Development of a Knowledge-Based Diagnosis and Management System for Diabetes Mellitus through Web

Mohammad Shorif Uddin and Morium Akter

Abstract—Diabetes mellitus is a common metabolic disorder that is characterized by hyperglycemia, due to absolute or relative deficiency of insulin, is increasing worldwide. It is a medical condition resulting in an excessive amount of sugar (glucose) in the blood and is associated with a range of severe complications including renal and cardiovascular diseases and blindness. Preventive care helps in controlling the severity of this disease. However, preventive measures require the correct educational awareness and routine health check. Medical doctors help in effective diagnosis as well as treatment of diabetes but it obviously associated with high costs. With this view, the purpose of the present research is to develop a low- cost automated knowledge-based system that helps in self diagnosis and management of this chronic disease. The system is implemented through a web-based technique, which is workable both in offline and online with a convenient interface. It works in analyzing the patient data to make decisions regarding diagnosis, prevention, and treatment of patients. To confirm the effectiveness of the system we have experimented with 100 data taking doctors prescriptions as ground truth. Among these 89 cases give correct responses.

Keywords—Diabetes mellitus, insulin deficiency, insulin resistance disease diagnosis, health care management, knowledge-based system.

1 INTRODUCTION

IN the year 2000, a study [1] among 191 World Health Organization (WHO) member states confirms that 2.8% people for all age groups had diabetes, and this is expected to be 4.4% by the year 2030. This implies that the total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030.

In Bangladesh, diabetes is reaching epidemic proportions; in some sectors of our society more than 10% of people have diabetes [2]. The most important demographic [3] change to diabetes prevalence across the world appears to be the increase in the proportion of people>65 years of age. Diabetes causes [4] severe life threatening complications, such as hypoglycemic coma, blurred vision, loss of memory, severe impairment of renal function, insulin allergy, acute neuropathy, etc. All of these complications contribute to the excess morbidity and mortality in individuals with diabetes. Each year, 3.2 million deaths worldwide are attributable to diabetes-related causes.

Hypertension is very common in diabetes affecting 20 to 60% of patients depending on obesity, ethnicity and age [5]. The prevalence of hypertension in Bangladesh among diabetic population is 1.5 to 3 times higher than that of nondiabetic age-matched groups. It is estimated that 30 to 75% of diabetic complication can be attributed to hypertension [4]. Among patients with type-II diabetes [6], [7] the mortality of cardiovascular disease is about 70 to 80%, with around 15% of patients dying from stroke. Coronary heart disease among diabetic population is 2 to 6 times higher than that of the nondiabetic population and there is a loss of pre-menopausal protection among diabetic women. Hypertension is also a major risk factor for cardiovascular disease and microvascular complications such as retinopathy and nephropathy. In type-I diabetes, hypertension often results of underlying nephropathy. Proper treatment of hypertension can reduce the complications of diabetes.

Diabetes management requires dietary control together with insulin administration. Medical doctors help in effective diagnosis as well as treatment of diabetes. However, it obviously associates with high costs. Despite remarkable medical advances, patient self-management remains the cornerstone of diabetic treatment. Knowledge-based intelligent system tool has been proven effective in solving many real-world problems requiring expert skills. Hence, to reduce the cost and to improve the early detection as well as self-awareness of diabetes mellitus, automated knowledge-based system might be a promising solution.

But at present in our country, there is no such system by the government or by the private hospitals or NGOs for the management of diabetes themselves. The only one way is the doctor. For these reasons, we have developed

- *Mohammad Shorif Uddin is with Dept. of Computer Science and Engineering, Jahangirnagar University, Savar, Dhaka, Bangladesh. E-mail: shorifuddin@gmail.com).*
- *Morium Akter is with Dept. of Computer Science and Engineering, University of Development Alternative, Dhanmondi, Dhaka, Bangladesh. E-mail: ecs_morium@yahoo.com).*

Manuscript received on 31 July 2010 and accepted for publication on 4 September 2010.

a low cost automated knowledge-based system for the diagnosis and management of diabetes.

Knowledge-based system for diagnosis can be used in variety of domains: plant disease diagnosis, crop management problem diagnosis, credit evaluation and authorization, financial evaluation, identification of software and hardware problems and integrated circuit failures etc. [8]-[10]. Recently, expert systems have been developed in laboratory stage for diabetes awareness and management, insulin administration [11]-[15]. Compared to these systems, our approach is more simple and pragmatic. The ultimate goal of this research is to develop a knowledge-based system incorporating the skills of medical doctors for diabetes diagnosis as well as management. Previously, we have developed a prolog-based diabetes management system [16]. In the present research we implemented the system using a web-based technique.

The paper is organized as follows. In section 2 the medical knowledge about diabetes is described briefly, section 3 describes diagnosis process, section 4 describes method of treatment of diabetes, section 5 presents architecture and implementation of the system as well as some experimental results, and finally section 6 draws the conclusions and future works.

2 Medical Knowledge of Diabetes

Diabetes mellitus is a common metabolic disorder that is characterized by hyperglycemia, due to absolute or relative deficiency of insulin. It is a medical condition resulting in an excessive amount of sugar (glucose) in the blood. This is caused by a deficiency of insulin, which is a hormone secreted by the pancreas. Insulin allows glucose to go from the blood into the cells of the body for use. The clinical signs seen in diabetes are largely related to the elevated concentrations of blood and urine glucose and the inability of the body to use glucose as an energy source due to the deficiency of insulin [2]-[4].

Diabetes is classified as follows [2], [4].

- Type-I (Insulin-Dependent Diabetes Mellitus-IDDM) diabetes tends to occur in the young, although it can occur at any age, and usually in people who are lean. It is caused by autoimmune destruction of the beta-cells in the pancreas, resulting in no insulin production. Patient with type-I diabetes are dependent on insulin to survive, so they are called insulin dependent diabetes mellitus(IDDM).

- Type-II (Non-Insulin-Dependent Diabetes Mellitus-NIDDM) diabetes mellitus occurs more often in older people who are obese and had sedentary lifestyles. In many cases symptoms is lower and the disease may remain undiagnosed for many years. It is associated with both impairment of insulin secretion and resistance to insulin action (insulin resistance). Type-II diabetes is often associated with a strong genetic predisposition. Once diagnosed, an improvement may result from weight reduction, dietary modification and increased exercise. Oral hypoglycemic agents and in advanced cases insulin may required.

- Gestational diabetes mellitus (GDM) is a glucose intolerance of any severity detected in a pregnant woman who was not known to have these abnormalities prior to conception .A significant portion of this type of diabetes become normal after delivery. Once the GDM woman becomes normal, she has increased risk of developing GDM in subsequent pregnancies. She have also an increase risk of becoming a diabetic in later life.

3 Diagnosis

Diagnosis [13], [14] is a process by which a doctor searches for the cause (disease) that best explains the symptoms of a patient. Our knowledge-based system is mainly used for performing diagnosis based on patient data. Patient data can be demographic or clinical. Demographic data relates the information such as patient's age, sex, location, income, etc. Clinical data is divided into physical signs and laboratory results. Physical signs are those detected by a physical examination of patient, like BMI (body-mass index), pulse rate and blood pressure. Laboratory results are those detected via laboratory tests, like blood test, urine test, etc. The diagnosis system is based on the following patient data [12].

a. Uurine test for glucose and ketones.
b. Measure random or fasting blood glucose:
    - Fasting plasma glucose >= 7.0 mmol/l
    - Random plasma glucose >= 11.0 mmol/l.
c. Oral glucose tolerance test:
    - Fasting plasma glucose 6.1-6.9 mmol/l
    - Random plasma glucose 7.0-11.0 mmol/l.

4 Method of Treatment

Diabetes mellitus is manageable through proper diagnosis and preventive measure. Diet can play a role in the treatment of Diabetes.

- Diet alone— 50% can be controlled adequately.
- Diet + oral hypoglycemic agent— 20-30% can be controlled.
- Diet and insulin— 30% can be controlled.

5 Architectures and Implementation of the System

We have realized our system using a web-based technique. The architecture of this technique consists of sys-

tem admin, patient computer, web server, diabetes database, database server, php processor and php rules. We have implemented the system using php and mysql. The architecture of the knowledge-based system implementing through a web-based technique is shown in Fig. 1 as below.

In this system there are two phases. One is diagnosis and another is database. In the diagnosis phase, patient input the data and then shows the result of diagnosis and management of diabetes. Figs. 3 and 4 present a sample input and output pattern obtained by our system. In the database phase the user have login window with user name and password, then shows the recorded data of the patient. The login window is shown in Fig. 5 and patient records are shown Fig. 6.

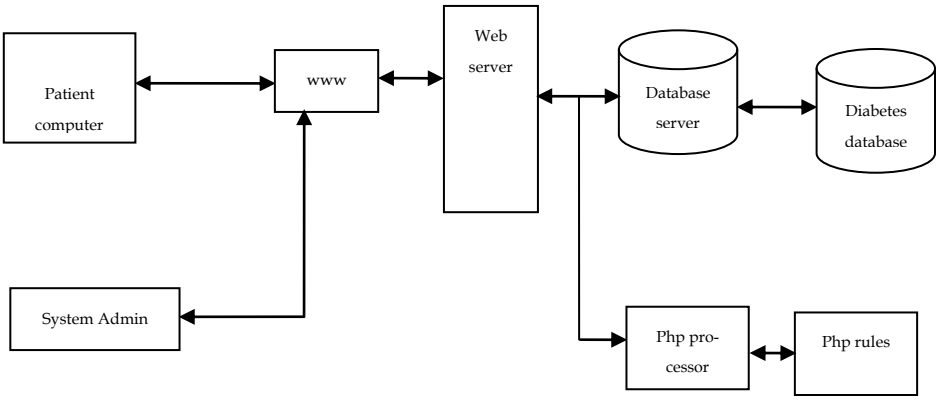

Fig. 1 Architecture of the system through web-based technique.

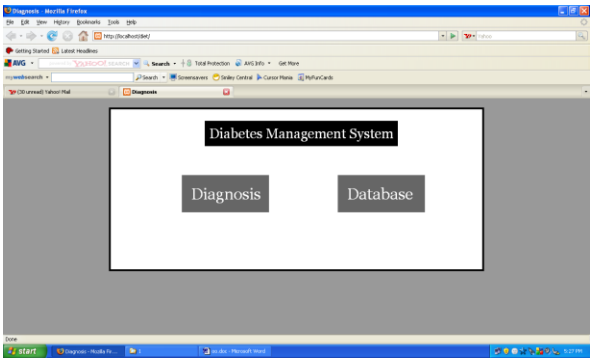

Fig.2 Starting window for diabetes management system.

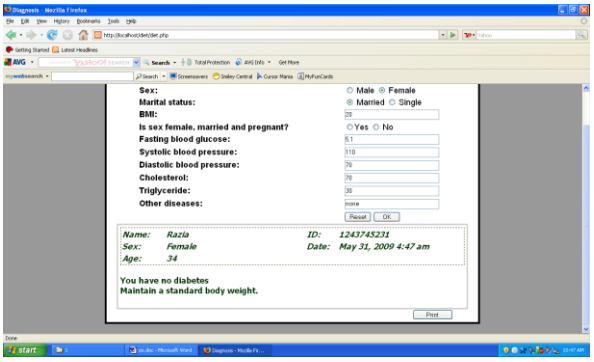

Fig. 4 Output for the inputs shown in Fig. 3.

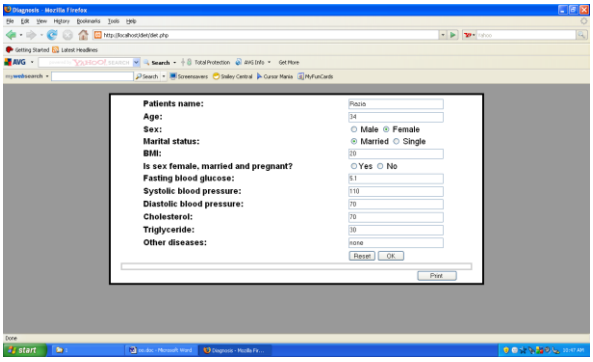

Fig. 3 Input data for the management of diabetes.

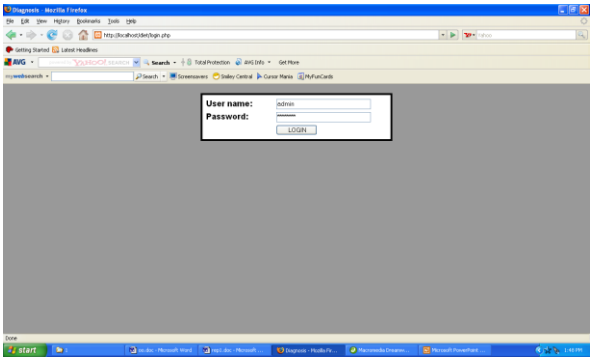

Fig. 5 Login window of the database.

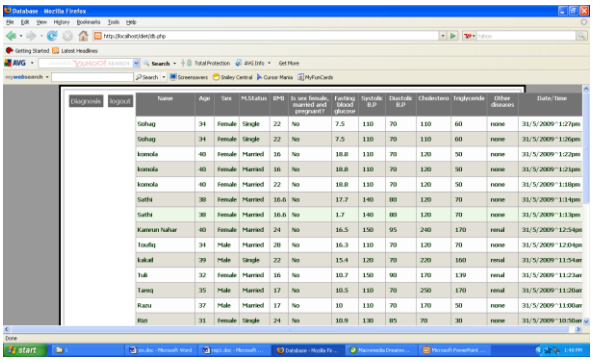

Fig. 6 Patient records.

We have implemented our system through web-based technique which is workable both in offline and online mode and it has more convenient interface. At present our system works on 30 rules. We have tested this system with 100 data taking doctors prescriptions as ground truth. There are 89 correct outputs of system. So these real life experimentations confirmed the effectiveness of the proposed system. The system can be used in both home and hospital environments in online as well as offline modes.

6 Conclusions and Future Works

A knowledge-based system for diagnosis and management of diabetes has been introduced in this research. Its objective is to provide a cost effective treatment and management system for the diabetes patients. We have implemented our system through a web-based technique, which is workable both in offline and online mode and it has more convenient interface. We have tested our system with 100 data taking doctors prescriptions as ground truth. The test result gives 11% error.

There are some limitations in the developed knowledge-based system. For example, the number of rules are not sufficient for a general robust knowledge-based system. Moreover, wide real-life experimentations are not performed yet. There are ample scopes for improvement of our developed expert system on the basis of patient's feedbacks. Our future goal is to overcome the above limitations to make a pragmatic one. We hope that our system will be an effective tool for millions of peoples with better diagnosis and management of diabetes.

References

[1] S. Wild, G. Roglic, A. Green et al., "Global prevalence of diabetes - estimates for the year 2000 and projections for 2030", *Diabetes Care*, vol. 27, pp. 1047-1053, (2004).

[2] Diabetic Association of Bangladesh, "Diabetes Mellitus", 2005, (ISBN: 984-32-2552-X).

[3] Sarah Wild, Gojka Roglic, Anders Green, Richard Sicree, Hilary King, "Global Prevalence of Diabetes-Estimates for the year 2000 and projections for 2030", *DIABETES CARE*, Vol. 27, Number 5, May 2004, pp-1047-1053.

[4] Hajera Mahtab, Zafar A Latif, Md. Faruque Pathan, "Diabetes Mellitus - A Handbook For Proffessionals", BIRDEM, 3rd Ed., 2004, (ISBN: 984-31-0100-6).

[5] Square Pharmaceuticals Ltd., Bangladesh vol. 3, no. 1, January-March 2005, "Inside Bangladesh", available online at http://www.squarepharma.com.bd/DiabetesNewsletter/3.1_JanuaryMarch_2005.pdf (accessed on January 22, 2008).

[6] Giuseppe Derosa, Sibill Salvadeo, Arrigo F. G. Cicero, "Recommendations for the Treatment of Hypertension in patients with DM: Critical Evaluation Based on Clinical Trials", available online at http://www.bentham.org/ccp/samples/ccp1-1/Derosa.pdf (accessed on February 15, 2008).

[7] P. Swaby, E. Wilson, S. Swaby, R. Sue-Ho, R. Pierre, "Chronic diseases management in the Jamaican setting: Hope worldwide Jamaica's experience", available online at http://www.pngimr.org.pg/Chronic%20diseases%20-%20Sep-Dec%202001.pdf (accessed on January 20, 2008).

[8] Jie Yang, Chenzhou Ye, Xiaoli Zhang, "An expert system for fault diagnosis", *Robotics*, vol.19, pp-669-674, (2001).

[9] Karthik Balakrishnan and Vasant Honavar, "Intelligent diagnosis systems", available online at http://www.cs.iastate.edu/~honavar/aigroup.html (accessed on December 10, 2008).

[10] Costas Papaloukas, I. Dimiritrios, Aristidis Likas, S. Christos Stroumbis, Lampros K. Michalis, "Use of novel rule-based expert system in the detection of changes in the ST segment and the T wave in long duration ECGs, *J. Electrocardiology*, vol. 35, no.1, (2002).

[11] V. Ambrosiadou and A. Boulton, "A knowledge-based system for education on management of diabetes", *Proc. IMACS World Congress on Scientific Computation*, 1988, pp. 186-189.

[12] Rudi Rudi, and Branko G. Celler, "Design and Implementation of Expert-Telemedicine ystem for Diabetes Management at Home", *Intl. Conf. on Biomedical and Pharmaceutical Engineering, 2006 (ICBPE 2006)*, pp.595-599.

[13] Kyung-Soon Park, Nam-Jin Kim, Ju-Hyun Hong, Mi-Sook Park, Eun-Jong Cha, Tae-soo Lee, "PDA based Point-of-care Personal Diabetes Management System", *Proceedings of the 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference Shanghai, China, September 1-4, 2005*, pp3749-3752.

[14] V. Ambrosiadou, Diabetes, "An expert system for education in diabetes management", in *Expert Systems Applications*, Sigma Press, UK, 1989, pp.227-238.

[15] G. Gogou, N. Maglaveras, V. Ambrosiadou, D. Goulis, C. Pappas, "A neural network approach in diabetes management by insulin administration", J. Med. Syst. Vol. 25, no. 2, pp. 119-31, 2001, (ISSN: 0148-5598).

[16] Morium Akter, Mohammad Shorif Uddin, Aminul Haque , "A Knowledge-Based System for Diagnosis and Management of Diabetes Mellitus", *13th International Conference on Biomedical Engineering (ICBME 2008)*, Singapore, pp. 1000-1003.

Mohammad Shorif Uddin received PhD in Information Science from Kyoto Institute of Technology, Japan, Master of Education in Technology Education from Shiga University, Japan and Bachelor of Science in Electrical and Electronic Engineering from Bangladesh University of Engineerong and Technology (BUET). He joined in the Department of Computer Science and Engineering, Jahangirnagar University, Dhaka in 1992 and currently he is a Professor of this department. He started his teaching career in 1991 as a Lecturer of the Department of Electrical and Electronic Engineering, Chittagong University of Engineering and Technology, (CUET). He did postdoctoral researches at Bioinformatics Institute, A-STAR, Singapore, Toyota Technological Institute, Japan and Kyoto Institute of Technology, Japan. His research is motivated by applications in the fields of computer vision, pattern recognition, blind navigation, bioimaging, medical diagnosis and disaster prevention. He has published a remarkable number of papers in peer-reviewed international journals and conference proceedings including well-reputed IEEE Transactions on ITS, British IOP Journal, Japanese IEICE Transactions, Optics Express and Applied Optics (Optical society of America), Elsevier Science Journal. He holds two patents for his scientific inventions. He received the best presenter award in the International Conference on Computer Vision and Graphics (ICCVG 2004), Warsaw, Poland. He is the author of two books. He is a member of IEEE, SPIE, and IEB.

Morium Akter was born in Gazipur, in Bangladesh in 1981. She received her BSc and MS in Computer Science and Engineering from Jahangirnagar University, Savar, Dhaka in 2005 and 2009, respectively. She has been working as a faculty in the University of Develpoment Alternative (UODA) from January 2009 to till now. She has four publications in the peer-reviewed conferences. Her research interests include Image Analysis and Software–Based Medical Diagnostic Systems.