TNC Transactions on Networks and Communications
SOCIETY FOR SCIENCE AND EDUCATION UNITED KINGDOM
VOLUME 2, ISSUE 1
ISSN: 2054 - 7420

A Hybrid Intelligent System for Diagnosis of Diabetes

Mashhour M. Bani Amer[1], Abed Saif Alghawli[2]
[1]*Department of Biomedical Engineering, Jordan University of Science and Technology, Jordan*
[2]*Department of Computer Science, Salman Bin Abdulaziz University, Saudi Arabia*
mashamer@yahoo.com; alghauly@yahoo.com

ABSTRACT

This paper presents a hybrid intelligent system for diagnoses of diabetes. It is based on neuro-fuzzy inference system which is trained and tested using experimental data collected from two hundred different patients. The main clinical feature of this system is that it can be used by a patient's smart phone, Pocket PC or PDA to provide local diagnosis of blood glucose level and to transmit the captured data to a remote hospital or clinician for assistance and medical advice. The performance of the system was tested and the results showed that it is capable to diagnose the diabetes with a high degree of precision.

Keywords: Neuro-Fuzzy; Diabetes; PDA; Intelligent System; Smart Phone.

1. INTRODUCTIN

The diabetes is a problem that affects a large percentage of the population and it is a main cause of death in the world. Recent statistics show that the diabetes affects more than 5% in the USA while this percentage exceeds 20% in some developing countries such as Saudi Arabia [1], [5].

Thus, the precise diagnosis of diabetes has great clinical benefits. These include good management of diabetes, determination of the optimum insulin dose required to reduce the blood glucose level to a normal one and also assessing the effectiveness of the diet, physical activity and medication. Last diabetes and as a result of new advanced in the field of smart phones, Pocket PC and Personal Digital Assistant (PDA), there has been growing demand for new diagnostic approaches in the field of diabetes decision-making systems [6]-[9].

Blood glucose measurements are usually show nonlinear behaviour specially in clinically ill diabetics. Thus, the conventional mathematical approaches are not suitable for development of diabetes decision-making system. In such cases, unconventional mathematical techniques based on fuzzy logic are very powerful. Fuzzy and neuro-fuzzy system have various features for modelling of imprecise and nonlinear information on which diagnosis and treatment of

DOI: 10.14738/tnc.21.120
Publication Date:10th February 2014
URL: http://dx.doi.org/10.14738/tnc.21.120

diabetes are based [10]-[14]. The diagnosis approach can be integrated in a PDA or smart phone which allows the patient to be diagnosed by a remote clinician.

In this paper, we propose a novel neuro-fuzzy approach for diagnosis of blood glucose level which has many valuable features (Fig. 1). First, it is capable to deal with imprecise blood glucose measurements. Second, it combines the feature of both fuzzy logic and neural networks and thus it is an intelligent system. Third, it provides effective and accurate tool for diagnosis of blood glucose. Last, it can be integrated on a patient's mobile to provide rapid diagnosis of his blood glucose level and consultation with remote clinician.

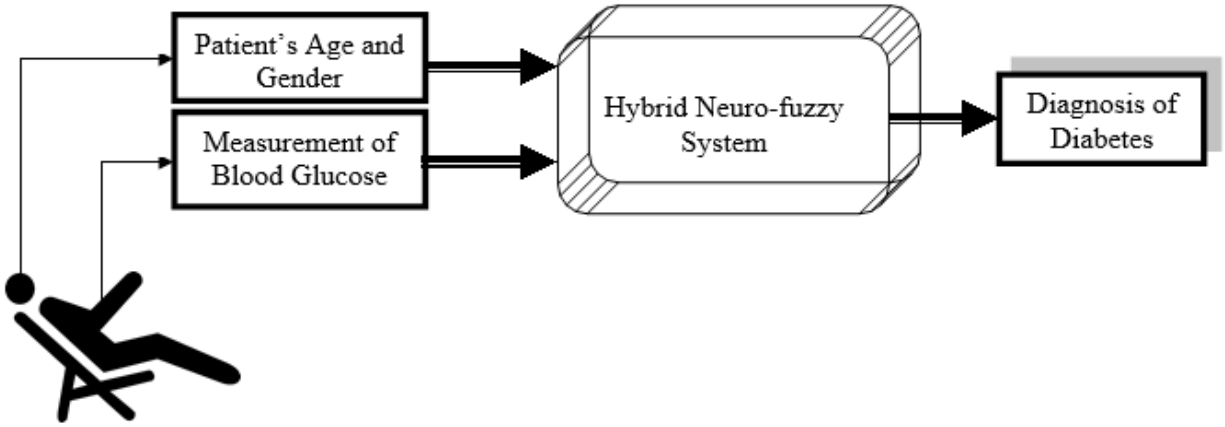


Figure 1: Simplified schematic of proposed intelligent system for diagnose of diabetes.

2. METHOLODOGY

Clinically, the diagnosis of diabetes depends mainly on the level of blood glucose level, patient's age and gender.

Table 1: Summary of classes for selected parameters

Age	Gender	Blood Glucose Level	Diagnosis
Infant	Male Female	Very low	Very critical hypoglycaemia
Child		low	Critical hypoglycaemia
Young		Medium low	Moderate hypoglycaemia
Middle aged		Normal	No diabetes
Old		Medium high	Medium severe diabetes
Very old		high	Highly severe diabetes
		Very high	Very high severe diabetes

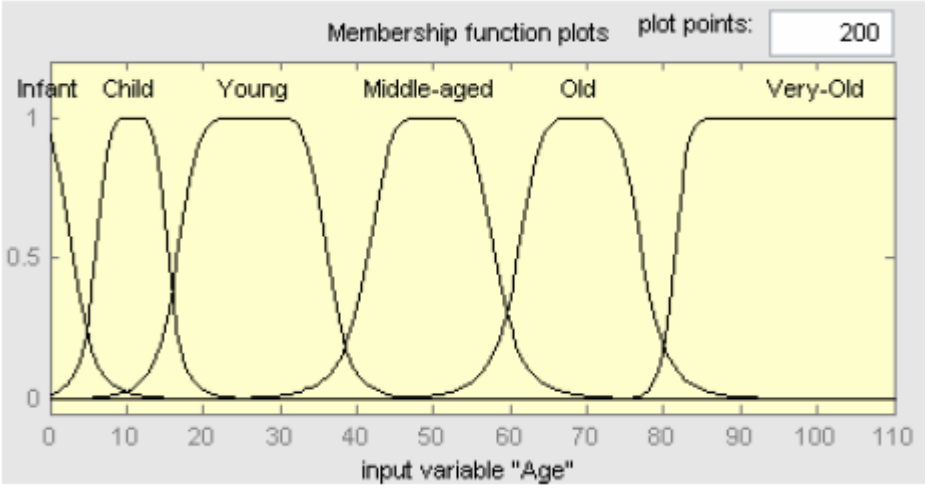
Each of these parameters is divided into different classes (Table. 1): six for age, two for gender, seven for blood glucose level and diabetes. To develop neuro-fuzzy inference system for diagnosis of diabetes, two hundred experiments were conducted on various patients with different ages, gender and blood glucose level. Then, the data set was divided into training

(130) and testing (70) cases taking into consideration the seven classes of blood glucose level (Table. 2).

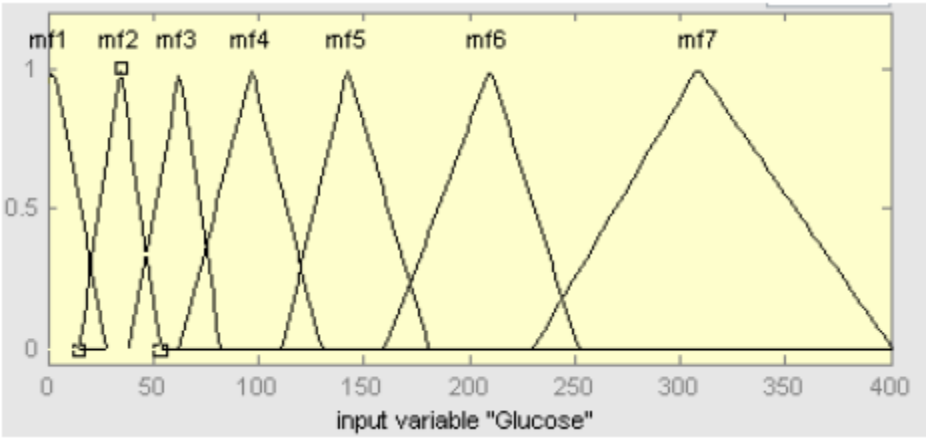
Table 2: Distribution of training and testing data

Diabetes	Very low	low	Medium low	Normal	Medium high	high	Very high
Training set	1	8	16	45	29	17	14
Testing set	1	1	7	27	18	9	7
Total	**2**	**9**	**23**	**72**	**47**	**26**	**21**

The membership functions shapes were chosen to be Trapezoidal for gender and Bell for age and blood glucose level (Fig. 2)



(a)



(b)

Figure 2: The membership functions a. for age and b. for blood glucose.

3. RESULTS AND DISCUSSION

The experimental data obtained from investigated patients were used for training and testing of the neuro-fuzzy system. The obtained root mean square error (RMSE) is equal 0.03 for 100 training epochs.

The level of this error is clinically insignificant which ensures that the proposed technique for diabetes diagnosis is accurate one. Further, the diagnosis obtained from this system was compared with the hospital diagnosis confirmed by specialized clinician, where the testing data 29 of thirty were diagnosed correctly. The developed approach can be implemented on the patient's smart phone or Pocket PC. An implementation of this system on a pocket PC is shown in Fig. 3.

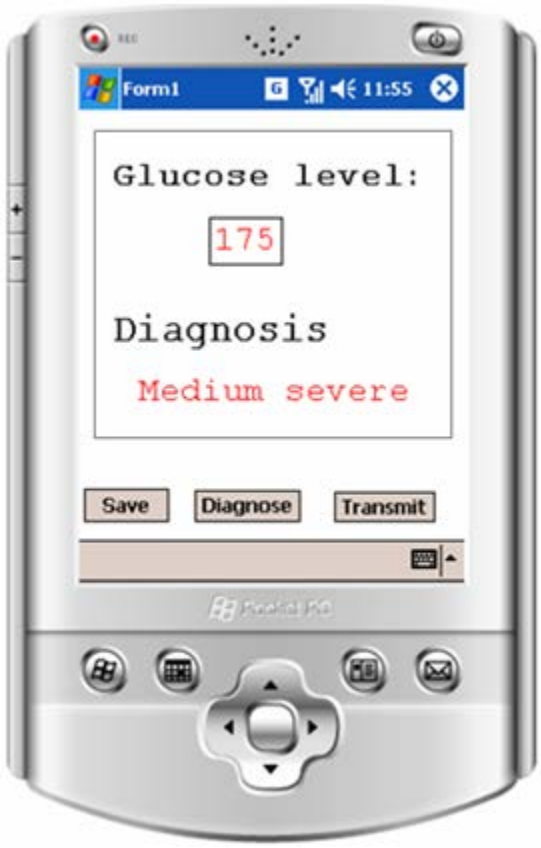


Figure 3: Implementation of developed system on a Pocket PC

4. CONCLUSION

In this paper we developed a neuro-fuzzy inference system for diagnosis of diabetes. The measured data collected from two hundred different patients were used for training and testing the performance of the system. The root mean square error of the developed system is about 0.03 which implies that it can be successfully used to diagnose the diabetes.

The developed system has various important clinical features. First, it is precise tool for diagnosis of diabetes and capable of dealing with nonlinear fluctuation of blood glucose level

specially in clinically ill diabetes. Second, it is an intelligent decision making system which is capable of classifying diabetes level into certain alert levels. Last, it can be integrated into patient smart phone, PDA or Pocket PC and thus provides local diagnosis of diabetes and also has the ability to call remote clinician in case of an emergency.

Finally, although the obtained results are promised, the system needs more investigations and larger number of data. So, the work will be continued to achieve more comprehensive system.

REFERENCES

[1]. Deiss, D., Bolinder, J., Riveline, J-P., Battelino, T., Bose, E., Tubiana-Rufi, N., Kerr, D., and Phillip, M. Improved glycemic control in poorly controlled patients with type 1 diabetes using real-time continuous glucose monitoring. Diabetes Care, 2006. 29 (12): 2730–2732.

[2]. Iris M. Wentholt, Marit A. Vollebregt, Augustus A. Hart, Joost B. Hoekstra, and J. Hans DeVries. Comparison of a Needle-Type and a Microdialysis Continuous Glucose Monitor in Type 1 Diabetic Patients. Diabetes Care, 2005 28: 2871–2876.

[3]. Steil, G.M., Rebrin, K. Mastrototaro,J., Bernaba, B., and Saad, M.F. Determination of Plasma Glucose During Rapid Glucose Excursions with a Subcutaneous Glucose Sensor. Diabet. Technol. Ther. 2003, 5: 27-31.

[4]. Wilhelm, B., Forst, S., Weber, M.M., Larbig, M., Pfûtzner, A., and Forst, T. Evaluation of CGMS During Rapid Blood Glucose Changes in Patients with Type 1 Diabetes. Diabet. Technol. Ther. , 2006, 8: 146-155.

[5]. Garg, S., Zisser H., Schwartz, S., Baile, T., Kaplan, R., Ellis, S., and Jovanovic, L. Improvement in Glycemic Excursions With a Transcutaneous, Real-Time Continuous Glucose Sensor, Diabetes Care, 2006. 29:44-50

[6]. Diabetes Statistics, NIDDK National Diabetes Information Clearinghouse. Available at http://diabetes.niddk.nih.gov/dm/ pubs/statistics/index.htm#7

[7]. D. Gavaghan, A. Garny, P. K. Maini and P. Kohl, Mathematical models in physiology, Phil. Trans. R. Soc. A, 2006, Vol. 364, PP. 1099–1106.

[8]. E. Ward, T. Martin, A Fuzzy Model of Glucose Regulation, Journal of Medical Systems, 2006, Vol. 30, No. 3, pp. 187 – 203.

[9]. Cobelli, C., Federspil, G., Pacini, G., Salvan, A., and Scandellari, C., An integrated mathematical model of the dynamics of blood glucose and its hormonal control. Math. Biosci, 1982, 58:27-60.

[10]. Cobelli, C., and Mari, A., Validation of mathematical models of complex endocrine-metabolic systems. A case study on a model of glucose regulation. Med. Biol. Eng. Comput, 1983, 21:390-399.

[11]. Kasabov, Learning fuzzy rules and approximate reasoning in fuzzy neural networks and hybrid systems, Fuzzy Sets and Systems, 1996, Vol. 82, No. 2, PP.: 135 - 149.

[12]. Takagi, T., and Sugeno, M., Fuzzy identification of systems and its applications to modeling and control. IEEE Trans. Syst. Man Cybern, 1985, 15:116-132.

[13]. Sugeno, M., and Yasukawa, T., A fuzzy-logic based approach to qualitative modeling, IEEE Trans. Fuzzy Syst, 1993, 1:7-31.

[14]. J. Jang, C. T. Sun, E Mizutani, Neuro-fuzzy and soft computing, Prentice-Hall, 1997.