

## **A Review on Classification of Diabetes using Fuzzy Logic and Optimization Technique**

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### **Abstract**

One in four people in any country are now either diabetic or pre-diabetic, which is very bad as this may lead to many severe diseases in the future. The purpose of this paper is to review various optimization techniques to be used for classification of diabetes depending on blood glucose level using fuzzy logic as well. This work will be carried out in various steps. Firstly, reducing the dimensions of training dataset and optimal fuzzy rule generation via optimization technique. Next is fuzzy model design and testing of fuzzified testing dataset. This classification will help doctors to confirm whether patient is diabetic (type 2, type 1 or gestational), pre-diabetic or non-diabetic.

**Keywords:** Diabetes, Fuzzy Inference System, Optimization

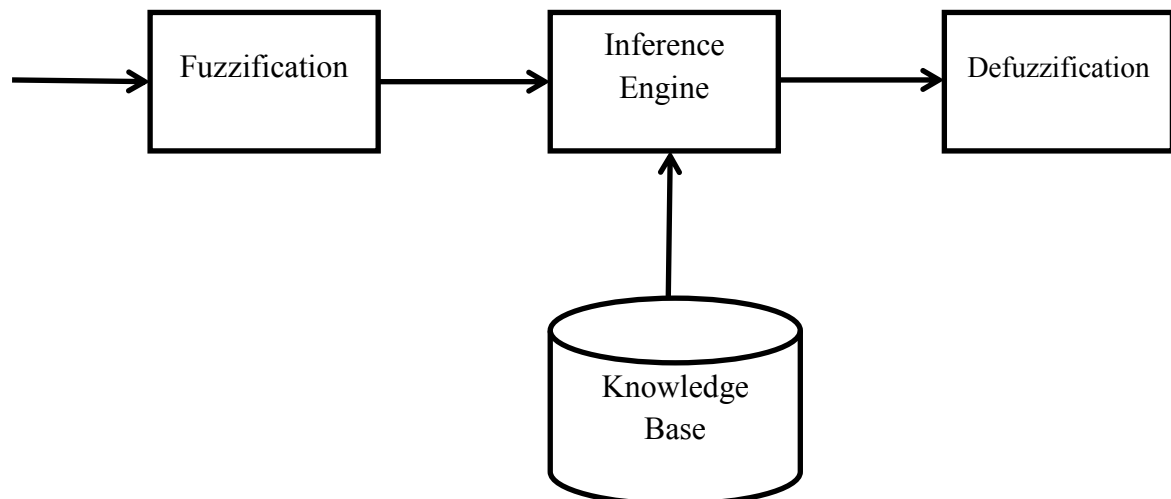
### **1. INTRODUCTION**

**1.1 Diabetes:** With increase in economic condition and population of a developing country, there is increase in number of diseases as well. Diabetes is one of those disease which is mainly found in 8/10 persons mainly in India. It is also known as Diabetes Mellitus. This disease results in high blood glucose level. This may lead to blindness, kidney failure, heart attacks, limb amputations, affects mental as well as physical health. 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.

1.1 **Fuzzy Inference System (FIS):** 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

Fuzzification Unit converts the crisp value into fuzzy value and provides it to inference engine for decision making. Inference Engine extracts the appropriate data from knowledge base as required by fuzzy input value , performs the decision making operation s and generates fuzzy output value. Diffuzification Unit converts the fuzzy output set into the crisp set as a result.

**1.3 Optimization:** This is the process of attaining the most effective result under specified condition by maximizing the desired value and minimizing the undesired ones. Optimization Techniques are categorised as Metaheuristic, Combinatorial, Integer Programming, and Linear Programming. Out of all this Metaheuristic are easier to implement and generate good results as compared to other techniques. Firefly Algorithm, Bat Algorithm and Cuckoo Search are some of the Metaheuristic Algorithms. Firefly is based on the behavior or motion of the flies. Bat algorithm is inspired by echolocation behaviour of bats, and Cuckoo Search is based on the egg laying behavior of cuckoo birds.

## **2. REVIEW OF PREVIOUS WORK**

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.

Comparison is made for three types of metaheuristic algorithms called firefly, bat and cuckoo search algorithm which were used to find optimal solutions. A series of computational experiments using each algorithm were conducted and results were analysed on the basis of minimum run time and success rate and it is observed that firefly algorithm seems to perform better than other two algorithm[2].Rajesh Kumar Sahoo et al. [3] has compared five types of metaheuristic algorithms such as Particle swarm optimization (PSO) algorithm, Bee colony optimization (BCO) algorithm, Bat algorithm (BA), Cuckoo search (CS), Firefly algorithms (FA) and it is clear from the comparison that BCO and Firefly algorithms are the most efficient optimization algorithms.

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 Levy 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]. The one rank cuckoo search (ORCS) algorithm was proposed, by applying two updates to the behaviour of the original cuckoo search (CS) algorithm: first is the one rank (combined evaluation) rule, and second is the bound by best solutions rule [9]. 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]. A multi-class genetic programming (GP) based classifier have been developed that assists doctors in diagnosis by taking data from patient and expert's opinion as input and generates better results [15].

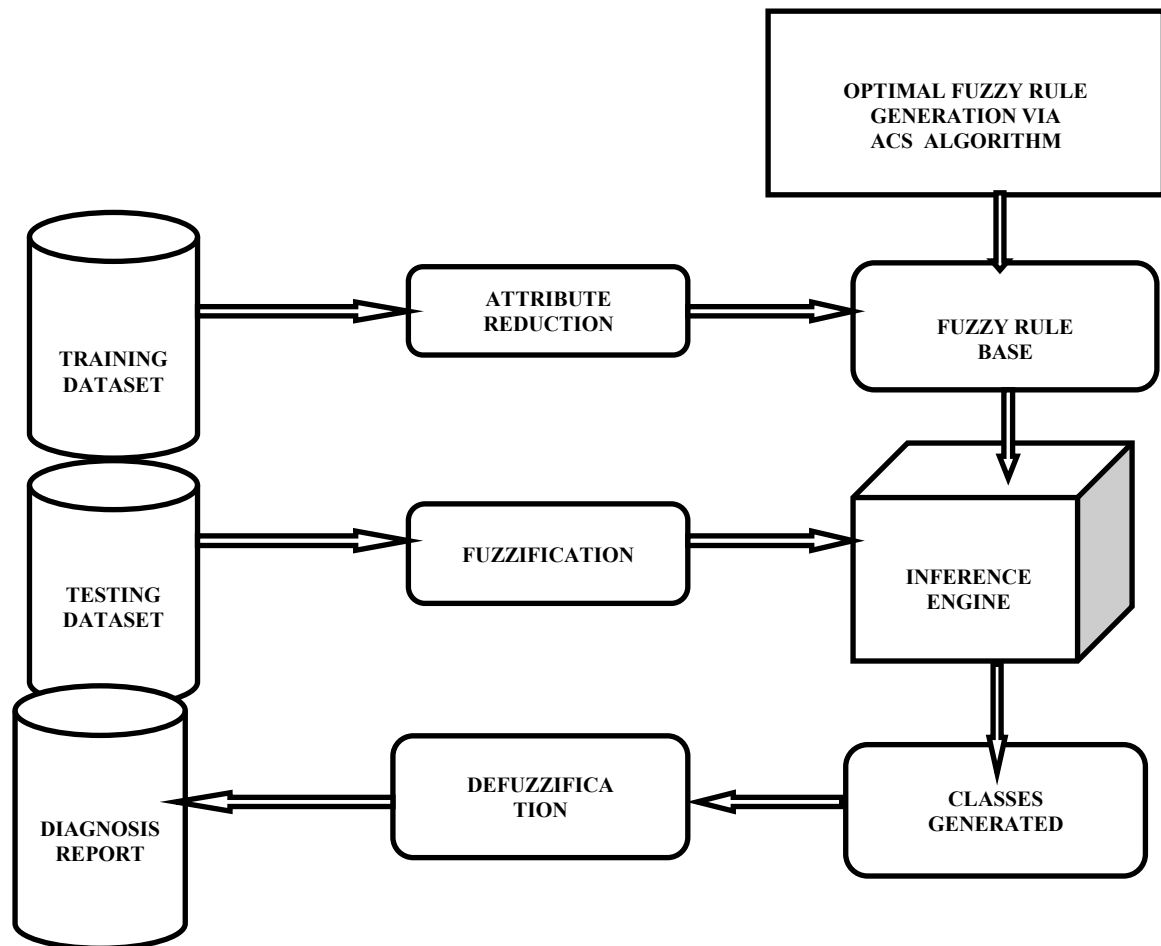
Gadekallu, T.R. and Khare, N. [16] have classified diabetes and heart disease data sets. They used a hybrid of rough sets and cuckoo search algorithms for feature reduction, classified the diseases using fuzzy logic system. Gandomi, A. H. et al. [17] have used a meta heuristic algorithm, Cuckoo search 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. et 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. Shehab, M. et al. [20] have done a comprehensive and exhaustive survey on applications and variants of cuckoo search algorithm. 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).

Amirkhani, A. et al. [22] overviewed the most important decision- making methods and applications of FCMs in the medical field in recent years with the aim of

introducing different types of FCMs and determining their contribution to the improvements made in the fields of medical diagnosis and treatment. Comas, D. S. et al. [23] have proposed a Type-2 Data-based Fuzzy Predicate Clustering (T2-DFPC) method for automatic discovering of interval type-2 fuzzy predicates in data clustering .Kar, A. K. [24] has reviewed and surveyed exhaustively about algorithms based on bio inspired computing and their applications.

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.

### 3. PROPOSED METHODOLOGY



**Figure 2:** Flow Diagram for proposed system using ACS technique

In previous research work FFBAT algorithm has been used. But FFBAT suffers with

the problem of local optima. So, cuckoo search (CS) can be used to replace it, since it does not suffer with local optima problem. But much better than CS is adaptive cuckoo search (ACS) algorithm. ACS is improved version of CS, parameter free algorithm, thinks beyond the levy flight, and has better convergence than CS in all respects. So, proposed system is going to be implemented using ACS algorithm. The flow diagram of proposed system is specified in Figure 2.

The proposed methodology consists of following steps: First, feature reduction using LPP algorithm. Second, Diabetes disease classification by means of rule based fuzzy classifier. Third, applying ACS algorithm for optimizing the generated rules, finally these optimized rules are used to classify the diabetes dataset.

The database 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.

The fuzzy system has following important steps: Collection of training data set, Dimensionality Reduction, Optimal Fuzzy Rule Generation via ACS, Fuzzy Model Design, Passing of fuzzified testing data set, and Result generation and evaluation.

Fuzzification: adapts the crisp input to a linguistic variable with the membership function gathered in the fuzzy knowledge base.

Fuzzy inference engine: with the help of If-Then type fuzzy rules, changes the fuzzy input into the fuzzy output.

Defuzzification: changes the fuzzy output of the inference engine to crisp using membership function equivalent to the fuzzifier.

#### **4. CONCLUSION**

In the proposed work, we have introduced the diabetes classifier by making fusion of fuzzy logic and adaptive cuckoo search optimization technique. The main steps evolved are dimension reduction, optimal rule generation, fuzzy model design, and classification. ACS will help in attaining higher accuracy since it is parameter free algorithm and have better convergence. The proposed system will enhance the recognition efficiency as compared to previously implemented techniques.

#### **REFERENCES**

- [1] Thippa Reddy, G., & Khare, N. (2016). FFBAT-Optimized Rule Based Fuzzy Logic Classifier for Diabetes. In *International Journal of Engineering Research in Africa* (Vol. 24, pp. 137-152). Trans Tech Publications.
- [2] Arora, S., & Singh, S. (2013, August). A conceptual comparison of firefly algorithm, bat

- algorithm and cuckoo search. In *Control Computing Communication & Materials (ICCCCM), 2013 International Conference on* (pp.1-4).IEEE. [3] Sahoo, R. K., Ojha, D., & Dash, S. (2016). Full Length Research Article.
- [4] 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.
- [5] 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.
- [6] 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.
- [7] Dash, M., & Mohanty, R. (2014). Cuckoo search algorithm for speech recognition. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, 3(10).
- [8] 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.
- [9] Tawfik, A. S., Badr, A. A., & Abdel-Rahman, I. F. (2013). One rank cuckoo search algorithm with application to algorithmic trading systems optimization. *International Journal of Computer Applications*, 64(6).
- [10] 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.
- [11] Yang, X. S., & Deb, S. (2014). Cuckoo search: recent advances and applications. *Neural Computing and Applications*, 24(1), 169-174.
- [12] 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.
- [13] 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.
- [14] 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.
- [15] Sonawane, R., & Chaudhari, J. (2014). A Review Paper on Diabetes Detection using Genetic Programming.
- [16] 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.
- [17] 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.
- [18] 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.
- [19] Pandey, A. C., Rajpoot, D. S., & Saraswat, M. (2017). Twitter sentiment analysis using hybrid cuckoo search method. *Information Processing & Management*, 53(4), 764-779.
- [20] Shehab, M., Khader, A. T., & Al-Betar, M. A. (2017). A survey on applications and variants of the cuckoo search algorithm. *Applied Soft Computing*.
- [21] Meza-Palacios, R., Aguilar-Lasserre, A. A., Ureña-Bogarín, E. L., Vázquez-Rodríguez, 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.
- [22] Amirkhani, A., Papageorgiou, E. I., Mohseni, A., & Mosavi, M. R. (2017). A review of fuzzy cognitive maps in medicine: Taxonomy, methods, and applications. *Computer Methods and Programs in Biomedicine*.
- [23] Comas, D. S., Meschino, G. J., Nowé, A., & Ballarin, V. L. (2017). Discovering knowledge from data clustering using automatically-defined interval type-2 fuzzy predicates. *Expert Systems with Applications*, 68, 136-150.
- [24] Kar, A. K. (2016). Bio inspired computing—A review of algorithms and scope of applications. *Expert Systems with Applications*, 59, 20-32.
- [25] 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.