Diabetes Detection and Care Applying CBR Techniques

Mukesh Kumar Jha, Debanjan Pakhira, Baisakhi Chakraborty

Abstract*— Diabetes is a lifelong (chronic) disease increase at a rapid rate because of sedate life style, changes into urban culture, unhealthy foods and lacking of physical activity. It is an incurable chronic disease, but through true diabetes screening and advanced sugar monitoring can prevent risky complications. A little information, Precaution and absolute care plan can go a long way to dealing with diabetes. It is very hard to make an excellent care plan and maintaining healthy blood glucose level for patients and their health care providers. In this research work we proposed a case base decision support system for patients with diabetes. Case based reasoning is an artificial intelligence technique to detect diabetes and its type, its seriousness and giving the appropriate care plan. This system helps doctors and patients to check, analyze and repair solutions. A case consists of a problem description (e.g. symptoms) and a solution (e.g. a care plan and a therapy). Cases are stored in a database of cases called case bases. To solve an actual problem a notion of similarity is used to retrieve similar cases from case bases. The solutions of these found similar cases are used as starting points for solving the actual problems at hand. The system analyzes the symptoms of the patients and gives the exact types of diabetes, its seriousness level and the appropriate care plan for appropriate patients. If it is not found then system generates basic care plan by ontology. After that system modified that case and stored in its ever expanding database for future use. The learning process of CBR is retaining the modified solved case in the data base is gives a big scope to solve new problems in future.

***Keywords*— Case-Based Reasoning, Detection, Diagnosis, Ontology.**

I. INTRODUCTION

The purpose of this project is to show the application of CBR through Diabetes detection and care system. Case-based reasoning (CBR) is defined as the process of solving new cases based on the solutions of similar past cases [1]. In CBR technology, a case usually denotes a problem situation. A previously experienced situation, which has been captured and learned in a way that it can reused in the solving of future cases, is referred to as a past case, Previous case, stored case, or retained case.

Correspondingly, a new case or unsolved case is the description of new cases to be solved. Cases are stored in a database of cases called a Case Base (CB). To solve an actual case a notation of similarities between cases are used to retrieve top most similar cases from the case base.

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The solutions of these similar cases are then used as starting points for solving the actual case. Our proposed model is a Diabetes Detection and care System (DDCS) that detects the disease type, its complexity and produce relevant care plan which pronouncedly produces certain symptoms experienced by the patients. From the symptoms observed by the patient and its severity, a particular disease type and its complexity is tried to be diagnosed through similarity matching with the past cases.

In recent years, we are facing a substantial growing number of chronic disease patients. The death ratio of chronic diseases has replaced acute infectious diseases in the past and diabetes death is in the fifth place of leading cause of death [2]. Currently, diabetes is not curable but can be controlled by drugs, diet, exercise and other helpful methods. Diabetes care needs long-term care. The drawback of giving long term care plan consumes a lot of medical man power and costs. For removing this major drawback of traditional and manual system of giving long term care plan requires a new way to producing efficient personalized care plan. In order to build a personalized care plan, this research combined case-based reasoning [3] and ontology [4] technology from artificial intelligence to solve this problem. One major feature of case-based reasoning is it can store successful solution of past problems (cases) in case base, and when there is a new problem (case) coming, it will search the case base to find similar cases solutions to solve the new one. For efficient usages of Case-based Reasoning method case base must have sufficient number of cases, so when the cases is insufficient or cannot match new cases, we use another technology, ontology, to support this situation. We collect diabetes care related knowledge, such as health information, pharmaceutical care, diet care, sports care and other knowledge, and then build diabetes care ontology directly and structurally. When case-based Reasoning cannot find similar cases, the system will initiate a querying process in diabetes care ontology [4] and generate a basic care plan for doctors to adjust and retain it. In this case, the system has new care knowledge again. Advantages of using ontology can share and reuse knowledge easily. Together these two technologies, we are able to personalized diabetes care suggestion efficiently and thus reduce the cost of diabetes care [5].

II. LITERATURE REVIEW

Diabetes Care Decision Support System, which combines CBR and Ontology to generate personalized care plan. The result of this research shows, this system can provide Diabetes care plan according to patient's profile and thus can reduce the consumption of medical Resources while provide consistent care quality at the Same time [5].

Emerging Applications for Intelligent Diabetes Management describes three emerging applications that employ AI to ease this task and shares difficulties encountered in transitioning AI technology from university researchers to patients and physicians. The 4 Diabetes Support System TM (4DSS) aims to: (a) automatically Detect problems in BG control; (b) propose solutions to detected problems; and (c) remember which solutions are effective or ineffective for individual patients. CBR was selected as the initial approach because: (a) Diabetes management guidelines are general in nature, requiring personalization; (b) a wide range of both physical and lifestyle factors [6].

Toward case based reasoning for diabetes management: A preliminary clinical studies and decision support presents a case-based decision support system prototype to assist patients with Type 1 diabetes on insulin pump therapy. These patients must vigilantly maintain blood glucose levels within prescribed target ranges to prevent serious disease complications, including blindness, neuropathy, and heart failure [7].

The study of Use of Case-Based Reasoning to Enhance Intensive Management of Patients on Insulin Pump Therapy was conducted to develop case-based decision support software to improve glucose control in patients with type 1 diabetes mellitus (T1DM) on insulin pump therapy. This software can screen large volumes of clinical data and glucose levels from patients with T1DM, identify clinical problems, and offer solutions. It has potential application in managing all forms of diabetes [8].

CBR has been used as a KM technique in medical sciences for decision support in diagnosis and partly for therapeutic tasks. CASEY has been one of the earliest medical expert systems using CBR for heart failure diagnosis, FLORENCE is for health care problem in nursing, MEDIC is a schema-based diagnostic reasoned on the domain of pulmonologist as in, PSIQ is for diagnostic and therapeutic advice in the domain of mental disorders, GS.52 supports the diagnosis of Dimorphic Syndromes and TROPIX is used to diagnose tropical diseases.

A CBR System for Decision support in Air Traffic Control for conflict resolution, ISAC has been developed in [9] that take into account safety critical issues. A conflict occurs in ATC when two or more aircraft pass too close together. It is the air traffic controller's job to resolve potential conflicts by adjusting the trajectories of the aircraft. The motivation in designing ISAC has been to reduce the decision making burden on controllers especially for the future as air traffic volumes increase.

III. CASE BASED REASONING

Case-Based Reasoning is an approach to model the way humans think and an approach to build intelligent systems. CBR solves a new problem by doing the following –recall similar experiences (made in the past) from memory reuses that experience in the context of the new situation (reuse it partially, completely or modified) –new experience obtained this way is stored to memory again It is sub-discipline of Artificial Intelligence. It belongs to Machine Learning methods. Case based reasoning solves new problems by selecting cases used for similar problems and by (eventually) adapting the belonging solution. Case based reasoning relevance's in these cases given below:

1. When a domain theory does not exist, but example cases are easy to find.
2. When an expert in the domain is not available, is too expensive, or is incapable of articulating verbally his performance, but example cases are easy to find.
3. When it is difficult to specify domain rules, but example cases are easy to find.
4. When cases with similar solutions have similar problem descriptions i.e. there exists a similarity metric for problem descriptions and a corresponding set of adaptation rules.
5. When a case base already exists.

A. The CBR cycle

At the highest level of generality, a general CBR cycle may be described by the following four processes [10]:

1. RETRIEVE the most similar case or cases
2. REUSE the information and knowledge in that case to solve the problem
3. REVISE the proposed solution
4. RETAIN the parts of this experience likely to be useful for future problem solving

A new problem is solved by retrieving one or more previously experienced cases, reusing the case in one way or another, revising the solution based on reusing a previous case, and retaining the new experience by incorporating it into the existing knowledge-base (case base). The four processes

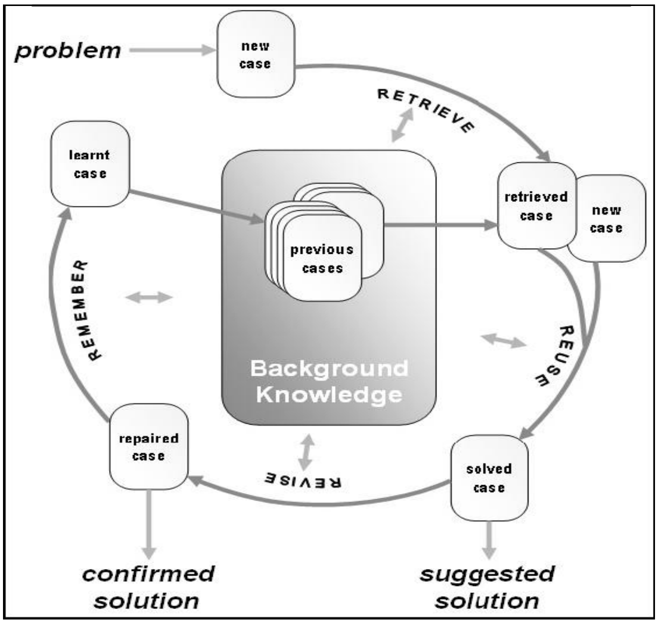

Fig. 1: The CBR Cycle [Aamodt and Plaza, 1994]

each involves a number of more specific steps, which will be described in the task model. In figure 1, this cycle is illustrated.

An initial description of a problem (top of figure) defines a new case. This new case is used to RETRIEVE a case from the collection of previous cases. The retrieved case is combined with the new case - through REUSE - into a solved case, i.e. a proposed solution to the initial problem. Through the REVISE process this solution is tested for success. During RETAIN, useful experience is retained for future reuse, and the case base is updated by a new learned case, or by modification of some existing cases [11].

B. Contents of a Case

Mandatory	Optionally
Problem part	Context (e.g. justifications) pointer to other relevant cases.
Solution part	Solution quality assessment steps of the solution.

The main difficulty arises, when the actual situation is not identical to the previous one. Then, in exactness is involved.

A main feature of CBR techniques is that they allow in exact or approximate reasoning in a controlled manner.

C. Advantage of Case Base Reasoning

1. Avoidance of High Knowledge Acquisition Effort.
2. Simpler Maintenance of the Knowledge in the Systemm.
3. Facilitation of Intelligent Retrieval (compared to data-base systems).
4. High Quality of Solutions for Poorly Understood Domains.
5. High User Acceptance.

IV. DIFFERENT TYPES OF DIABETES

Diabetes mellitus, often simply referred to as diabetes, is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because cells do not respond to the insulin that is produced. This high blood sugar produces the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) an polyphasia (increased hunger) [2].

There are three main types of diabetes:

Type 1 diabetes: results from the body's failure to produce insulin, and presently requires the person to inject insulin (Also referred to as *insulin-dependent* diabetes mellitus, *IDDM* for short, and *juvenile* diabetes).

Type 2 diabetes: results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency (Formerly referred to as *non-insulin-dependent* diabetes mellitus, *NIDDM* for short, and *adult-onset* diabetes) [12].

Gestational diabetes: is when pregnant women, who have never had diabetes before, have a high blood glucose level during pregnancy. It may precede development of type 2 DM [13].

Other forms of diabetes mellitus include congenital diabetes, which is due to genetic defects of insulin secretion, cystic fibrosis-related diabetes, steroid diabetes induced by high doses of glucocorticoids, and several forms of monogenic diabetes.

The Complication of Diabetes includes Heart disease, Stomach Nerve Damage, Kidney Failure etc. Risk Factor of Diabetes mainly concerns with obesity, pancreatic diseases and genetics and family history, and Seriousness of Diabetes defines as the situation where risk factor and complications of Diabetes is more and makes very bad impact to the patients [16]. Diabetes care plan is totally depends upon these three aspect of the disease.

V. SYSTEM CONCEPT DEVOLOPMENT

A. Goals of Proposed System

Our research work proposed a case base decision support system for patients with diabetes. It is an artificial intelligence technique (Case based reasoning) to detect diabetes and its type, its seriousness and giving the appropriate care plan. This system helps doctors and patients to check, analyze and repair solutions. A case consists of a problem description (e.g. symptoms) and a solution (e.g. a care plan and a therapy). Cases are stored in a database of cases called case bases. To solve an actual problem a notion of similarity is used to retrieve similar cases from case bases. The solutions of these found similar cases are used as starting points for solving the actual problems at hand. If it is not found then system generates basic care plan by ontology. After that system modified that case and stored in its ever expanding database for future use.

B. Some Case Attributes and their corresponding Weight for each types of Diabetes

The case base in this research work has been populated through continuous studies of diabetes from various websites [12] [13] [14] [15]. An effort has been made to find a co-relation between the initial cases and the input parameters/attributes of the cases to arrive at the relative importance of the parameters/attributes. Weights have been assigned to each attribute on assumptions based on conclusions by experienced Medical Professionals. The figure 2 shows the different weights of some of the symptoms against the various types of diabetes:

Symptoms	Weighted Values (0 to 1) of all types of Diabetes			
	D1	D2	D3	D4
Age	0.8	0.4	0.2	0.6
Sex	0.7	0.4	0.9	0.2
Family history of diabetes	0.8	0.8	0.4	0.8
Less physical activity	0.8	0.9	0.8	0.9
Obesity	0.8	0.8	0.4	0.9
Stress Level	0.8	0.9	0.7	0.9
Unhealthy life style	0.8	0.8	0.8	0.7
Increasing age	0.8	0.7	0.2	0.4
Sedentary jobs with long hour of work	0.8	0.8	0.1	0.7
Inexplicable work pressure	0.8	0.8	0.4	0.7
Stress full living	0.6	0.9	0.7	0.9
Ailment	0.6	0.8	0.8	0.9
Fatty and junk food	0.7	0.9	0.8	0.8
Changes in urban culture	0.8	0.7	0.2	0.9
Excessive thirst	0.9	0.9	0.1	0.9
Excessive hunger	0.9	0.2	0.1	0.7
Frequent urination	0.9	0.8	0.9	0.9

Fig. 2: Case attributes and their weight value

C. System Architecture

This system consists of four main modules namely the User Interface module, the CBR module, the Diabetes Care Ontology module and the Knowledge engineering modules. In our example the user is a qualified medical Knowledge engineering module professional and his interaction with the system environment is through menus and tables that allow him/her to simulate the patient's condition. Figure 3 depicts the architecture of DDCS.

1. User Interface Module: In this module users enter their profile and symptoms. That entered data going to the next module named case based reasoning module for further processing. After processing the result is also showing in this module.

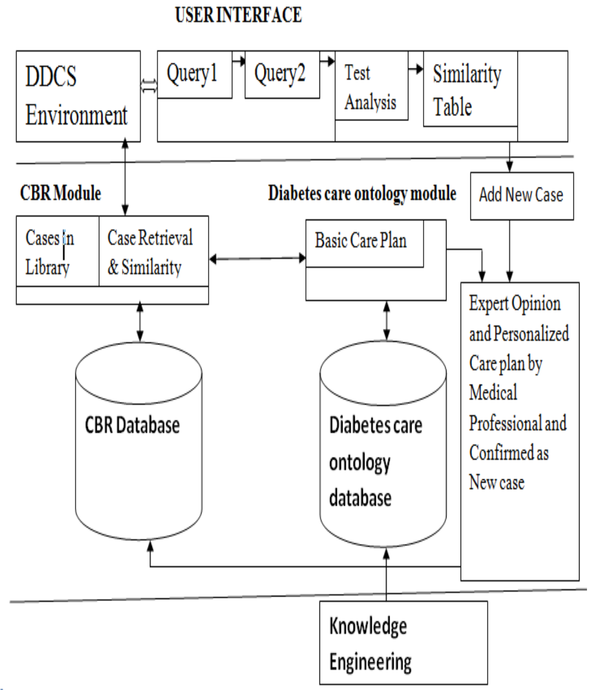

Fig. 3: System architecture

2. Case-based reasoning module (CBR Module): According to the users profile and symptoms (Query) condition this module retrieve the cases. Based on similarity function, only cases passed the similarity limit will send back to the user interface module for browsing. User can select any one of the cases to see the detail information or modify the information.
3. Diabetes care ontology module: This system will reason diabetes care concepts and relations through the information passed from CBR. It is the case when the case-based reasoning module cannot found satisfied cases and the system will consult this module to have a general care recommendation. This recommendation is reviewed by professionals to confirm or revise, and it becomes a new knowledge and will store in case database for future use.
4. Knowledge engineering modules: This module is used to construct diabetes care knowledge database, i.e. ontology. The knowledge comes from diabetes care expert.

D. Care Plan

A care-based decision support system designated to provide an efficient care plan for specific patients. For each new case, a basic care plan is generated by ontology. If the system fails to produce nearly similar cases then this basic care plan will be the starting point of making decisions for doctors. Our plan include medicine care plan, diet care plan, exercise care plan. For diabetes patients these cares are very much needed and necessary. Doctors who use this system can modify the care plan for each new case and store it into the database. For every complication, risk factors and seriousness level of the disease, care plan varies. Each past care plan which are retrieve by the system can help the doctors in making decision as well as they can introduces new care plans for specific new cases, which can be store in the database by the doctors for future use. Figure 4 shows the partial ontology structure of this Care Plan.

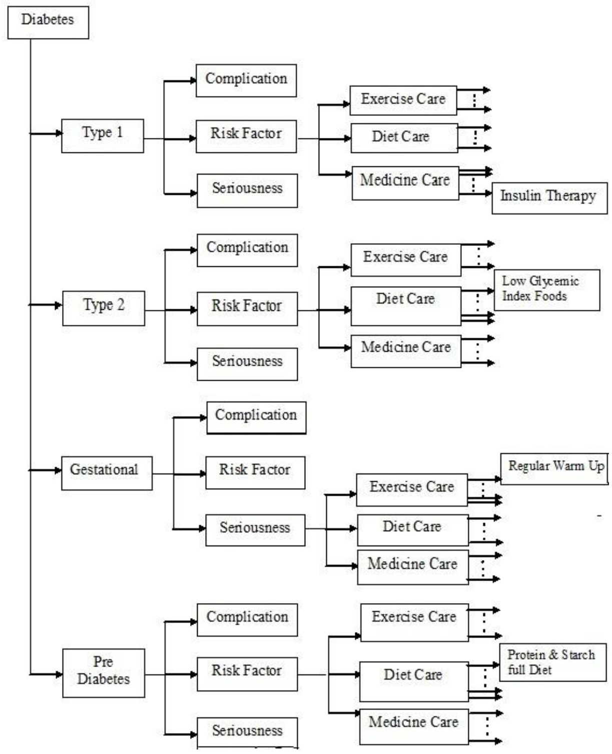

Fig. 4: Partial ontology structure of Care Plan

VI. ALGORITHM AND FLOW CHART

Step1: First check for 15 most common symptoms of diabetes. 'Query1' is the first phase query that is submitted. By patient real case study and discussing with health care provider the intensity (F) and weight (W) of these symptoms for a healthy human has fixed. As we know healthy human have certain range and sign of these symptoms. Then we calculate the weighted average of these symptoms as

$$T \text{ (for i=1 to n)} = \sum (W_i * F_i) / \sum (W_i)$$

This "T" is the threshold value for passing the first step i.e. this weighted average value shows patient has the chance of diabetes.

Now the system calculate the same weighted average for each new case (say Ti) and compare if $\{T_i > T\}$ then go to the second step for type, complexity and risk factor of diabetes as the patient have chance of Diabetes.

If $\{T_i < T\}$ then no need to check further because there are no chance of having diabetes.

Step2: 'Query2' is the second phase query that is submitted having all symptoms that from patients suffering for the checking of type, complexity and risk factor of Diabetes.

To check similarity between new case and past case the system first calculate the distance between values of individual symptoms (Local similarity) and distance between new and past cases (Global similarity).

New case and past case have values (p) and (c) for symptoms

(f). To find the local similarity

1. For Numeric features :-

δf (New case, Past case) = $\{|p - c| / \text{(max difference)}\}$

2. For Symbolic features :-

δf (New Case, Past case)

$= 0$ if $p = c$

= 1 otherwise

3. So the distance between two cases (Global similarity) is given as

Δ (New Case, past case) = weighted sum of {δf (New case, Past case)} for all features

Hence the Similarity between coming new case and stored past cases is given as

Similarity Index {Sl} (problem, case) =1/(1+ Δ (New Case, Past case))

Step3: For each of the case in the case base. We calculate the Similarity Index (SI) with respect to the Query2, and maintain a reverse sorted list of the case bases using this SI.
Step4: Check the maximum value of the SI (Wmax) against the Threshold value that is determined by Initial Learning Knowledge (**£**) i.e. W_{max}<**£**, then we go to the step6.
Step5: We regard the given query as a new case and add it to the existing case base for future use and go to step10.
Step6: We analyze the top similar cases from the case base and accordingly suggest the remedial measure and go to step10.
Step7: Go for further medical test and investigation. If medical test proves the patients have particular types of diabetes then go to step8, otherwise go to step9.
Step8: Add that case to the case base or adopt the case with some modifications.
Step9: Learned from the failed case.
Step10: End of the Query2 cycle.
Step11: End of the Query1 cycle
The flow chart for our proposed system is shown in figure5:

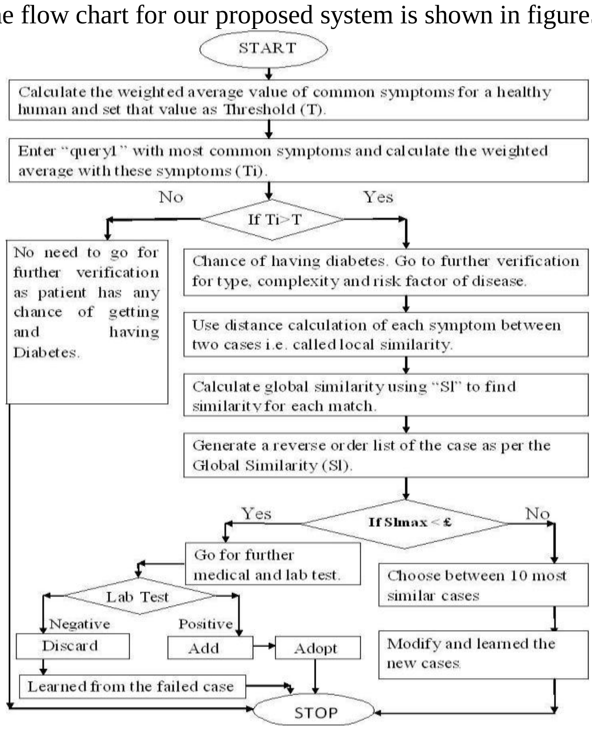

Fig. 5: Flowchart of DDCS

VII. METHODOLOGY AND RESULTS

In the first phase of the process user provides the symptoms which he/she suffers from. This symptom is the query1 of a new case to the DDCS system.

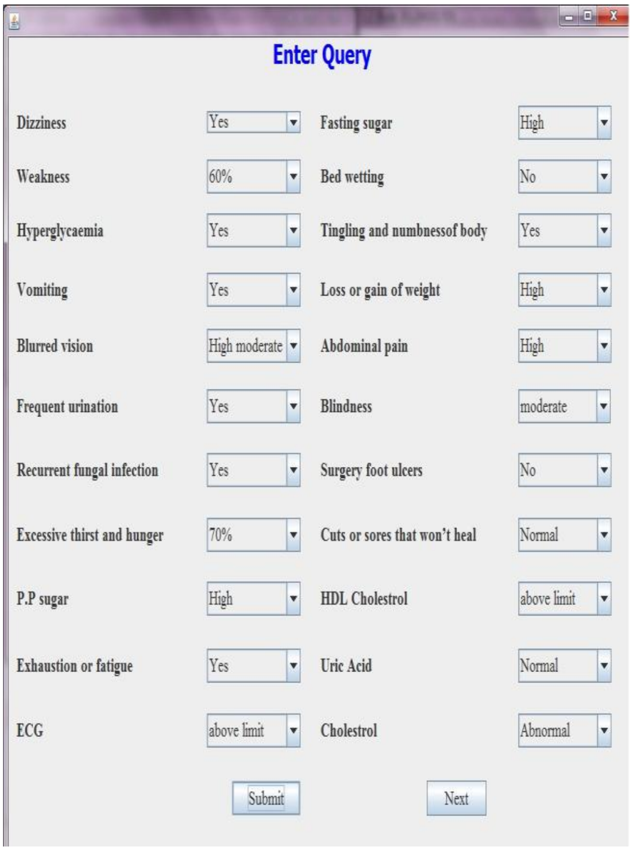

Fig. 6: Typical CBR partial Query for DDCS

If the weighted average of these common symptoms is greater than the threshold value (i.e. set for healthy human) then there is high probability of having Diabetes. For checking the complexity, risk factor and seriousness level of disease user again give all the symptoms which the patients is suffering from along with some medical test report. This is the query2 of the DDCS system. A typical CBR partial query for Diabetes Detection and care System is look like figure 6.

After that the system retrieves the similar cases from the case base according to the similarity index and based on the data provided by the patient. Similarity index is calculated by using local and global similarity of cases. The local and global similarity index is calculated by distance method as explained in the algorithm. According to similarity index similarity table is generated and it gives the reverse order of most similar cases. Check the maximum value of the SI (SI**max**) against a Threshold Score value (**£**) that is determined by Initial Learning Knowledge of the DDCS. If the SImax is greater than threshold score then system retrieves most similar cases. If not then go to further medical test, and after that case may be adopted by user or discarded. After retrieving similar cases the system produce care plan for new case according to the similar past case and doctor can adopt that care plan or may refer new cares for specific patients. If the system is unable to find the similar cases then a basic care plan will be generated by ontology. Based on new case provided by the patient, a similar case with its care plan will be retrieved is shown in figure 7.

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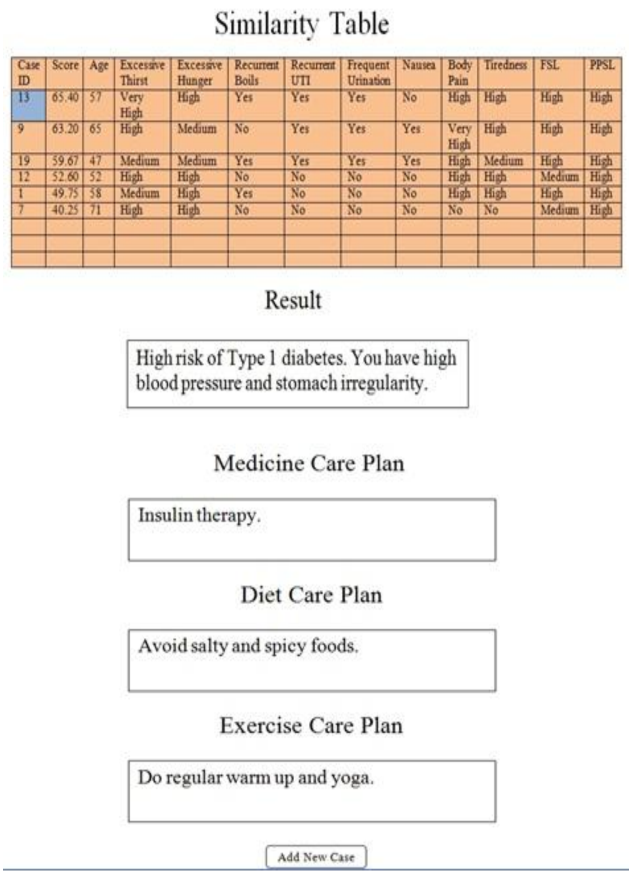

Case ID	Score	Age	Excessive Thirst	Excessive Hunger	Recurrent Boils	Recurrent UTI	Frequent Urination	Nausea	Body Pain	Tiredness	FSL	PPSL
13	65.40	57	Very High	High	Yes	Yes	Yes	No	High	High	High	High
9	63.20	65	High	Medium	No	Yes	Yes	Yes	Very High	High	High	High
19	59.67	47	Medium	Medium	Yes	Yes	Yes	Yes	High	Medium	High	High
12	52.60	52	High	High	No	No	No	No	High	High	Medium	High
1	49.75	58	Medium	High	Yes	No	No	No	High	High	High	High
7	40.25	71	High	High	No	No	No	No	No	No	Medium	High

Fig.7: An example of Similarity Table & Care Plan of DDCS

VIII. CONCLUSION

Currently, chronic patients grow constantly in aging society and require lots of health care resources. In order to demonstrate how information technology can be used to help chronic disease care and Detection, our proposed system combines CBR and ontology to detect the type and complications of diabetes and generate personalized care plan. Diabetes care is chosen by us as an example to use this system for it needs multi-profession care. This system shows, our system can provide diabetes care plan according to patient's profile and thus can reduce the Experiences learned from this system are useful for developing other disease care decision support systems as well. However, CBR is under the assumption of similar problems have similar solutions, and new problem can be solved by retrieving similar problems or adapting retrieved solutions. So a rich CBR case database is needed before it can match user's condition. Otherwise, when consulting diabetes care ontology, care expert need to involve and review the proposed care plan. In order to better fit the user's condition, adjustment is needed. Another issue is to structure such comprehensive diabetes care ontology requires different fields of care experts to contribute and integrate his knowledge. It takes a lot of efforts to do it and afterwards, how to maintain this ontology effectively when concepts or relationships need to be adjusted is another issue. In the future, evaluating the potential of using this system in practice is worth to explore. In addition, this system is not limited to support diabetes care. In the future, this system can be expanded to other disease care and it may be available for all people through the Internet using CBR system, grid computing and web technology.

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