AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/

Diagnosis of diabetes using a combination of the Sugeno fuzzy inference systems and glow worms algorithms

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ARTICLE INFO

Article history:
Received 2 April 2014
Received in revised form
13 May 2014
Accepted 28 June 2014
Available online 23 July 2014

Keywords:
diagnosis of diabetes, Sugeno fuzzy inference system, intelligent glow worm's algorithm.

ABSTRACT

Today, a large percentage of people are likely to develop diabetes. Diabetes is one of the most serious diseases in modern societies and timely detection of the disease has a significant role in its treatment. In this paper, by using Sugeno fuzzy inference systems and intelligent glowworms algorithms, a new method are presented for the diagnosis of diabetes. The proposed method can detect diabetes carefully by using a few simple fuzzy rules. Simple experimental results show that this method has more accuracy on standard PIDs in the face of other available algorithms.

To Cite This Article: Badrooh Iman, Mosalanezhad Reza, Mousavi Yashar., Diagnosis of diabetes using a combination of the Sugeno fuzzy inference systems and glow worms algorithms. ***Adv. Environ. Biol., 8(12),*** *269-272, 2014*

INTRODUCTION

Nowadays most people who live in cities tend to have less physical activity, the global population is growing, and most people have more longevity than ever before. However, people use more unhealthy and high-volume foods than the past. So poor combining (low physical activity and unhealthy foods) cause increasing in the uncontrolled prevalence of diabetes. Sugar diseases or in other words diabetes, is a chronic disease that is the result of impairing in production and function of insulin in the body. Insulin is a hormone that the pancreas produces and enables cells to take glucose of blood and use for energy production. Pancreas of person with diabetes does not produce required insulin of the body (diabetes type 1) or insulin does not have the required application in the body (diabetes type 2). Hence, people with diabetes cannot use glucose efficiently for their body metabolism. As a result, blood sugar levels dramatically increases. In a respective research in 1985 it was observed that 30 million people worldwide had diabetes. If this epidemic progression wasn't stopped by 2025 the number of people with diabetes will reach 333 million. Hyperglycemia cause early and late complications of diabetes in the body. If diabetes left untreated, and does not be prevented, many effects of diabetes will be fatal. Therefore timely prediction of this disease has an important role in preventing of its effects [1]. Numerous studies in machine learning and the relation between diabetes and its prediction is done [2-4]. Also, some studies in the field of machine learning algorithms using for caregivers of diabetes patients has been done which blood glucose levels prediction, administer insulin proper value to it [5] and also discovering of effective proteins in diabetes can be mentioned [6,7] . More work has been done in the machine learning area in the field of diabetes on PID dataset of the UCI [8] dataset. In [9], two methods are proposed. The first method by using evolutionary algorithms has reached to 76.16 percent accurately. The second method that uses the ANFIS the accuracy achieved is 79.69 percent. In [10], the method of nearest neighbor is used and the result is accuracy of 75.55 percentages. [11] Also used a decision tree And accuracy of 78.178 % have been reported. [12] Also uses a combination of decision tree and fuzzy clustering algorithm and accuracy has increased to 84.33 percent. All these methods have been tried to increase the accuracy of detection however success achievement in this area was not very good. And accuracy of the methods given much importance the issue is still far from ideal. In this paper a method based on the combination of fuzzy methods and glow worms algorithms is proposed. The proposed method by using the glowworms algorithm tries to adjust the parameters of a fuzzy system. The article continuation is organized as follows. In the third section, we will explain the proposed method. In The fourth

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section the results of implementation of the proposed method are described finally, in the last section we will summarize and doing some works for future.

Fuzzy inference systems and glowworms algorithms:

The proposed method in this paper use Sugeno fuzzy system [13] to classify the data. The fuzzy system is composed of a number of the IF-THEN fuzzy. Unlike the Mamdani rules, Sugeno rules are not membership functions, but they are analytic functions or fixed numbers. This feature allows the system to complex knowledge with low the rules of expression.

The proposed fuzzy system includes m (the number of features) input and n-rule. Any rule that is expressed as follows:

$$R_i: if(x_1 \ is \ f_{i1}) \ and \ \ (x_j \ is \ f_{ij}) \ and \ \ \ldots.(x_m \ is \ f_{im}) \ then \ output = yi \tag{1}$$

Where, x_j is the j-th input membership function and f_{ij} is the i-th output on x_j and y_i is the ruleoutput. The Gaussian membership functions are used:

$$f_{ij}(x) = \exp\left(-\frac{1}{2}\left(\frac{x - c_{ij}}{\sigma_{ij}}\right)^2\right) \tag{2}$$

Multiplying is used as the "AND" operator. As a result, we have:

$$\mu_i = \Pi_{j=1}^{m} f_{(ij)}(x_j) \tag{3}$$

This indicates the degree of activation. The output of the system with respect to the center of gravity is calculated as follows:

$$y(x) = \frac{\sum_{i=1}^{n} \mu_i . y_i}{\sum_{i=1}^{n} \mu_i} \tag{4}$$

The system parameters that must be specified are the center and radius of the gaussian functions and also the output of each rule. To determine these parameters the firefly algorithms is used. Firefly algorithm was introduced by Yang [14] and its definition was based on three rules.

• Glow-worms are attracted to others glow-worms, regardless of their gender, is absorbed.

• Attractiveness is relative, i.e. glow worms with less light are absorbed to glow worms with more light. In case there be no other lighter worms, these worms will move randomly.

• Glow worms with spreading more light attract bait into itself and eventually share the victim with other worms.

Glow worms algorithm is an evolutionary algorithm based on population, which inspired by glow worms treats of search for food and their population intelligence. In nature, glow worms move randomly and each one which finds better bait emit more light, to attract others to it. The greater the distance between two worms, the less absorption between them. In other words, spacing varies inversely with rate and extent of absorption. The algorithm consists of two main parts:

A) Light intensity changes:

The amount of light intensity depends on the amount of the fee function[15]. Therefore in the minimization problems (maximization), glow worms with more light (less) will absorb the low light glow worms (higher). Suppose n is the number of worms, x_i position of the particle i And $f(x_i)$ the cost function. Therefore, the brightness of each worm will be equal to its cost function.

$$I_i = f(x_i), \quad 1 \le i \le n \tag{5}$$

B) Moving toward more glow worms with light:

Each worm has an absorption characteristic, which shows how strong the worm is. These characteristics are relative amounts, in which changes due to the distance between two worms i and j. The attraction equation would be as follows:

$$\beta(r) = \beta_0 e^{-\gamma r^2} \tag{6}$$

Where the absorption rate $is\ \beta_0$ as a result of $r = 0$ and γ is the light absorption coefficient. The movement of worm i with the position x_i towards glow worms with more light can be obtained from the following equation.

$$x_i(t+1) = x_i(t) + \beta_r(x_j - x_i) \quad (7)$$

Glow worms algorithm pseudo-code would be as follows:

1. Define and initialize of worms (participants) of population.
2. Obtain a cost function for each individual of the population in their position.
3. Until the stopping conditions has not established:
4. Assigned randomly of the light intensity to each individual of the population.
5. Determine the best (brightest) individual in the population by function calculating of the total cost of population.
6. Moving the rest of the population towards the best individual and update light intensity according to it.
7. End of the algorithm.

Glow worms algorithm performance entirely depends to the initial population, the uptake and absorption coefficient. The more light absorption coefficient is greater the absorption rate of people population towards the brightest is more.

Also the fitness function is defined as follows:

$$MSE = \sum_{i=1}^{k}(S_i - T_i)^2 \quad (8)$$

Where k is the number of training data, S_i is the desired output for training data and T_i is the output of the i-fuzzy system for the data.

Diabetes diagnosing by using fuzzy inference systems and glow worms algorithms:

The proposed method was implemented using the MATLAB and the proposed algorithms [9], [10], [11] and [12] were compared with PID dataset. This dataset contains 8 Characteristics of the 768 women who were at least 21 years. Among these 500 subjects were healthy and 268 patients with diabetes. Eight Characteristics according to the World Health Organization definition is: (a) pregnancies times, (b) plasma glucose concentration in two hours, (c) blood pressure, (d) body mass index, (e) Two-hour insulin levels: brachial triceps skin thickness, (f) history of diabetes, (g) age. The results of the comparison are shown in Table 2.

Table 2: Accuracy of different methods and provided procedures

Method	Accuracy
ANFIS[9]	% 76.69
Evolutionary algorithm [9]	% 76.17
K Nearest neighbor [10]	% 75.55
Decision tree [11]	% 78.178
Fuzzy Clustering [12]	% 84.33
Proposed method	% 87.24

Accuracies shown in Table 2 indicate that the proposed method is efficient and bears more accuracy. As it can be observed simultaneously using of fuzzy inference systems and glow worm algorithms, the proposed method is more intelligent and applicable.

Conclusion and Recommendations:

In this paper, a novel method by using glow worms algorithm and fuzzy inference system for diagnosing diabetes was proposed. Experimental results the on PID dataset show that the proposed method is more accurate than other existing methods in this field. The use of fuzzy systems with the power of strong inference, as a Mamdany fuzzy system and Rank two fuzzy systems can also help smart way to increase the accuracy of diagnosis. Also some more accurate and powerful optimization algorithms such as Memetic algorithm and colonial competitive algorithm for the diagnosis of diabetes is recommended.

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