

# AN INTELLIGENT DIAGNOSTIC SYSTEM FOR DIABETES USING RULE BASED REASONING AND OBJECT-ORIENTED METHODOLOGY

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## ABSTRACT

Diabetes is one of the most prevalent chronic diseases with many short and long term complications. This paper presents an intelligent diagnostic system specifically developed for Type 1 and Type 2 diabetes, using rule-based reasoning and object-oriented methodology. The system accurately diagnoses Type 1 and Type 2 diabetes based on the sign-symptoms entered, and also provides an explanation to reasoning. We believe that great improvements can be provided to the medical practitioners and also the diabetics with the implementation of this system.

## KEYWORDS

Diabetes diagnosis; intelligent system; rule-based reasoning; object-oriented methodology

## 1. INTRODUCTION

Diabetes is a complex metabolic disorder which is characterized by persistent hyperglycemia. It is a chronic disease that has a high prevalence rate worldwide. It has been estimated that the total number of people in the world with diabetes to rise from 171 million in 2000 to 366 million in 2030 (Wild et al., 2007). With the growing number of diabetics, Malaysia is also experiencing the same phenomenon, as prevalence stands at 14.9% of adult population. It was also recorded that diabetes is one of the top ten causes of death in Malaysia (Tan, 2009). The healthcare for a diabetes patient is far more expensive compared to one without diabetes, however, with proper care and management, this disease can be controlled.

Diabetes can be categorized into two main types, namely, Type 1 (insulin-dependent) and Type 2 (noninsulin-dependent). Diabetics are prone to develop various complications, especially when the disease is not well controlled. The major complications are categorized as micro vascular (nephropathy, retinopathy, and neuropathy) and macro vascular (coronary artery disease, stroke, and peripheral arterial disease).

Early detection of diabetes is of paramount important. Generally, a physician diagnoses a diabetic by evaluating the current test results of a patient or by comparing the patient with other patients who have the same condition. This may consume time. Early detection and screening for individuals with impaired glucose tolerance can help lower risk of developing diabetes and reduce the long term burden to individuals and health services. For this reason, an intelligent diagnostic system for diabetes was developed. Intelligent system in Malaysia is not so widely spread but with the development of information and communication technology (ICT), it is no doubt that Malaysians will utilize and advance to this new era.

## 2. RELATED WORK

Knowledge-based systems (KBS) and intelligent computing models (ICM) are the two main techniques used in designing intelligent systems. KBS are used in the areas where knowledge is predominant, unlike ICM which is data dominant. Many variants to KBS exist, namely, rule-based reasoning (RBR), case-based reasoning (CBR) and model-based reasoning (MBR). In RBR, the knowledge is represented by symbolic rules and inference is performed by chaining through the rules recursively. Examples of RBR systems include MYCIN, to diagnose and treat infections in blood and nervous system (Pandey et al., 2009) and HEpathology

Rule-based Medical Expert System (HERMES) for chronic liver disease diagnosis (Bonfa et al., 1993). CBR technique uses stored solutions from previous cases, expertise and knowledge to solve current new cases (Liao, 2004). An example of CBR is CASEY, used to diagnose heart failures (Schmidt et al., 2001). For MBR, models are used to represent knowledge for the observation, prediction and evaluation. YAQ, a diagnosis system for respiratory distress syndrome (Pandey et al., 2009) and ONYX, an oncologic embodied model to develop possible plans and recommendations for cancer patient's chemotherapy treatments (Shortliffe, 1986) are two examples of MBR developed in medical industry.

ICM techniques include artificial neural network (ANN), genetic algorithm (GA) and fuzzy logic (FL). ANN is one of the widely used artificial intelligence technique for pattern recognition and machine learning as it is considered to be highly accurate in data prediction. ANN has been successfully used in confirming dengue cases (Hani et al., 2010) and coronary artery disease (Akay, 1992), however, it is criticized for the lack of explanatory power. FL uses a fuzzy set of mathematical theory to make the computer system behave less precisely than normal computers to simulate the unstructured reasoning (Liao, 2004). It uses linguistic variables to define the system's knowledge base as a collection of fuzzy IF-THEN rules. A popular intelligent system based on FL is DoctorMoon, capable of diagnosing pulmonary tuberculosis, lung abscess, lung cancer, asthma, pneumonia and bronchiectasis (Phuong et al., 2001). FL is simple and can be easily used to design a system and the rules are easy to produce as well, however, FL systems are not easily maintained when large number of conditions change, and this can affect the performance of the FL system. Finally, GA is a search method based on the principles of natural selection and population genetics. It is an iterative procedure that generates and mutates new sample points in the search space using crossover and mutation (Whitley, 1994). Examples of GA intelligent systems are GENIFER that diagnoses breast cancer (Llora et al., 1999) and computerized detection for mammographic diagnosis (Kupinski et al., 1997).

Other approaches include data mining and agents. Data mining is defined as the extraction of implicit, previously unknown, and potentially useful information from data (Han et al., 2006). Most of the data mining methods in medical domain deploy different techniques for the diagnosis of various diseases such as classification and regression tree for diabetes (Breault et al., 2002) and prediction rule for obstructive sleep apnea (Kwiatkowska et al., 2007). Meanwhile, agents are software and/or hardware that are capable of acting exactly in order to accomplish tasks on behalf of its user (Jennings & Wooldridge, 1998). In medical, an example would be AMPLIA, a system to diagnose rheumatic fever (Vicari, 2003).

Object-oriented (OO) methodology has been widely used in intelligent systems as well. It is commonly used for knowledge representations and knowledge learning as it enables data and real world concepts to be modeled in a more natural way. Examples of OO systems are DRAMA (Lin et al., 2003), a system to contain and process knowledge, and Electronic Nursing Record System (ENRS) for clinical, reference and administrative purposes in Bundang Seoul National University Hospital, Korea (Park et al., 2007).

Based on the literature reviews, it can be noted that many approaches can be considered to design and develop a diagnostic system. In this study, a diagnostic system using RBR-OO approach was developed. The advantage of using RBR is it is easy to construct, debug and maintain the system and by using an Oracle database for knowledge representation, rules are more structured whereas OO methodology helps to structure the whole system in a conceptual view which eases the system implementation. The main objective of this study is to build a prototype for diabetes diagnosis (Type 1 and Type 2) based on RBR-OO methodology. To be precise, we aim to (i) design a general framework of the intelligent diagnostic system based on RBR-OO, (ii) implement RBR algorithm to perform the diagnoses and (iii) demonstrate the applicability of RBR-OO methodology in the healthcare environment.

### 3. METHODOLOGY

Figure 1 depicts the overall overview of the system. The database layer is where the knowledge resides, gathered by performing literature reviews and interviewing two medical experts. The IF-THEN rules were then formulated to diagnose both Type 1 and Type 2 diabetes, and they reside in the relational database. An example of the rules used to diagnose a non-diabetic is as follows:

```
If age < 40
  If fasting plasma glucose < 7mmol/l
  Then patient is negative for Diabetes
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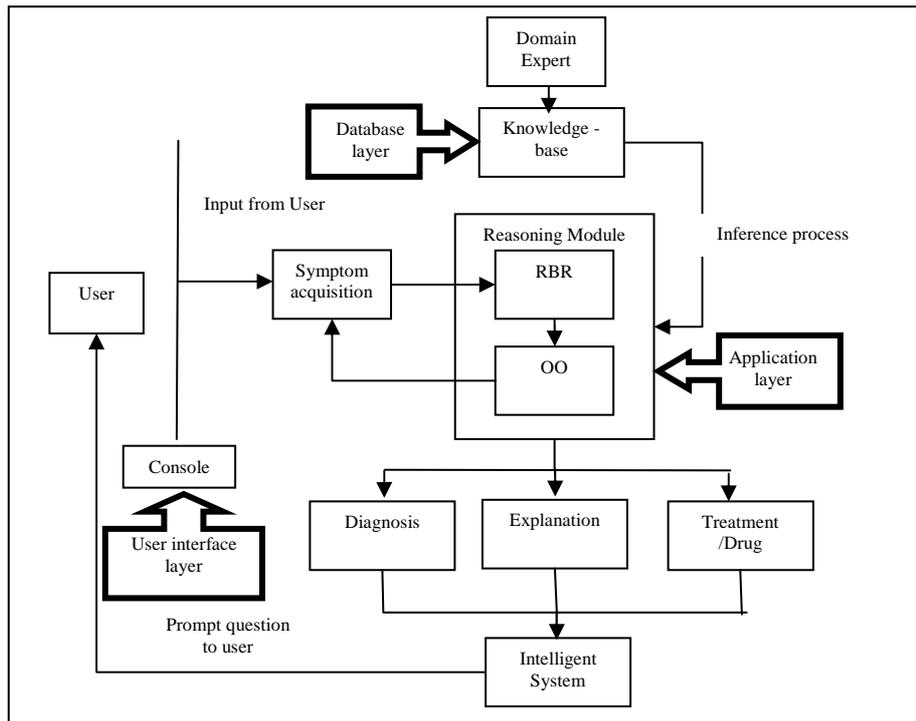


Figure 1. Overall overview of the system

The application layer actually refers to the inference engine that was developed in Java. The inference engine will access the knowledge base and all the rules that match the patient's symptoms will contribute to the reasoning process and then to the final conclusion. Forward-chaining method where the engine tries to prove a rule conclusion by confirming the truth of all its premises was used in this study. These premises may themselves be conclusions of other rules. All the sign-symptoms of patients are entered by the users via the console, which is the user interface layer. Apart from diagnosing, the system is able to explain its diagnosis, a feature that enables the subsystem to examine its own reasoning process.

The system was built using OO approach, fully utilizing the benefits of using objects and inheritance. Diabetes was used as the parent object consisting of common attributes and methods needed to diagnose both types of diabetes. Two other objects, Type 1 and Type 2 were derived from the parent object. As the name implies, Type 1 consists of all the attributes to diagnose Type 1 diabetes whereas Type 2 is for diagnosing Type 2 diabetes.

#### 4. RESULTS AND DISCUSSION

The system was tested by three medical practitioners who concluded that all the diagnoses are accurate. In addition, five patients (two Type 1 diabetics and three non-diabetics) also tested the system, and their diagnoses were accurate as well. The system was also tested in terms of the response time. An example of Type 1 diagnosis is depicted in Figure 3. The diagnosis is done once all the relevant questions are answered, and it can be noted that the overall time taken for this example is merely 15 seconds, which is a fast response. The patient is diagnosed to be Type 1 diabetic as the fasting plasma glucose level is more than 7 mmol/l, as explained by the system. If the user wishes to view a general treatment plan, then the system displays it accordingly. The specific drug prescriptions etc. were not included as part of the treatment plan as these can only be administered by the medical practitioners.

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Welcome to Intelligent Diabetes Consultant
Answer the question below to diagnose.
Please answer Y or N for the following questions.
If the question requires user to input a value, please do so with an integer value.
What is your name? Vithya
2011/Apr/28 14:31:27
Please enter your age:
34
Is your visit to toilet increased from normal?
y
Do you drink alot of water?
y
Do you have an increased urge to eat sweet foods like chocolates, sweets, canned drinks lately?
y
Do you feel tired lately (fatigue)?
n
Is there a noticeable weight loss lately?
y
Please enter your fasting plasma glucose level from your last check up:
8
Hi VITHYA
Your fasting plasma glucose level shows that you are positive for type 1 diabetes.
There are some positive diabetes symptoms as well.
Do you want to view the treatment plans?
y
You are insulin dependent. Please check with you physician your insulin jab intake.
2011/Apr/28 14:31:42

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Figure 2. Type 1 diabetes diagnosis

The system accurately diagnoses Type 1 and Type 2 diabetes, and at a fast rate as well. Therefore, it has been proved that RBR-OO methodology can be successfully used to develop diagnostic system, in this case, the disease being Type 1 and Type 2 diabetes. We believe this simple integration can be extended to other diseases as well, for example, heart disease. It is to note that the authors do not claim this approach to be the best approach, however, we have successfully showed that simple techniques can be used to diagnose diseases.

## 5. CONCLUSION

The diagnosis of diabetes can be improved by incorporating the advancements of information technology. With that in mind, an intelligent diagnostic system for Type 1 and Type 2 diabetes was developed using RBR-OO methodology. The system was tested using real data, and the diagnoses were done accurately and quickly. With this, all the three objectives were met as it is proved that a diagnosis system can be successfully developed using simple methodologies, in this case, RBR-OO.

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