EXPERT SYSTEM FOR DIAGNOSIS AND
TREATMENT OF DIABETES

GRADUATE PROJECT TECHNICAL REPORT

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by

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ABSTRACT

A user-friendly medical intelligent assistant was developed to aid patients with diabetes and also medical personnel using the software as a diagnostic and reference tool. The software is an important asset to detect and treat diabetes. The prototype was developed as a knowledge-based system with a graphical interface which permits patients and medical practitioners to enter detailed information and laboratory results. The intelligent assistant then gives a diagnosis and steps to follow in order to achieve the optimum health status for the patient.
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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Diabetes Mellitus, commonly known as diabetes, is a chronic condition associated with abnormally high levels of glucose (sugar) in the blood. It can cause serious health complications like heart disease, blindness, kidney failure, and lower-extremity amputations. Diabetes is a lifelong disease in which your body does not make enough insulin or cannot properly use the insulin it produces. To understand diabetes, one needs to know how the body normally uses sugar or glucose for energy.

The food that a person intakes is converted into glucose (sugar). Glucose is the source of energy required by the human body to perform its tasks. The pancreas takes an important part in this process, secreting a hormone called insulin, which helps to work on the glucose and makes it easily absorbable by the cells. People with diabetes can not secrete the right amount of this hormone or can not use it properly for normal body functions. This causes a buildup of sugar in the blood. Heart diseases, blindness, and other serious health complications can be caused by diabetes.

When the glucose is not used, symptoms of diabetes begin to appear. Some of the symptoms of diabetes are:

- Frequent urination
- Excessive thirst
- Extreme hunger
- Unusual weight loss
- Increased fatigue
- Irritability
• Blurry vision

Since the body cells are not using glucose for energy, it starts to use stored fat for energy. Other signs of diabetes include vomiting, abdominal pain, and weakness.

There are 2 types of diabetes: Type I and Type II. In Type I, the body makes little or no insulin as shown in figure 1.1 where the dotted lines indicate the range of glucose concentration expected in a normal individual, and insulin must be given by injection. Type I diabetes is commonly called Juvenile Diabetes or Diabetes Mellitus. About 10% of all people with diabetes have Type I. It usually occurs in younger people, but can occur in older adults. This type of diabetes can be controlled by daily injections, meal planning, exercise, self-blood glucose monitoring, and education.

In Type II diabetes, the most common type of diabetes, occurs when the body makes insulin, but the cells cannot use it properly. Thus, it most often occurs in people who are over 40 years of age, overweight, and/or have a family history of diabetes. This type can be controlled through:

• Meal planning
• Reaching & maintaining a healthy weight
• Exercise
• Possible use of diabetes pills or insulin injections
• Self blood glucose monitoring
• Education.

Diabetes is a disease that affects more then 100 million people in the world, including 16 million Americans [HeJlesen 2000]. Diabetes is now being recognized as a public health problem of potentially enormous proportions. In Canada, there are more
than 1 million people living with either Type I or Type II diabetes. Diabetes is ranked as the seven leading cause of death in Canada and the United States [Minister 1999].

Although the cause is unknown, some factors contributing to the Type II diabetes are:

- Heredity
- Obesity Pregnancy
- Physical or Emotional Stress Aging
- Infections and History of Pancreatic Disease

Figure 1.1: Glucose tolerance curve. Insulin-dependent diabetes mellitus (IDDM) vs Normal
1.2 Expert System

An expert system is a computer application that performs a task that would otherwise be performed by a human expert. For example, there are expert systems that can diagnose human illnesses, make financial forecasts, and schedule routes for delivery vehicles. Some expert systems are designed to take the place of human experts, while others are designed to aid them [Webopedia 1996]. Medical software tools began to emerge during the 1980's, some became known as 'expert systems'. In contrast to conventional software which process data, expert systems process 'knowledge'. For this reason, expert systems are also called 'Knowledge Based Systems' (KBS). The most well known medical example is MYCIN. This expert system was developed at Stanford University in 1976 to aid physicians in diagnosing and treating patients with infectious blood diseases caused by bacteria in the blood. These diseases can be fatal if not recognized and treated quickly. Many other medical expert systems have followed the success of MYCIN.

An expert system with a graphical user-friendly interface is used in this project as diagnostic-aid tool by medical practitioners to guide in the diagnosis and treatment of diabetes. The system allows the medical practitioners to diagnose, develop a treatment plan, and have a follow up of the patients. The expert system uses a user-friendly graphical interface and asks for information required for determining the diagnosis and treatment for patients with diabetes.
Due to the recent high cost of health care, medical software is becoming very popular and useful for medical practitioners. Diabetes’ diagnosis involves a great number of complex features such as age, hereditary, physical activity, etc. Advantages of medical software include more accurate prediction, correct diagnosis and less time spent in diagnosis [Levine 1990]. The intelligent assistant developed monitors, calculates, and helps to obtain the correct diagnosis of a patient with diabetes. An intelligent system in diabetes is an efficient tool for medical practitioners to perform successful diagnose, treatment, and follow-up of patients’ suffering of this disease. The extensive implementation of expert systems in medical science has proven to successfully reduce cost [Giarratano 1994]. Duarte et al [Duarte 2001] developed a prototype expert system using CLIPS for the “Sick Day Rules of Diabetes.” A more complete and user-friendly expert system for the treatment and diagnose of diabetes with a graphical interface and Web portability was developed for this project.

CLIPS (C Language Integrated Production System), is a knowledge-based expert system shell originally developed at NASA (National Aeronautics and Space Administration). CLIPS lacks a friendly graphical user interface. JESS is a rule engine and scripting environment written entirely in Sun's Java language by Ernest Friedman-Hill at Sandia National Laboratories in Livermore, CA. Sandia National Laboratories is a multiprogram engineering and science laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the US Department of Energy’s National Nuclear Security Administration.

JESS was originally inspired by the CLIPS expert system shell, but has grown into a complete, distinct Java-influenced environment of its own [Sun 2002]. Allowing
for a user-friendly graphical interface with Web portability makes JESS the most appropriate expert system shell to be used in this project. This system uses JESS as the expert system shell to develop a more complete and user-friendly expert system for the treatment and diagnose of diabetes.

Dr Steve Ponder, from the Driscoll Children's Hospital is a diabetes expert dedicated to the treatment and diagnosis of diabetes. He was the human expert in this project. Dr Ponder is aware that the development of a user-friendly expert system with a graphical interface and Web portability will enable his patients to deal better with their disease. Graphical interfaces will be very useful for patients with diabetes. Since the system developed provides a user-friendly graphical interface, it offers a very efficient tool for patients with their treatment and diagnosis of diabetes. It gives users the ease and efficiency, in terms of access, which allows for a more informed and healthy patient.
2. JESSDIABETES

JESSDIABETES improves the efficiency in the process of treatment and diagnosis of diabetes by utilizing artificial intelligence technology to provide instant access to a diabetes expert system. Diabetes is there 24 hours a day, every day, but patients do not see their doctors every day. Occasional office visits may not control the blood sugars that determine their health in an efficient way. The ability to access the diabetes expert system anytime is very beneficial to patients suffering with diabetes because of the convenience and accuracy of its results.

Usually, most patients with diabetes self-monitor their blood glucose several times a day and go to the hospital once a month. This process of treatment is very tiresome for the patient. Monitoring blood glucose periodically and making appropriate adjustments are constant challenges for people with diabetes. The expert system JESSDIABETES' reliable and powerful instant diabetes diagnose and treatment software makes that process easy. Every patient with the condition of diabetes needs to keep track of his or her health in order to have a normal daily life. Therefore, JESSDIABETES, a graphical user-friendly expert system for diabetes, is of great benefit for patients with the condition.

The patients accessing the system are first introduced to the expert system by displaying a welcoming message in the user-friendly interface and then he or she will be informed of the purpose of the system. The patients are informed that they are using medical software for diagnosis and treatment of diabetes. There will also be a general warning and a normal disclaimer.
The next screen of the graphical user interface to the expert system prompts the patient with some questions that he or she is able to choose from a list of pre-selected optional answers. The expert system then presents more questions to gather all the information necessary from the patient in order to obtain the most accurate diagnosis.

The prototype expert system presents a list of diagnostic questions, which are similar to the questions that would be asked to a patient who goes to a normal visit to the doctor. The user can select age, symptoms, urine test values, choice of tests to perform, blood glucose values, and other test values from different options available. Depending on the response from the patient, the output from the prototype expert system is either a diagnosis and suggested treatment of diabetes or a statement that the patient is in danger and should go to the doctor as soon as possible.

For instance, the patients are asked some questions such as if they are feeling ill, if they have been nauseated or sick to their stomachs, if they have thrown up or vomited in the past six hours. The system then will inquire how many times has the patient vomited, and it will also ask if he or she is taking any prescribed medication.

If the patient presents any of the symptoms in question following this diagnostic process, then the system asks the patient to perform a glucometer test. The system will instruct the patient how to perform the test and also inform the patient that the blood glucose level will be measured using a few drops of blood during the test in order to check if there is need for insulin. Then the patient will be informed that the normal values are between 110 and 160 mg/dl and will be asked to enter the values obtained in the test.
Next, the patient is asked to perform a UA dipstick test in order to measure the ketones in his body. The system informs the patient on how to perform the test and why it is important and what is being tested. Patients are informed by the system that the litmus stick test is to check for blood, bacteria, sugar and ketones in the urine which are symptoms of diabetes. If the patients have obtained positive response to the glucometer test and UA dipstick test, then the system asks the patient to perform some other test to continue with the diagnosis.

Once the system has all the required information obtained from the series of questions answered by the patient and combined with the laboratory results entered, the system displays the diagnosis and treatment for the condition of the patient. Finally, patients with diabetes mellitus receive optimal therapy which includes feeding therapy, exercise therapy, and insulin or drug therapy. The expert system outputs on screen the treatment plan to be followed. The treatment plan to be followed displays the type of insulin the patient needs to take depending on the input and the symptoms entered in the system. The system also advises the patient to carry on with some precautions. For example, if the patient suffers form hyperglycemia (abnormally high sugar in the blood) then he or she is advised to control sugar consumption at once and must constantly check blood glucose level until it reaches a stable value.

Aspects such as nutrition and fitness management are also part of the system's suggestions in order to maintain stable glucose levels within a normal range. Maintaining a healthy diet and a regular exercise regimen is encouraged by the system as key to good health for patients with diabetes.
3. SYSTEM DESIGN

3.1 ENVIRONMENT

The expert system developed utilizes a user-friendly graphical interface. The system was developed using the Java Expert System Shell JESS. JESS is a rule engine and scripting environment written entirely in the Java language. JESS was originally inspired by the CLIPS expert system shell, but has grown into a complete, distinct Java-influenced environment of its own. Using JESS, it is possible to build Java applets and applications that have the capacity to "reason" using knowledge you supply in the form of declarative rules. JESS is surprisingly fast, and for some problems is faster than CLIPS itself [Sun 2002]. JESS uses JAVA to implement Rule-Based Expert Systems. JESS gives the applets and applications the ability to “reason” using the declarative rules. Other components needed for the project will be the Java developers kit (variously know as JDK or SDK) version 1.2 or higher.

JESS 6.0 System Requirements:

The following are the system requirement for developers and the user.

- Intel Pentium, 100 MHz processor or higher.
- Windows 3.1, 95 / 98 / XP or Windows NT workstation operating systems.
- 10 MB available hard drive space.
- Minimum 16 MB RAM.
3.2 Method and Procedure

The development of the expert system prototype for diagnosis of diabetes required several phases as follows:

1. Knowledge acquisition
2. Knowledge representation
3. Coding
4. Testing

The method and procedure for the development of the expert system prototype for diabetes consisted of three sections. The first section was the data identification and acquisition for the condition of diabetes. The second section consisted on the analysis of the knowledge and its classification in order to be organized into facts and rules for the expert system shell JESS syntax and structure. Finally, the third section was the creation of the user interface and the Web portability for the prototype expert system.

The expert system developed is for the treatment and diagnosis of diabetes. The system is flexible enough to allow for modifications in the future. New discoveries or procedures in the treatment and diagnosis of diabetes will be able to be incorporated into the system to make it more precise and efficient.
3.3 Knowledge acquisition

3.3.1 Knowledge sources

The knowledge sources that were utilized for the prototype expert system in diabetes include the following:

1. Books and reference manuals such as Diabetes Mellitus Diagnosis and Treatment, Mellitus Manage Reference [Mcgraw K.L. 1989].
2. Interviews with Dr Ponder, expert in the field of medical science specifically in the treatment and diagnosis of diabetes.
3. Previously developed prototype systems for the treatment and diagnose of diabetes.
4. Videotapes and other material about the disease of diabetes and its treatment provided by Dr Steve Ponder from the Driscoll Children’s Hospital.

Knowledge acquisition is the most important element in the development of an expert system. An expert system is a program which uses knowledge to solve human problems [Prerau 1990]. Initially, knowledge was obtained form several books and publications pertaining to the causes, types, complications, signs and symptoms of diabetes. Knowledge about diagnostic procedures, looking at historical patients cases, which is comprised of age, symptoms, insulin dosage and physical reaction to the previous treatment. Several online sources such as the American Diabetic Association have also been used.
Dr Steve Ponder, professor of pediatrics at Texas A&M College of Medicine and Director of the Diabetes and Endocrinology Center at the Driscoll Children’s Hospital, was interviewed in several occasions to understand current procedures and to determine the actual requirements of the system. During these interviews, information was gathered about diagnosis and evaluation processes of diabetes.

The process of knowledge acquisition was an important one for the development of this project. Since the beginning of the project, I met with Dr. Ponder at least twice a month for one or two hours to discuss the data in the system and its manipulation. Dr Ponder’s extensive knowledge of the treatment and diagnosis of diabetes was the main key for the success of the expert system. Essential medical examinations such as blood sugar level tests, checking for ketones either in the urine or in the blood stream, among others were covered during this important process of the knowledge acquisition.

The main knowledge source for this project was the operational information from various medical practitioners. After basic knowledge was obtained about diabetes mellitus, different experts in the field of medical science were interviewed. The expertise in the treatment of the condition of diabetes of Susan Sullivan, a certified diabetes educator, was of great asset to the project.

After collecting theoretical information about the condition of diabetes, knowledge about the applied aspects of diabetes was incorporated into the knowledge base of the expert system. Medical practitioners were interviewed regarding the symptoms presented by patients with diabetes. The information gathered by medical practitioners from questioning patients in order to arrive to the initial diagnosis of diabetes was also used to develop the system.
The knowledge obtained from the experts, and the other knowledge sources were transferred into the expert system's knowledge base as shown in figure 3.1. The system uses this information in order to come up with the best suggested treatment for the patient suffering diabetes.

Figure 3.1 Transferring knowledge from diabetes expert to the expert system