International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 3 Issue: 9
ISSN: 2454-4248
252 – 255

Diabetes Classification using Fuzzy Logic and Adaptive Cuckoo Search Optimization Techniques

[1]Nikita Sahu
MTech scholar, Computer Science Engineering
Rungta College of Engineering & Technology, Bhilai
Bhilai (CG), India
e-mail: nsahu360@gmail.com

[2]Toran Verma
Assistant Professor, Dept. of Computer Science Engineering
Rungta College of Engineering & Technology, Bhilai
Bhilai (CG), India
e-mail: toran.verma@rungta.ac.in

[3]G Thippa Reddy
Assistant Professor, Dept. of Information Technology
VIT University, Vellore
Vellore (Tamil Nadu), India
e-mail: thippareddy.g@vit.ac.in

***Abstract*—** Diabetic patients can be detected now a days globally. It's main reason of growth is the incapability of body to produce enough insulin. So, majority of people today are either diabetic or pre-diabetic. Therefore, it is very much required to develop a system that can detect and classify the diabetes in optimal time period effectively and efficiently. So, proposed system make use of fuzzy logic and adaptive cuckoo search optimization algorithm (ACS) for diabetes classification. This work has been carried out in various steps. Firstly, the training dataset's dimensionality reduction and optimal fuzzy rule generation via ACS optimization technique. Next is fuzzy model design and testing of fuzzified testing dataset. In this paper, outcome of FF-BAT algorithm has been compared with ACS algorithm. Experimental results were examined and it is noticed that ACS algorithm seems to perform better than FF-BAT algorithm.

Keywords- *Diabetes, Fuzzy Inference System, Adaptive Cuckoo Search Algorithm*

*****

I. INTRODUCTION

A. *Diabetes*

Diabetic patients can be detected now a days globally. It's main reason of growth is the incapability of body to produce enough insulin. So, majority of people today are either diabetic or pre-diabetic. This disease results in high blood glucose level. Diabetes classification has been specified in Table 1.

Table 1: Classification of Diabetes

Type2(Adult Onset) Diabetes	Effects the way the body processes blood glucose and requires proper medical diagnosis, lab tests or imaging.
Type1(Juvenile/Insulin Dependent/Early Onset) Diabetes	Pancreas produces little or no insulin and it can't be cured, but treatment and medical diagnosis may help
Pre Diabetes(Impaired Glucose Tolerance)	Blood glucose is high, but not high enough to be Type2 diabetes. It can be cured via proper medical diagnosis and lab tests.
Gestational Diabetes (Diabetes during pregnancy)	High blood glucose level affecting pregnant ladies and requires daily blood glucose monitoring, baby monitoring, proper diet and exercise.

B. *Fuzzy Inference System*

It is well known as fuzzy expert system , fuzzy model or fuzzy rule based system. FIS is basically a decision making system that usesfuzzy logic or IF-THEN rule for generating results. FIS is used mainly for uncertain and approximate reasoning. The architecture of FIS model is given in Figure 1.

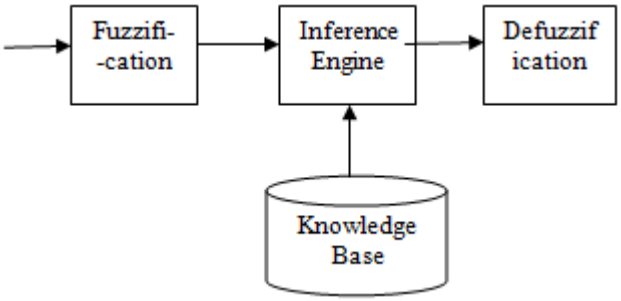

Figure 1: Fuzzy Inference System Model

C. *Adaptive Cuckoo Search Algorithm (ACS)*

This is one of the nature inspired metaheuristic optimization technique. It is the extended version of cuckoo search optimization technique. Cuckoo search uses the property of levy distribution for finding new search space. But in adaptive cuckoo search levy's concept has been eliminated for better performance.

The adaptive Cuckoo search algorithm step can be modeled as

$$Step_i(t+1)=(1/t)^{|\,[bestfit(t)-fit_i(t)]\,/\,[bestfit(t)-worstfit(t)]\,|}$$

 ISSN: 2454-4248
252 – 255

Where

t = Generation of Cuckoo search.

fit_i (t) = Fitness value of i^{th} nest in t^{th} generation.

bestfit (t) = Best fitness value in t^{th} generation.

worstfit (t) = Worst fitness value in t^{th} generation.

The step size initially high, but when the generation increases the step size decreases.

That indicates when the algorithm reaches to the global optimal solution step size is small.

It clearly indicates that the step size adaptively decides from the fitness value.

Then the adaptive Cuckoo search algorithm (ACS) is modeled:

$$Xi\ (t+1) = Xi\ (t) + randn \times stepi\ (t+1)\ .$$

where

Xi (t) is search space for ith cuckoo at time t

Xi(t+1) is new search space at time t

II. Literature Review

Many research works have been carried out in past related with this work. Some of the relevant studies are: G. Thippa Reddy et al. [1] have proposed a system that classifies the diabetes into various categories using Firefly and BAT optimization algorithm and Rule Based Fuzzy Logic (RBFL). Main steps performed are dimension reduction using LPP ALGORITHM, rule generation by RBFL ALGORITHM, and optimize the rule using FFBAT-ALGORITHM.

To improve the refining ability and convergence rate of cuckoo search algorithm for finding optimal solution an improved cuckoo search algorithm with adaptive method is proposed which is having better performance when lots of test functions are considered; and also has faster convergence speed and higher precision[4].Special lifestyle of Cuckoo has been the basic motivation for cuckoo search optimization algorithm and is widely applied in Engineering followed Pattern Recognition, Software Testing & Data Generation, Networking, Job Scheduling and Data Fusion and Wireless Sensor Networks. CS performs efficiently with all test problems [5].It may be very useful to carry out parameter tuning in some efficient variants and see how parameters can affect the behaviour of a cuckoo search algorithm. Furthermore, applications should focus on large-scale real-world applications [6].For speaker recognition optimization Cuckoo Search algorithm is used which aims at finding and short listing the features from voice which can uniquely identify it [7].

Cuckoo Search in combination with L´evy flights, based on the breeding strategy of some cuckoo species and flight behaviour of many animals and insects, two important characteristics are selection of the fittest and adaptation to the environment [8]. Adaptive Cuckoo Search (ACS) algorithm has been proposed which is the combination of cuckoo search and parameter free algorithm. ACS has been proposed for improvising the search pattern and rate of convergence [10].Cuckoo Search has both local and global search capabilities and controlled by a switching/discovery probability, it can deal with very large-scale problems [11].

Fuzzy logic is used for risk classification of coronary artery heart disease. The performance of the proposed risk classifier is measured in terms of classification accuracy, sensitivity and specificity [12].Based on fuzzy logic and cuckoo search concept PD controller for inverted pendulum has been designed [13]. Fuzzy logic and expert system provides more accurate result as number of parameters to be consider during diagnosis of diabetes increases and urine culture has proven to be one of the important parameter [14].

Gadekallu, T.R. and Khare, N. [16] have classified diabetes and heart disease data sets. Hey used a hybrid of rough sets and cuckoo search algorithms for feature reduction, classified the diseases using fuzzy logic system. Gandomi, A. H. et al. [17] have used a meta heuristic algorithm, Cuckoo search to solve structural optimization tasks. To validate the algorithm, cuckoo search is applied to 13 design problems the authors have found that cuckoo search outperforms the existing works in optimizing the solutions.Cui, Z. e al. [18] have designed an oriented cuckoo search algorithm in this global search capability is dominated by the combination of two different random distribution Levy distribution and Cauchy distribution. Pandey, A. C. et al. [19] proposed a metaheuristic method, which is based on k-means and cuckoo search to find optimum cluster-heads from the sentimental contents on twitter datasets.

Meza-Palacios et al. [21] have developed of a Fuzzy Expert System (FES) to help doctors assess the nephropathy control in patients with Type 2 Diabetes Mellitus (T2DM). Reddy, G. T., &Khare, N. [25] have classified heart disease dataset using hybrid of oppositional based learning with Firefly-BAT algorithm. They used LPP for feature reduction, and then used combination of OFBAT with hybrid of BAT and Firefly optimization algorithms to optimize the fuzzy rule based classifier for heart disease classification.

III. Methodology

In this section, we will discuss about the proposed framework for the generation of optimal result. The flow diagram of proposed system is specified in Figure 2.
This proposed work follows the following step :

- Collection of data set
- Dimensionality Reduction
- Optimal Fuzzy Rule Generation via ACS
- Fuzzy Model Design
- Passing of fuzzified data set
- Result generation and evaluation

- *Collection of data set*:

The data is collected from pathological lab and is divided into two sets, training dataset and testing dataset .The training dataset is used to generate the fuzzy rules and the designing of fuzzy system. The classification accuracy of the proposed system is evaluated on the testing data.

 ISSN: 2454-4248
252 – 255

- *Dimensionality Reduction*:
  The functionality reduction of the dataset is achieved using LPP algorithm. It is required to minimize the features space

  without losing the precision of prediction. In addition, it removes the irrelevant, unnecessary or noisy information.

- *Optimal Fuzzy Rule Generation via ACS*:
  ACS Algorithm

1. Initialization
   Randomly initialize the N number of host nests
   $Xi=(x_i^1,\ldots,x_i^d,\ldots,x_i^n)$
   for i=1,2,..,N for n dimensional problem and define the fitness function fit (X).
   Initially take t =1 and evaluate the fitness function of the host nests fit (Xi) for i=1,2,..,N for the first time.
2. Iterative algorithm
   A. Find the bestfit and worstfit of the current generation
   among the host nests.
   B. Calculate the step size using the equation
   $Step_i(t+1)=(1/t)^{|[bestfit(t)-fit_i(t)]/[bestfit(t)-worstfit(t)]|}$
   Where
   t = Generation of Cuckoo search.
   fit_i (t) = Fitness value of i^{th} nest in t^{th} generation.
   bestfit (t) = Best fitness value in t^{th} generation.
   worstfit (t) = Worst fitness value in t^{th} generation.
   C. Then calculate the new position of Cuckoo nests using
   the Eq
   $Xi\ (t+1) = Xi\ (t) + randn * stepi\ (t+1)$
   D. Evaluate the objective function of the host nests fit (Xi) for i=1,2,..,N.
   E. Then choose randomly a nest, j, among N
   If ($fit_i > fit_j$)
   Update jth nest by the new solution.
   End
   F. The worst nests are abandoned with a probability (pa)
   and new one are built.
   G. t = t + 1.
   H. Verify (t <= tmax) or (End creation not satisfied),
   if yes then go to A; otherwise end.

- *Fuzzy Model Design*:
  Fuzzy Inference System(FIS) provides a way of mapping input space to output space. The primary task of fuzzy inference system is decision making based on IF-THEN rules. Along with IF-THEN rules FIS uses "AND" or "OR" connectors for making necessary decisions. Input to FIS need not be always fuzzy; it may be crisp or fuzzy, but the output is always a fuzzy set from the FIS. The process of fuzzification and defuzzification is of great importance in FIS. Fuzzy Inference System is also known as fuzzy expert system, fuzzy model and fuzzy rule-based system. This is built using reduced training dataset and ACS algorithm.
- *Passing of fuzzified data set*:
  Fuzzification adapts the crisp input to a linguistic variable with the membership function gathered in the fuzzy knowledge base. Testing dataset is fuzzified and passed to inference engine for result generation.

- *Result generation and evaluation*:
  Inference Engine classify the fuzzified diabetic dataset into different classes than defuzzification is carried to generate the diagnosis report. Defuzzification changes the fuzzy output of the inference engine to crisp using membership function equivalent to the fuzzifier .

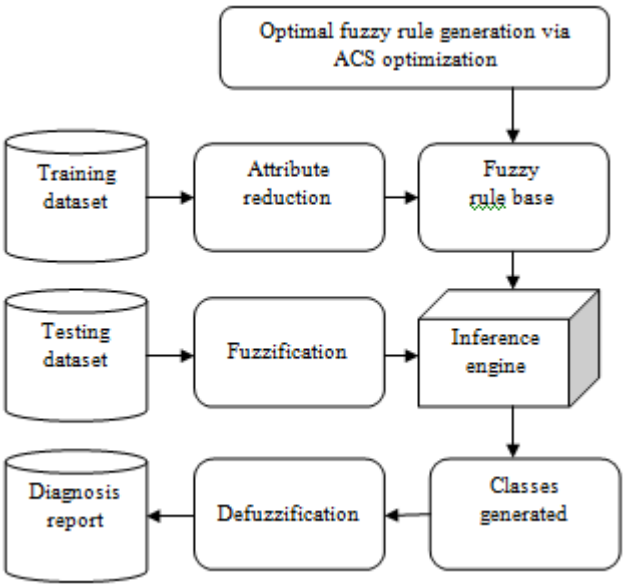

Figure 2: Flow Diagram for proposed system using nature inspired metaheuristic optimization technique

IV. RESULT

We have performed experiment for k=10 folds by dividing input dataset into population size 10, 15, 20 samples respectively for 10, 50, 100 iterations. The performance of the proposed system is analysed with the help of accuracy, specificity, and sensitivity metrics. Figure 3 show the accuracy performance, figure 4 show the sensitivity performance and figure 5 show the specificity performance respectively for population size 15 and iteration 50. These figures illustrate that the ACS approach outperforms the FF-BAT approaches with respect to the three measures Accuracy, Sensitivity, and Specificity.

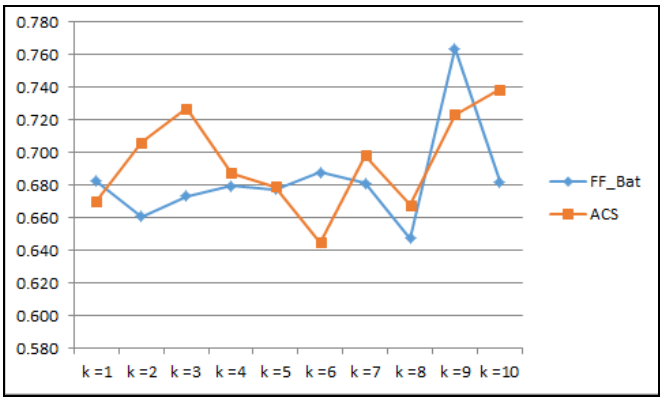

Figure 3: Accuracy plot for population size 15, iteration 50

 ISSN: 2454-4248
252 – 255

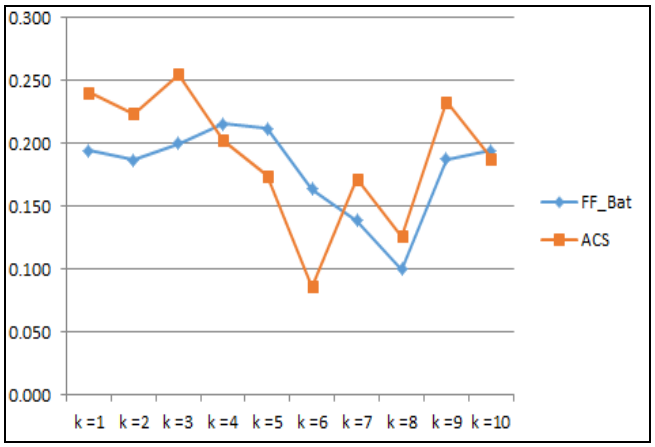

Figure 4: Sensitivity plot for population size 15, iteration 50

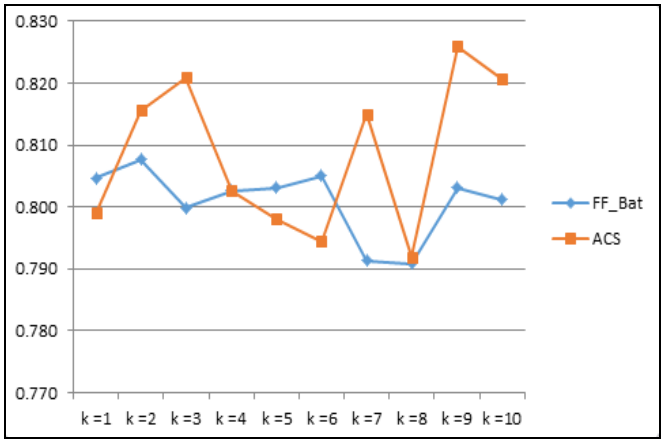

Figure 5: Specificity plot for population size 15, iteration 50

V. Conclusion

This paper used the adaptive cuckoo search optimization technique for optimal rule generation for classification of diabetes. Experimental results indicate that the proposed classification framework has attained higher accuracy, specificity, and sensitivity by ACS algorithm for population size 15 and iteration 50 as compared to FF-BAT algorithm. The proposed work can be extended by applying other nature inspired metaheuristic optimization techniques like extended bat algorithm, lion optimization algorithm, dragonfly algorithm, etc in order to increase the accuracy.

References

[1] Thippa Reddy, G., & Khare, N. (2016). FFBAT-Optimized Rule Based Fuzzy LogicClassifier for Diabetes. In International Journal of Engineering Research in Africa (Vol. 24, pp. 137-152). Trans Tech Publications.

[2] Zhang, Z., & Chen, Y. (2014, July). An improved cuckoo search algorithm with adaptive method. In Computational Sciences and Optimization (CSO), 2014 Seventh International Joint Conference on (pp. 204-207). IEEE.

[3] Zainal, N., Zain, A. M., Radzi, N. H. M., & Othman, M. R. (2016). Glowworm swarm optimization (GSO) for optimization of machining parameters. Journal of Intelligent Manufacturing, 27(4), 797-804.

[4] Fister Jr, I., Yang, X. S., Fister, D., & Fister, I. (2014). Cuckoo search: a brief literature review. In Cuckoo search and firefly algorithm (pp. 49-62). Springer International Publishing.

[5] Dash, M., & Mohanty, R. (2014). Cuckoo search algorithm for speech recognition. International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 3(10).

[6] Yang, X. S., & Deb, S. (2009, December). Cuckoo search via Lévy flights. In Nature & Biologically Inspired Computing, 2009. NaBIC 2009. World Congress on (pp. 210-214). IEEE.

[7] Naik, M., Nath, M. R., Wunnava, A., Sahany, S., & Panda, R. (2015, July). A new adaptive Cuckoo search algorithm. In Recent Trends in Information Systems (ReTIS), 2015 IEEE 2nd International Conference on (pp. 1-5). IEEE.

[8] Yang, X. S., & Deb, S. (2014). Cuckoo search: recent advances and applications. Neural Computing and Applications, 24(1), 169-174.

[9] Narasimhan, B., & Malathi, A. (2014, March). A fuzzy logic system with attribute ranking technique for risk-level classification of CAHD in female diabetic patients. In Intelligent Computing Applications (ICICA), 2014 International Conference on (pp. 179-183). IEEE.

[10] Kumar, P., Nema, S., & Padhy, P. K. (2014S, May). Design of Fuzzy Logic based PD Controller using cuckoo optimization for inverted pendulum. In Advanced Communication Control and Computing Technologies (ICACCCT), 2014 International Conference on (pp. 141-146). IEEE.

[11] Jain, V., & Raheja, S. (2015). Improving the Prediction Rate of Diabetes using Fuzzy Expert System. International Journal of Information Technology and Computer Science (IJITCS), 7(10), 84.

[12] Gadekallu, T. R., &Khare, N. (2017). Cuckoo Search Optimized Reduction and Fuzzy Logic Classifier for Heart Disease and Diabetes Prediction. International Journal of Fuzzy System Applications (IJFSA), 6(2), 25-42.

[13] Gandomi, A. H., Yang, X. S., &Alavi, A. H. (2013). Cuckoo search algorithm: a metaheuristic approach to solve structural optimization problems. Engineering with computers, 29(1), 17-35.

[14] Cui, Z., Sun, B., Wang, G., Xue, Y., & Chen, J. (2017). A novel oriented cuckoo search algorithm to improve DV-Hop performance for cyber–physical systems. Journal of Parallel and Distributed Computing, 103, 42-52.

[15] Pandey, A. C., Rajpoot, D. S., &Saraswat, M. (2017). Twitter sentiment analysis using hybrid cuckoo search method. Information Processing & Management, 53(4), 764-779.

[16] Meza-Palacios, R., Aguilar-Lasserre, A. A., Ureña-Bogarín, E. L., VázquezRodríguez, C. F., Posada-Gómez, R., & Trujillo-Mata, A. (2017). Development of a fuzzy expert system for the nephropathy control assessment in patients with type 2 diabetes mellitus. Expert Systems with Applications, 72, 335-343.

[17] Reddy, G. T., &Khare, N. (2017). An Efficient System for Heart Disease Prediction Using Hybrid OFBAT with Rule-Based Fuzzy Logic Model.Journal of Circuits, Systems and Computers, 26(04), 1750061.