABETES

The field of reasoning methodologies is very important in the area of knowledge computing and engineering. Reasoning techniques has provided greatest support for predicting diagnosis and treatment of disease with correct case of results. Diabetes needs greatest support of reasoning techniques for diagnosis and treatment [18].

Four reasoning methodologies which are commonly used in developing diabetic expert systems, namely; reasoning with production rules, fuzzy reasoning, case-based reasoning, and ontological-case based reasoning. From our study in diabetes [19].

- It can be seen that all the reported research papers are focused on the diagnosis of diabetics.
- Few extended their work to treatment but only for Type 1.

From our study in diabetes reasoning techniques [20].

- Most of the case based reasoning systems were developed in JAVA.
- Most of fuzzy based reasoning systems were developed in MATLAB.
- Rule based reasoning were developed with dot net/ESTA/VP expert shell.
- Reasoning techniques used for deferent purpose in diabetes domain.
- All of the ontology case based reasoning systems developed in Protégé tool and the ontology presented by OWL.
- Rule-based systems are very time-consuming to build and maintain.
- Case based reasoning is a powerful methodology regarding to the issues of maintenance and knowledge representations.

4 KNOWLEDGE ACQUISITION

We have gathered knowledge from medical books and experts. We have contacted the Military Hospital in Khartoum for both medical resources and managed to schedule some interviews and observations. Exchange lists are groups of foods that contain roughly the same mixture of carbohydrates, protein, fat, and calories, see Table 1. Serving sizes are defined so that each will have the same amount of carbohydrate, fat, and protein as any other. Foods can be "exchanged" with others in a category while still meeting the desired overall nutrition requirements. There are six exchange lists [21]

Table 1. Exchange lists.

	Carbohydrate (grams)	**Protein (grams)**	**Fat (grams)**	**Calories (grams)**
Starch/Bread	15	3	Trace	80

Meat	Medium Fat High fat	- - -	7 7 7	3 5 8	55 75 100
Vegetable		5	2	-	25
Fruit		15	-	-	60
Milk	Skim Low fat Whole	12 12 12	8 8 8	Trace 5 8	90 120 150
Fat		-	-	5	45

According to the World Health Organization (WHO) classification, the Body Mass Index of the diabetes is divided into 6 categories [22] Table 2.

$$MBI= (weight\ (KG))/ (height\ (M)^{2}), \qquad (1)$$

Table 2. BMI WHO classification.

BMI	**Classification**
Less than 18.5	Slim
18.5-25	Normal
More than 25-30	Overweight
More than 30	Obese
More than 30-less than 35	Obese(class 1)
More than 35	Obese(class 2)

Furthermore, the activity type for the patient is needed to be specified where it could be (very active, moderate activity or little activity) according to Table 3 then equation: (2) is used to calculate the total calories (TC).

$$TC=activity\ type\ (calorie/K\text{-}gram)*weight\ (KG), \qquad (2)$$

Table 3. Calories according to activities and BMI.

Activities / **BMI**	**High activity calorie/K-gram**	**Moderate activity calorie/K-gram**	**Little activity calorie/K-gram**
Obese	30	25	20
Normal	35	30	25
Slim	40	35	30

Actually, we determine the amount of each item in the food groups in Table 4.

Table 4. Standards of items.

Fat & Milk		**Sugar**		**Proteins**	
Name	Amount	Name	Amount	Name	Amount
Oil	Spoon(20 gram)	Sugar	Spoon(20 gram)	Chicken	1/4 piece(250 gram)
Shortening	Spoon(20 gram)	Jam	Spoon(20 gram)	Egg	1 piece
Synths	Spoon(20 gram)	Cake	1 piece	Fish	125 gram
Milk	1 cup	Tahnia	Spoon(20 gram)	Meat	Kumsha(100 gram)
Yogurt	100 gram	Sweet	1 piece	Tamiea	4 pieces(40 gram)
Cheese	50 gram	S_drinks	75 ml	Bean	Kumsha(100 gram)
_	_	Pasta	Small piece	Lentils	Kumsha(100 gram)
_	_	_	_	Foul	Kumsha(100 gram)
Fruits		**Vegetables**		**Starch**	
Name	Amount	Name	Amount	Name	Amount
Banana	Small piece(100 gram)	Salad	Free (open)	Custer	1 cup
Orange	Small piece(100 gram)	Molokhia	Kumsha	Kissra	2 pieces(100 gram)
Mango	Small piece(100 gram)	Bazenjan	Kumsha	Gorasa	1/2 piece (100)
Dates	3 pieces(24 gram)	Okra	Kumsha	Bread	1 piece (120 gram)
Grapes	10 pieces (120 gram)	Potatoes	2 Kumsha	Rice	1 cup
W_melon	2 slices (120)	Regla	2 Kumsha	Macaroni	1 cup
Apple	Small piece(100 gram)	Taglia	Kumsha	Potato	Big piece
Guava	Small piece(100 gram)	Roub	2 Kumsha	Noodles	1 cup

5 DESIGN AND IMPLEMENTATION

The development used visual prolog for designing the graphical user interface and the implementation of the system. The system consists of two main graphical user interface components. The first component is the Patient dialog which consist of name, gender, age, weight, height, activity type, BGL, favorite-meals and additional diseases. The second is the Food groups dialog which consists of items names and items list Fig. 2, Fig. 3, Fig. 4 and Fig. 5 give sample screen shots of the user interface.

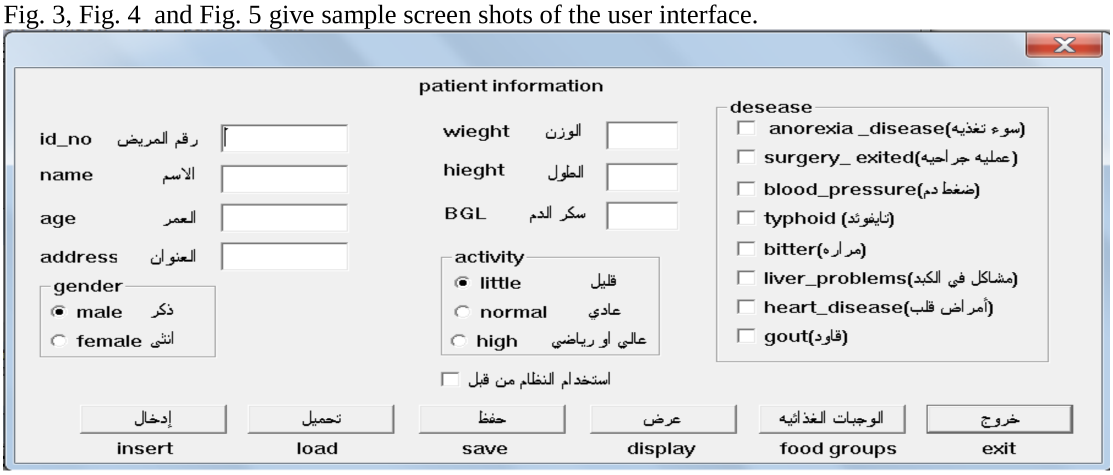

Fig. 2. Patient dialog.

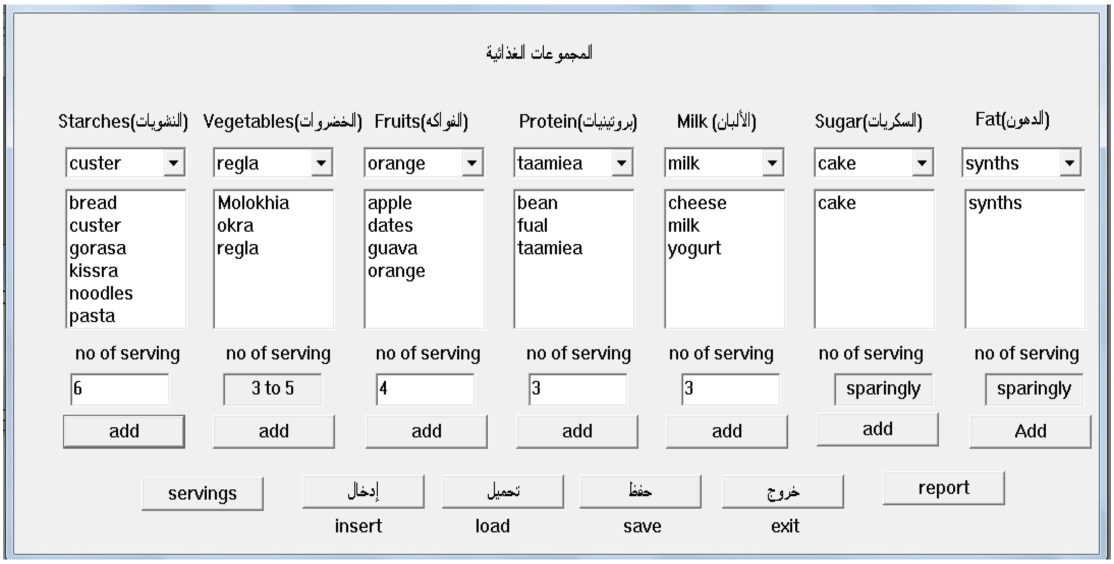

Fig. 3. Food groups servings dialog.

The report contains maximum five recommended meals and minimum three. See Fig. 4 and See Fig. 5.

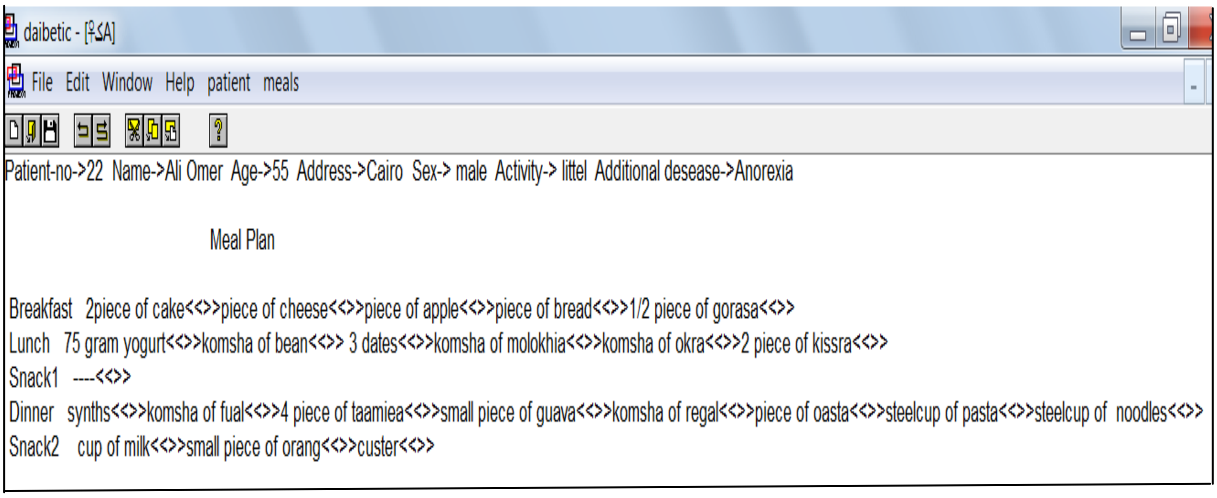

Fig. 4. Serving based meal plan report.

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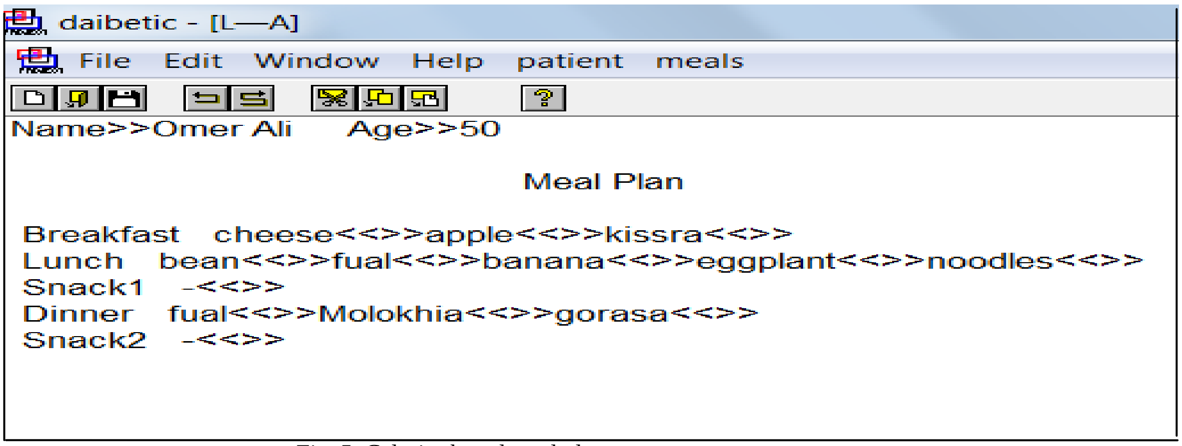

Fig. 5. Calories based meal plan report.

6 RESULT

The system connect all gathered information and performs inferences through its knowledge process to output a recommended maximum five and minimum three meals for every patient per day. If the user used the meal plan for 3 monthes and his BGL still above 140 the system recommended him to visit the doctor.

7 CONCLUSION

The research in diabetic systems is important for both medical staff and diabetes patients. An efficient tool for diagnosis and treatment of diabetes is urgently needed for helping both specialist doctors and patients. Type-2 diabetes is the most common form of diabetes. Self-monitor for patient of type 2 diabetes is possible by getting proper amount of daily calories with a list of the proper diet which satisfies the amount of those calories .

Actually, I focused my efforts and time on helping the society to minimize the effect of this widely spreading disease by means of an easy to use and accessible expert system. I designed this tool to provide information that users can use to minimize the damage done by this disease and its complications so that they can maintain a healthy lifestyle and provides the basic service regarding diet .

Many interviews were conducted to validate my study. I spent 6 months collecting the required information and to find the missing information during the interviews and documentations. This paper discusses the design and implementation of a medical expert system for diabetes diet that intended to be used in Sudan, as a result the system connects all gathered information and performs inferences through its knowledge engine process to output a recommended five meals a day for every patient: breakfast, lunch, snack1, dinner and snack2. It performs correct meal planning and suggests appropriate diet using calories base or serving base. Owing to this, patient's daily quality of life improves.

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