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Reasoning Techniques for Diabetics Expert Systems

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Abstract

The field of reasoning methodologies is very important in the area of knowledge computing and engineering. Reasoning methodologies has been one of the standard and improving techniques with strong methods for health expert systems industry. Reasoning techniques has provided greatest support for predicting diagnosing and treatment of disease with correct case of results. Diabetes needs greatest support of reasoning techniques for diagnosis and treatment. This paper focus on the main technical characteristics of 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. In addition, this paper proposes the best reasoning technique for diabetic expert systems. The main result of this study covers a variety of four reasoning methodologies, which reveals that case based reasoning paradigm is the best reasoning technique methodology regarding to the issues of maintenance ,powerful and knowledge representations .

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Keywords: Diabetes;Rule based reasoning;case based reasoning; fuzzy reasoning; ontological reasoning; medical expert systems;

1. Introduction

Studies in the field of medical decision support systems have been established and due to the high success rate of these studies, interest in this field is increasing every day. These systems frequently use various artificial intelligence techniques. Reasoning techniques is one of major branches of artificial intelligence and, indeed, it is one of the most rapidly developing subfields of AI research.

Reasoning techniques were from the very beginning designed and used to analyse medical data sets. Today reasoning techniques provides several indispensible tools for intelligent data analysis. Especially in the last few years and in particular there is a lot of work done in medical diagnosis in small specialized diagnostic problems.

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There is a greater interest in the study of diseases that are common throughout the world. Diabetes is one of them [1].

Diabetes mellitus is a syndrome with disordered metabolism and inappropriate hyperglycemia due to either a deficiency of insulin secretion or to combination of insulin resistance and inadequate insulin secretion to compensate. Fortunately, diabetes can be managed very effectively through healthy lifestyle choices, primarily diet and exercise. Mostly, Type 2 diabetes is strongly connected with obesity, age, and physical inactivity [2]. Most medical resources reported that 90 to 95% of diabetic is diagnosed as type-2. Simply, in these cases the pancreas is not able to produce enough insulin to keep the blood sugar level within normal ranges. In addition, the majority of this type diabetics do not know they are suffering from it. Over 80-90% of Type 2 diabetes is overweight. 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]. Reasoning techniques has been an excellent support for making prediction of a particular from the data which is provided. Reasoning techniques in recent years have been the evolving, reliable and supporting tool in medical domain. Automatic learning has fetched a greater amount of interest in medical domain due to less amount of time for detection and less interaction with patient, saving time for patients care. There are many methods used in the reasoning technique rule based, case based ontology case based and fuzzy based. Among these methods, the case based is widely used. On the other hand, the development of computer technology and tools has provided a valuable assistance for Medicare [4].

An expert system is a computer program that provides expert advice as if a real person had been consulted where this advice can be decisions, recommendations or solutions [5]. The intention of our research is to provide self-monitor for patient of type 2 diabetes to get proper amount of daily calories with list of proper diet satisfy the amount of the calories. In this paper we propose the comparison results using reasoning techniques in diabetes exert systems. The paper goes through the reasoning techniques identifications, related works, comparison, discussion, results and conclusion.

2. Reasoning techniques in expert systems

The abilities of inference, reasoning, and learning are the main features of any expert system. The research area in this field covers a variety of reasoning methodologies, e.g.; automated reasoning, case-based reasoning, commonsense reasoning, multi-model reasoning, fuzzy reasoning, geometric reasoning, non-monotonic reasoning, model-based reasoning, probabilistic reasoning, causal reasoning, qualitative reasoning, spatial reasoning and temporal reasoning [6,7]. In this section we focus our discussion about the main characteristics of three of the reasoning methodologies which are commonly used in developing diabetic expert systems, namely; reasoning with production rules, fuzzy-rules, and case-based reasoning.

2.1 Reasoning with Production Rules

Production rules are the most commonly technique used in developing the inference engine of expert system. Forward chaining can be used to produce new facts (hence the term “production” rules), and backward chaining can deduce whether statements are true or not. Rule-based systems were one of the first large-scale commercial successes of artificial intelligence research. An expert system or knowledge-based system is the common term used to describe a rule-based processing system. It consists of three major elements, a knowledge base (the set of if-then rules and known facts), a working memory or database of derived facts and data, and an inference engine, which contains the reasoning logic used to process the rules and data[8,9].

Rule-based systems solve problems by taking an input specification and then “chaining” together the appropriate set of rules from the rule base to arrive at a solution. Given the same exact problem situation, the system will go through exactly the same amount of work to come up with the solution. In other words rule-based systems don’t inherently learn. In addition, given a problem that is outside the system’s original scope, the system often can’t render any assistance. Finally, rule-based systems are very time-consuming to build and maintain because rule extraction from experts is labor-intensive and rules are inherently dependent on other rules, making the addition of new knowledge to the system a complex debugging task.

Forward chaining is a data-driven reasoning process where a set of rules is used to drive new facts from an initial set of data. It does not use the resolution algorithm used in predicate logic. The forward-chaining algorithm generates new data by the simple and straightforward application or firing of the rules. As an inferencing procedure, forward chaining is very fast. Forward chaining is also used in real-time monitoring and diagnostic systems where quick identification and response to problems are required.

Backward chaining is often called goal-directed inferencing, because a particular consequence or goal clause is evaluated first, and then we go backward through the rules. Unlike forward chaining, which uses-rules to produce new information, backward chaining uses rules to answer questions about whether a goal clause is true or not. Backward chaining is more focused than forward chaining, because it only processes rules that are relevant to the question. It is similar to how resolution is used in predicate logic. However, it does not use contradiction. It simply traverses the rule base trying to prove that clauses are true in a systematic manner. Backward chaining is used for advisory systems, where users ask questions and get asked leading questions to find an answer. One advantage of backward chaining is that, because the inferencing is directed, information can be requested from the user when it is needed. Some expert systems also provide a trace capability which allows the user to ask the inference engine why it asking for some piece of information, or why it came to some conclusion.

2.2 Reasoning with Fuzzy Rules

In the rich history of rule-based reasoning in AI, the inference engines almost without exception were based on Boolean or binary logic. However, in the same way that neural networks have enriched the AI landscape by providing an alternative to symbol processing techniques, fuzzy logic has provided an alternative to Boolean logic-based systems [7]. Unlike Boolean logic, which has only two states, true or false, fuzzy logic deals with truth values which range continuously from 0 to 1. Thus something could be half true 0.5 or very likely true 0.9 or probably not true 0.1. The use of fuzzy logic in reasoning systems impacts not only the inference engine but the knowledge representation itself [7]. For, instead of making arbitrary distinctions between variables and states, as is required with Boolean logic systems, fuzzy logic allows one to express knowledge in a rule format that is close to a natural language expression.

The difference between this fuzzy rule and the Boolean-logic rules we used in our forward- and backward-chaining examples is that the clauses “temperature is hot” and “humidity is sticky” are not strictly true or false. Clauses in fuzzy rules are real-valued functions called membership functions that map the fuzzy set “hot” onto the domain of the fuzzy variable “temperature” and produce a truth-value that ranges from 0.0 to 1.0 (a continuous output value, much like neural networks).

Reasoning with fuzzy rule systems is a forward-chaining procedure. The initial numeric data values are fuzzified, that is, turned into fuzzy values using the membership functions. Instead of a match and conflict resolution phase where we select a triggered rule to fire, in fuzzy systems, all rules are evaluated, because all fuzzy rules can be true to some degree (ranging from 0.0 to 1.0). The antecedent clause truth values are combined using fuzzy logic operators (a fuzzy conjunction or and operation takes the minimum value of the two fuzzy clauses). Next, the fuzzy sets specified in the consequent clauses of all rules are combined, using the rule truth values as scaling factors. The result is a single fuzzy set, which is then defuzzified to return a crisp output value.

2.3 Reasoning with Cases

Case-Based Reasoning (CBR) means reasoning from experiences (old cases) in an effort to solve problems, critique solutions and explain anomalous situations. The CBR approach to problem-solving and learning has got a lot of attention within the Artificial Intelligence's community over the last few years, because as an intelligent-systems' method enables information managers to increase efficiency and reduce cost by substantially automating processes. People tend to be comfortable using the CBR methodology for decision making, in dynamically changing situations and other situations were much is unknown and when solutions are not clear.

The case is a list of features that lead to a particular outcome. (e.g. The information on a patient history and the associated diagnosis). Determining the appropriate case features is the main knowledge engineering task in developing medical case-based expert systems [10]. This task involves defining the terminology of the domain and gathering representative cases of problem solving by the expert. Representation of case can be in any of several forms (predicate, frames). The CBR systems' expertise is embodied in a collection (library) of past cases rather, than being encoded in classical rules. Each case typically contains a description of the problem plus a solution and/or the outcomes. The knowledge and reasoning process used by an expert to solve the problem is not recorded, but is implicit in the solution. A case-library can be a powerful corporate resource allowing everyone in an organization to tap in the corporate library, when handling a new problem. CBR allows the case-library to be developed incrementally, while its maintenance is relatively easy and can be carried out by domain experts.

The methodology of CBR is becoming popular in developing expert systems because it automates applications that are based on precedent or that contain incomplete causal models [6].In a rule-based systems an incomplete mode or an environment which does not take into account all variables could result in either an answer built on incomplete data or simply no answer at all. Case-based methodology attempt to get around this shortcoming by inputting and analyzing problem data. Case-based expert systems solve new problems by adapting solutions that were used for previous and similar problems. Adaptation is one of the main difficulties in developing Case-Based expert systems.

2.4 Ontological Case Base reasoning Methodology for Diabetes Management

Ontology is a formal and explicit specification of a shared conceptualization. Ontology defines a common vocabulary for researchers who need to share information in a domain. It includes machine-interpre definitions of basic concepts (classes) in the domain, properties of each concept describing various features and attributes of the concept (slots, relationships) and restrictions on slots (facets or role restrictions) . Ontology together with a set of individual instances of classes constitutes a knowledge base [20].

Domain knowledge ontology supports the implementation of intelligent Case Based Reasoning (CBR) systems. Standardized terminologies support efficient indexing and processing of patient data. It is an essential element for the implementation of knowledge-based clinical decision support by exploiting pre-defined semantic relationships, both hierarchical and non-hierarchical in nature. Systemized Nomenclature of Medicine-Clinical Terms (SNOMED CT) is the most comprehensive and complete terminology. For semantic retrieval purpose in CBR system and for the semantic interoperability of data collected from distributed EHR systems, a common terminology is needed to encode case-base knowledge. The unique identifiers and the conceptual structure representing each concept in a terminology system allow an unambiguous interpretation of the concept meaning across systems [21].

3. Literature Review and Related Work

M. Beulah et. al (2007) [11] introduced the ability to access diabetic expert system from any part of the world. They collect, organize, and distribute relevant knowledge and service information to the individuals. The project was designed and programmed via the dot net framework using rule based. The 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.

S. Kumar and B. Bhimrao (2012) [12] developed a natural therapy system for healing diabetic, they aim integrate all the natural treatment information of diabetes in one place using ESTA (Expert System Shell for Text Animation) as knowledge based system. Their system begins with Consultation asking the users to select the disease (Diabetes) for which they want different type of natural treatment solution then describes the diabetes diseases and their symptoms. After that describes the Natural Care (Herbal /Proper Nutrition) treatment solution of diabetes disease.

C. Marling et. Al (2014) [13] Presented systems are for CARE-PARTNER, which supports the long-term follow-up care of stem-cell transplantation patients; diabetes Support System, which aids in managing patients with type 1 diabetes on insulin pump therapy; renal disease; diagnosis and treatment of stress-related disorders using case-based reasoning.

N. Nnamoko et.al (2013) [14] proposed a fuzzy expert system framework that combines case-based and rule-based reasoning effectively to produce a usable tool for Type 2 Diabetes Mellitus (T2DM) management, to produce crisp outputs to patients in the form of low-risk advice. The extended framework features a combined reasoning approach for simplified output in the form of decision support for clinicians. With seven operational input variables and two additional pre-set variables for testing, the results of the proposed work will be compared with other methods using similarity to expert's decision as metrics. Using MATLAB as a tool.

Tawfik. S. Zeki et.al (2012) [15] designed an expert system for diagnosis all types of diabetes. After data acquisition and designing a rule-based expert system, there system has been coded with VP_Expert Shell and tested in Shahid Hasheminezhad Teaching Hospital affiliated to Tehran University of Medical Sciences and final expert system has been presented.

Margret Anouncia S. et.al (2013) [16] proposed a diagnosis system for diabetes. The system is implemented to diagnose the type of diabetes with the input symptoms given by the user. The system proves to be advantageous in aspects, such as accuracy and time consumption due to the rough set based knowledge representation. The system is adaptable for any number of symptoms and is evaluated with respect to the rule based. The inference engine interacts with the knowledge base which is constructed using rough sets for the process of diagnosis. The system is implemented using Java and JSP.

Abdelhak.M et. al (2013) [17] proposed an approach based on using a multi-criteria decision guided by a case-based reasoning (CBR) approach. The study is intended to experiment with a multiple criteria decision approach to medical care in the diagnosis and the proposed therapy for diabetic patients. The system is developed in JAVA with an interconnecting module to the JCOLIBRI system.

M. Kalpana and A.V Senthil Kumar (2011) [18] proposed a fuzzy expert system framework which constructs large scale knowledge based system effectively for diabetes. The knowledge is constructed by using the fuzzification to convert crisp values into fuzzy values. By applying the fuzzy verdict mechanism, diagnosis of diabetes becomes simple for medical practitioners. The proposed fuzzy expert system for diabetes application was implemented with the MATLAB using rules for knowledge representation.

Cindy. M et.al (2009) [19] presents a case-based decision support system prototype to assist patients with Type 1 diabetes on insulin pump therapy, detect common problems in blood glucose control, and retrieval metrics were developed to find the most relevant past cases for solving current problems to control blood glucose levels.. The system is developed in JAVA.

Shaker H. El-Sappagh et. al (2014) [20] Proposed an ontology engineering methodology to generate case bases in the medical domain. they mainly focuses on the research of case representation in the form of ontology to support the case semantic retrieval and enhance all knowledge intensive CBR processes A case study on diabetes diagnosis case base had been provided to evaluate the proposed methodology, the ontology is created and implemented using OWL 2 language and Protégé tool.

Jian-xun .C et.al (2013) [21] proposed a system which combines CBR and ontology to generate personalized care plan. they choose diabetes care as an example to use this system. When there is no matched case, embedded in there system diabetes care ontology can be consulted, they choose OWL DL(OWL with Description Logics) as the language of designing there ontology and builted by Protégé.

D. Forbes and J. Singh (2012) [22] introduces a novel approach using new technology to improve understanding between the patient and healthcare practitioner they developed a framework that links medical information with different language and cultural information to provide ease of understanding and communication between the patient from a minority group with a healthcare practitioner from a different cultural group. The key component of this framework is the Type-2 Diabetes Management Patient-Practitioner Assistive Communication Ontology, The tool used in the implementation process is protégé 4.2.

4. Results and Discussion

Tables 1, 2 , 3 and 4 show the results of our analysis of the expert systems in diabetes domain, based on the type of the reasoning methodology, during the last five years. Our frame work includes the flowing features:
• The reasoning based of the system, it is either rule or case or fuzzy or ontology.
• The system's purpose.
• The developing tool, it is either langue or shells.
• The knowledge representation technique of the system's knowledge-base, it is, frame, ontology, rule or case or graphs.

Table 1: Rule based expert systems for diabetes

System	Purpose	Knowledge technique	Developing tool	Authors
Fully Automated Real-Time Web-Centric Expert System	detect and give early diagnosis of three types of diabetes	Rule	Dot net	P. M. Beulah et.al (2007) [11]
knowledge Base Expert System for Natural treatment of Diabetes disease	describes the Natural Care (Herbal /Proper Nutrition) treatment solution of diabetes disease.	Rule	ESTA	S. Kumar and B. Bhimrao (2012) [12]
An Expert System for Diabetes Diagnosis	diagnosis all types of diabetes	Rule	VP_Expert Shell	Tawfik. S. Zeki et.al (2012) [15]

Table 2: Case based reasoning expert systems for diabetes

System	Purpose	Knowledge technique	Developing tool	Authors
case-based reasoning in medical domains	managing patients with type 1 diabetes	Case	NA	C. Marling et. Al (2014) [13]
Toward case based reasoning for diabetes management	control blood glucose levels	Case	JAVA	Cindy. M et.al (2009) [19]
Decision support system application on healthcare	diagnosis for diabetic patients	Case & graphs	JAVA + JCOLIBRI	Abdelhak .M et. al (2013) [17]

Table 3: Fuzzy-based expert systems for diabetes

System	Purpose	Knowledge technique	Developing tool	Authors
Design of a Diabetic Diagnosis System Using Rough Sets	diagnose the type of diabetes	Rule	Java and JSP	Margret Anouncia S. et.al (2013) [16]
Fuzzy Expert System for Type 2 Diabetes Mellitus	management of Type 2 Diabetes	Rule & case	MATLAB	N. Nnamoko et.al (2013) [14]
Fuzzy Expert System for Diabetes	constructs large scale knowledge based system effectively for diabetes	Rule	MATLAB	M.Kalpana and A.V Senthil Kumar (2011) [18]

Table 4: Ontology case based reasoning expert systems for diabetes

System	Purpose	Knowledge technique	Developing tool	Authors
Ontology for Type2 Diabetes Management	Understanding between Type-2 Diabetes Patient and healthcare practitioner	Ontology	protégé 4.2	D.Forbes and J. Singh (2012)[22]
Diabetes Care Decision Support System	generate personalized care plan for diabetes	Ontology	Protégé	Jian-xun .C et.al(2013) [21]
An Ontological Case Base Engineering Methodology for Diabetes Management	diagnosis for diabetic patients	Ontology	Protégé	Shaker H. El-Sappagh et. Al(2014) [20]

From our analysis presented in tables 1,2,3, and 4 as well as the reported research mentioned in section 3 , it can seen the following observations and results:

1- Most of the case based reasoning systems were developed in Java, most of fuzzy based reasoning systems were developed in MATLAB, and rule based reasoning were developed with dot net/ESTA/VP expert shell. Reasoning techniques used for deferent purpose in diabetes domain.
2- All of the ontology case based reasoning systems developed in Protégé tool and the ontology presented by OWL, because OWL (Web Ontology Language) is easier to express meaning than XML, RDF, RDF-S.
3- Rule-based systems are very time-consuming to build and maintain because rule extraction from experts is labor-intensive and rules are inherently dependent on other rules, making the addition of new knowledge to the system a complex debugging task.
4- Case based reasoning is a powerful methodology regarding to the issues of maintenance and knowledge representations over the rule based system.

5. Conclusion and future work

The research in diabetic systems is important for both medical industry and diabetes patients. Reasoning techniques for diagnosing and treatment diabetes is urgently needed for helping both specialist doctors and patients. The abilities of inference, reasoning, and learning are the main features of any expert system. The research area in this field covers a variety of reasoning methodologies, e.g.; case-based reasoning, ontology case-based reasoning, fuzzy reasoning and rule reasoning. Case based reasoning is the more efficient, powerful and less cost.Our research was motivated by the need of such techniques, therefore the reasoning techniques for diabetics expert system has been presented in this paper as platform towards designing and implementation expert systems for diabetes. Now we are developing expert system for diabetes diet that intended to be used in Sudan and Arab countries we finished the knowledge acquisition stage and going to design and implement an intelligent mobile base expert system in Arabic language interface using the case based reasoning as reasoning technique. In future we need develop a new approach and then compare it with the current methods in this paper.

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