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Features of Metaheuristic Algorithm for Integration with ANFIS Model

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Abstract—**In recent years, many applications based on the Neural Network, Neuro-Fuzzy, and optimization algorithms have been more common for solving regression and classification problems.In the Adaptive Neuro-fuzzy inference system(ANFIS), many researchers used the adaption of metaheuristic algorithms with ANFIS to propose the best estimation model. However, many researchers only focused on the experiment without the demonstration mathematical or indicating which characteristic of optimization algorithm, during the run, affect and settable in coordination with ANFIS. The paper provides an adaption of metaheuristic algorithms with ANFIS which has been performed by considering accuracy parameters in layer 1 and layer 4 for the estimation problem. It is integrated six well-known metaheuristic algorithms and extracting the characteristic of them. In the experiment, the metaheuristic algorithms based on the evolutionary computation have been demonstrated more stable than swarm intelligence methods in tuning parameters of ANFIS.**

Keywords— ANFIS, Metaheuristics Algorithm, Genetic Algorithm, Mutation, Crossover

I. INTRODUCTION

The adaptive network-based fuzzy inference system (ANFIS) is based on the artificial neural networks and features of fuzzy logic which provides decision-making as human thinking [1]. The power structure of the artificial neural network can be learning and expert best output can be given to fuzzy logic inference systems including the decision-making as human. The integration of two paradigms provides the estimation tools which is proper to show the input and output relations [2]. The ability of ANFIS by considering estimation is computationally less expensive, transparency, simple implementation, and best results in comparison by statistical model [3,4].In recent years popular to use data-driven ANFIS which is applied to real datasets and used by researchers frequently[5-11]. When Researchers used these tools with hybrid various optimization methods, just focused on experiment and result without any discussing which type of optimization method proper to hybrid it. This paper aims to evolutionary computation and swarm intelligence to discover characteristic sets. In the inner of structure, ANFIS has many learning parameters for presentation the best result which should be set with the proper algorithm.

II. ANFIS MODEL

The adaptive network-based fuzzy inference system (ANFIS) is one of the Artificial intelligence methods, which include combining two concepts are artificial neural network (ANN) and fuzzy logic (FL) methods. The ANFIS Framework provides the relation between inputs and outputs. The Framework has 5 layers with containing nodes which each layer feed to the next layer

Except the first layer and the last layer is set with independents variables and dependents variables of the dataset respectively.To describe the ANFIS Framework. (Figure 1)

Rule 1: İF x is $A1$ and y $B1$ then z is$f1\ (x, y)$
Rule 2: İF x is $A2$ and y $B2$ then z is $f1\ (x, y)$ x,y:Inputs of ANFIS A,B: Fuzzy sets z: $fi\ (x, y)$ outputs of Sugeno Fuzzy inference systems.

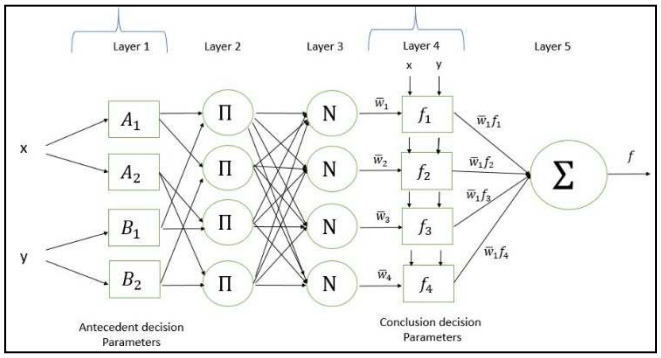

Fig1.The ANFIS model for two inputs data

The nodes of layers 1 and 4 indicate parameter sets that are tuned with the optimization algorithm. Layer 2 and 3 are fixed in the Framework. The first layer includes adaptive nodes with functions mentioned in the following:

o1,i -μAx (x) For i=1, 2 (1)
o1,i -μBi−2 (x) For i=3, 4 (2)
$\mu(x)$, $\mu(y)$
the membership functions, which can be defined a bell shape the formula are given in the following:
$(x) = 1\ 1+(\ x-ci\ ai\ )\ 2bi$ (3)
Or $(x) = exp\ \{-(\ x-ci\ ai\ )\ 2\ \}$ (4)

a , ci , biParameters are called premise parameters. They will be changed in the training step, which means the parameters of the bell-shaped functions are being changed. Each fixed nodes in the second layer multiplied with input signals from the first layer and the output of them arewi shows the power of a rule.

o2,i = wi = μAi (x). μBi (y) For i=1, 2 (5)

In the third layer, every node, normalize the input signal by considering all rules. The formula is given as follows.
o3,i = wi= wi ∑ wi = wi w1+w2 for i=1, 2 (6)

In the Forth layer, each node isan adaptive layer which is defined and described as follows.
$o4, = wi\ .fi$ For i=1, 2 (7)

Rule 1: if x is $A1$ and y is $B1$ then$f1=p1x+q1y+r1$ Rule 2: if x is $A2$ and y is $B2$ then$f2=p2x+q2y+r2$ p , qi , riParameters are called consequent parameters. The last layer, compute the overall output and estimate the output during running [12, 13]. o5,i = fout = ∑iwi .fi=overall output

iii. Optimization ALGORITHM AND RESLT

EXPRINCE By considering ANFIS as a system that requires parameter set as accuracy, the role of metaheuristic algorithm plays an important in the system. Due to the nature of metaheuristic algorithm applies to any kind of problems directly or indirectly. They are used to the effectiveness of a range of design, planning, operational, management, and policy options[14-18].In this study, we integrated ANFIS with particle swarm optimization (PSO), Genetic Algorithm (GA), Firefly Algorithm(FA), Harmony Search (HS), Bat algorithm (BAT), and Artificial Bee Colony Algorithm (ABC). All algorithms sets with standard initialized parameters such as population size 25 and iteration 1000 and the other side for the individual we used Figure 2. The comparison of performance with 30 runs for the integrated ANFIS with metaheuristic algorithms demonstrated the GA algorithms with specific features are more powerful than the others. Some characteristic sets are following Table 1. After observing the experiment results three components such as Roulette Wheel, Mutation and Evolutionary-based are important in integration with ANFIS. Roulette Wheel helps to select the best chromosome (here is parameter set) and mutation also tries to scape of local minimum. As we view the algorithm should be based on the no-leader agent like Evolutionary-based. This package is demonstrated the best result in integration with ANFIS.

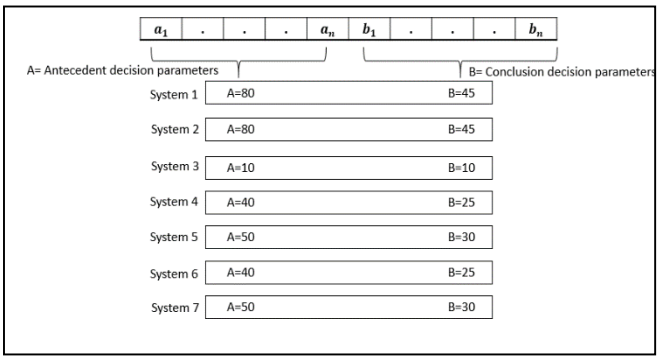

Fig. 2. Parameters set for each system

Table 1. The characteristic of metaheuristic algorithms

Algorithm	Probability Distribution	Search Characteristics	Category
PSO	Uniform	Guided search in search space	Swarm-based
GA	Roulette Wheel	Cross Over, Mutation, selection based on exponential	Evolutionary-based
FA	Gaussian, Uniform	Nonlinear attraction(EXP) in search space	Swarm-based
HS	Uniform	HMCR, PAR	Evolutionary-based
BAT	Uniform	Frequency-tuning	Swarm-based
ABC	Roulette Wheel	There Guided agent in search space	Swarm-based

CONCLUSION

This study performed a comparison of meta-heuristic optimization algorithms with the integration of the ANFIS model.We observed the gap in integration and tried to discover the important characteristic set of them. As view the experiment result, three components are important such as Roulette Wheel, Mutation and Evolutionary-based. By observing these package it can be guide to researcher for using. Of course, It is required specific designed them in integration.

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