An Improved Cooperative Harmony Search for Function Optimization

Malarvvizhi G, Subramanian K M

Abstract- **Harmony Search (HS) is one of the metaheuristic algorithms for solving optimization problems which is inspired by musical improvisation process. A Cooperative Harmony Search (CHS) enhances the performance of HS by applying Cooperative approach. CHS can able to solve complex optimization problems such as function optimization and also embedding this with other optimization algorithms is possible. In this paper, an Improved Cooperative Harmony Search (ICHS) is proposed to enrich the performance of CHS. It combines the CHS with the genetic algorithm. Genetic algorithm is a popular known optimization algorithm. ICHS experimented with different benchmark functions that show the ICHS gives amended solutions than CHS.**

Index Terms- **Harmony Search, Cooperative approach, Genetic algorithm, function optimization, benchmark functions.**

I. INTRODUCTION

The main objective of optimization is to get values for a set of parameters that minimizes or maximizes the objective functions. In prior days, numerical methods like Newton's method, Gauss seidel are used for optimization [1]. But the problem with this case is they need derivative of objective function and calculating derivatives for real-world problems is very complex. So that optimization algorithms are introduced. Metaheuristic algorithms are optimization algorithms which are the process inspired by natural phenomena or activities. For example, particle swarm optimization algorithm which is inspired by behaviour of flock of birds. All metaheuristic algorithms are includes random process and the results shows approximations around the solutions. Harmony Search (HS) is also a type of metaheuristic algorithm that is inspired by musical improvisation process [2]. HS has good performance but one drawback is it holds single harmony memory for optimization process. This problem is solved by cooperative harmony search (CHS) that uses cooperative approach with multiple harmony memories. In this proposal, an Improved Cooperative Search (ICHS) upgrades the performance of CHS by involving genetic algorithm (GA).

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II. HS ALGORITHM

HS algorithm is one of the metaheuristic algorithms and that is inspired by musical improvisation process. A musician can play a harmony in three ways: (a).Play what he/she exactly knows; (b).Play by slightly adjust the pitch and (c). Play a new composition.
These are converted as HS algorithm, the steps are:

i. Initialize the problem and algorithm parameters
ii. Initialize the Harmony Memory (HM) which is similar to population in GA
iii. Improvise new harmony
iv. Update HM
v. Repeat step iii and iv until reach optimal solution

Harmony Memory (HM) is similar to the musician memory. The solution vectors are stored with its fitness value. Based on the fitness value the solutions are sorted within the HM. By applying some parameters, the optimal result will achieved. Those parameters are Harmony Memory Size (HMS), Harmony Memory Consideration Rate (HMCR), Pitch Adjusting Rate (PAR), bandwidth (*bw*). HMS limits the HM,HMCR defines how many harmonies are considered from HM for improvisation process and normally its value is 0.9 or 0.95.PAR and *bw* are used for improvisation process where PAR commonly assigned as 0.3 and *bw* is 0.01 [16]. These parameters are initialized at the first step. In second step, the set of solution vectors are initialized in HM. Then the improvisation process which includes the worst solution vector is replaced by new better solution. It is repeated up to reach certain criteria that may end of iteration or any condition according to the problem.

This HS algorithm is a new forthcoming optimization technique to solve optimization problems such as function optimization, Sudoku puzzle solving, multicast routing and so on [9].Hybridizing with other algorithm is possible [8] [12] [14].HS broaden by applying some new approaches with it.

III.CHS ALGORITHM

The Cooperative Harmony Search (CHS) algorithm simply combines the cooperative approach [4] [10] [11] [17] with HS algorithm. In HS algorithm, single harmony memory is used and optimization process is carried over it. Instead of the single harmony memory, if multiple harmony memories are applied then the performance will increase. This is the base for CHS. In CHS, the set of solution vector

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is divided into multiple subsets of components and they perform cooperatively [15].

$$HM = \begin{bmatrix} x_1^1 & x_2^1 \dots & x_n^1 \\ x_1^2 & x_2^2 \dots & x_n^2 \\ \vdots & \vdots & \vdots \\ x_1^{HMS} & x_2^{HMS} \dots & x_n^{HMS} \end{bmatrix} \quad (1)$$

$$HM = \left[\begin{array}{cc|cc|c} \multicolumn{2}{c|}{H_1} & \multicolumn{2}{c|}{H_2 \dots} & H_m \\ x_1^1 \dots & x_i^1 & x_{i+1}^1 \dots x_{2i}^1 & & \dots x_n^1 \\ x_1^2 \dots & x_i^2 & x_{i+1}^2 \dots x_{2i}^2 \dots & & x_n^2 \\ \vdots & \vdots & & & \vdots \\ x_1^{HMS} \dots & x_i^{HMS} & x_{i+1}^{HMS} \dots x_{2i}^{HMS} & & \dots x_n^{HMS} \end{array}\right] \quad (2)$$

These subsets are considered as multiple harmony memories. The format of HM in HS algorithm is given in equation (1) and (2) shows the format of HM in CHS algorithm [15].Then the formal steps of HS are followed in CHS. This algorithm can able to solve the problems which are solved by HS algorithm and hybridizing with other algorithm is possible [7].

```
Initialize the problem& algorithm parameters
Divide the n decision variables into m groups
for all HM do
    Initialize HM randomly
end for
while stopping criteria is false do
calculate PAR &bw
for all HM do
        generate and evaluate new harmony
end for
end while
```

Pseudocode-1: CHS Algorithm

IV. ICHS ALGORITHM

Improved Cooperative Harmony Search algorithm is the combination of CHS and genetic algorithm (GA). The parameters of CHS are included in this algorithm and the GA is involved to enrich the solution. The GA is given as pseudocode-2. These steps are involved after a new harmony is generated by CHS algorithm, it refines the harmony. ICHS algorithm is stated as in pseudocode-3. A new harmony generated by CHS is given as chromosome and its HM is the population in GA. The fitness value of chromosomes in population are generated and based on that fitness value chromosomes are sorted [5].

```
begin
Initialize population of chromosomes
Evaluate fitness of chromosomes
while specific condition is false do
Selection genetic operator
    Create new chromosomes by crossover
& mutation
Evaluate fitness of new chromosomes
Update population
end while
end
```

Pseudocode-2: Genetic Algorithm

In GA, [12] there are few operator likely selection, crossover and mutation. The selection operator chooses the highest fitness value chromosome for create intermediate population and based on that the other genetic operators will work. The crossover operator is for generate new chromosomes from the intermediate population. The mutation operator is for change any of genes in chromosome [5] [18]. It avoids the stagnation of population at any of local optima and honestly the probability of 0.01 gives good impact. The result of ICHS can be shown by the experiments with some of standard benchmark function and also ICHS is compared with previous two algorithms.

```
Initialize the problem& algorithm parameters
Divide the n decision variables into m groups
for all HM do
    Initialize HM randomly
end for
while stopping criteria is false do
calculate PAR &bw
for all HM do
        generate and evaluate new harmony
end for
callgenetic_algorithm()
end while
```

Pseudocode-3: ICHS Algorithm

V. EXPERIMENTS

The experiment involves the following standard benchmark functions [6]:

The Ackley's function

$$f_1(X) = -20exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right)$$

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$$+\ 20 - \exp\left(\frac{1}{n}\sum_{i=1}^{n} cos(2\pi x_i)\right) + e \quad (3)$$

where n=30, X ϵ[-30,30]^{30} , with the global optimum X^*= (0,0,……,0).

The Quadric function

$$f_2(X) = \sum_{i=1}^{n}\left(\sum_{j=1}^{i} x_j\right)^2 \quad (4)$$

where n=30, X ϵ[-100, 100]^{30} ,with the global optimum X^*= (0,0,……,0).

The Sphere function

$$f_3(X) = \sum_{i=1}^{n} x_i^2 \quad (5)$$

where n=30, X ϵ[-100, 100]^{30} , with the global optimum X^*= (0,0,……,0).

The Rosenbrock's function

$$f_4(X) = \sum_{i=1}^{n-1}(100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2)(6)$$

where n=30, X ϵ[-30, 30]^{30}, with the global optimum X^*= (0,0,……,0).

The parameters PAR and *bw* are calculated as[3] [13]:

$$PAR(gn) = PAR_{min} + \frac{(PAR_{max} - PAR_{min})}{NI} \times gn, (7)$$

$$bw(gn) = bw_{max} \exp(Ln(\frac{bw_{min}}{bw_{max}})/NI) \quad (8)$$

A. Configuration of Algorithms

These algorithms experimented with 3×10^4 iterations. The parameters of all algorithms are:

(a) Parameters of HS algorithm: HMS = 30, HMCR = 0.9,PAR = 0.3, *bw* = 0.01 [2] [3].

(b) Parameters of CHS algorithm: HMS= 30, HMCR= 0.9, PAR_{min} = 0.01, PAR_{max} = 0.99, bw_{min} = 0.01, bw_{max} = 5, the number of divisions m=10 [6].

(c) Parameters of ICHS algorithm: HMS= 30, HMCR = 0.9, PAR_{min} = 0.01, PAR_{max} = 0.99, bw_{min} = 0.01, bw_{max} = 5, the number of divisions m = 10, the crossover probability = 0.6, and the mutation probability = 0.01 [6] [5].

These values are used in the experiment and the result is shown in the next section.

B. Experimental Results

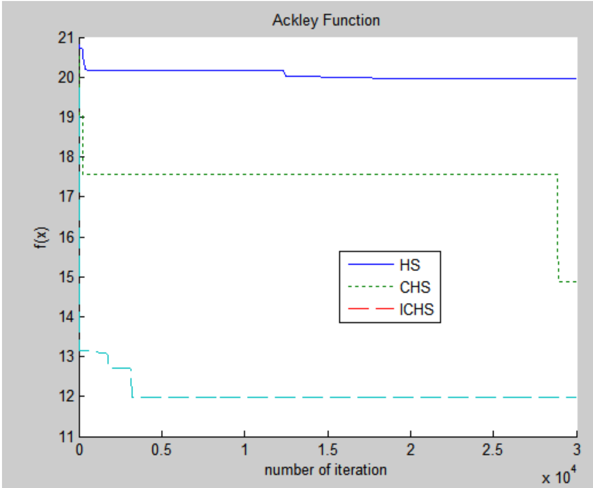

Fig.1-Algorithms performance on Ackley Function is presented.

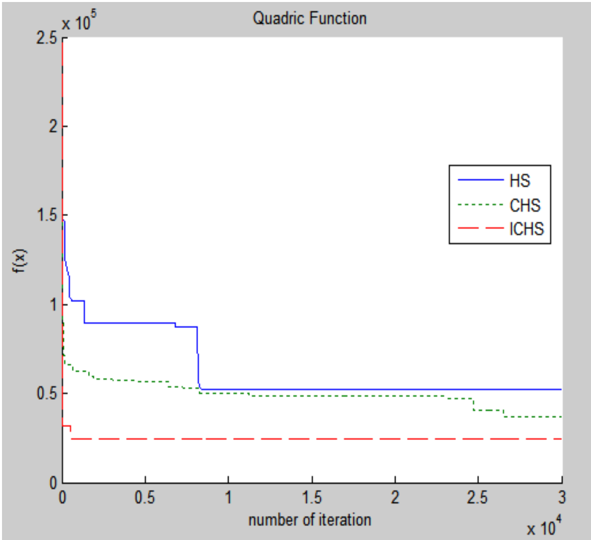

Fig.2-Algorithms performance on Quadric Function is presented.

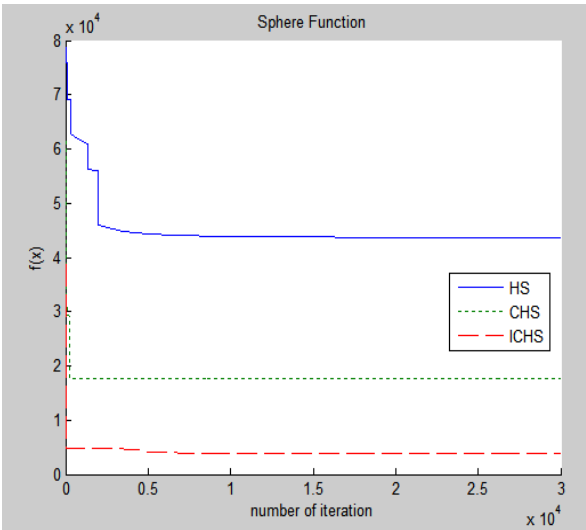

Fig.3- Algorithms performance on Sphere Function is presented.

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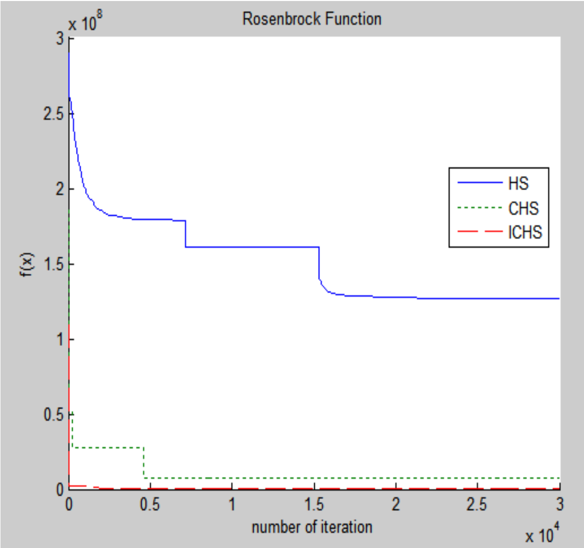

Fig.4- Algorithms performance on Rosenbrock Function is presented.

VI. CONCLUSION

The Improved Cooperative Harmony Search algorithm is proposed here, by the experimental result we can able to conclude that this algorithm adds some interesting value to the existing CHS algorithm. By combining GA with CHS gives an optimal solution than CHS. Hybrid one HS algorithm with other optimization algorithm is possible as like the same the ICHS algorithm is done. In forthcoming research, mathematical analyses to improve the algorithm parameter's effectiveness or the betterment of the performance of the algorithm are interestingly inviting proposals.

REFERENCES

[1] K. S. Lee and Z. W. Geem, "A new meta-heuristic algorithm for continuous engineering optimization: harmony search theory and practice," Computer Methods in Applied Mechanics and Engineering, vol. 194, no. 34-36, pp. 3902, 2005.

[2] Xin – She Yang, "Harmony search as a metaheuristic algorithm," in Musical – Inspired Harmony Search Algorithm: Theory and Applications, Studies in Computational Intelligence, Springer Berlin, vol. 191,pp. 1-14,2009.

[3] M. Mahdavi, M. Fesanghary, E. Damangir, "An improved harmony search algorithm for solving optimization problems," Applied Mathematical and Computation, vol. 188, no. 2, pp. 1567-1579, 2007.

[4] K. A. De Jong and M. A. Potter, "Evolving complex structures via cooperative coevolution," in Evolutionary Programming, pp. 307-317, 1995.

[5] M. A. Potter and K. A. De Jong, "A cooperative coevolutionary approach to function optimization," in Parallel Problem Solving from Nature- PPSN III, vol. 866, pp. 249-257, Springer, 1994.

[6] Gang Li and Qingzhog Wang, "A cooperative harmony search algorithm for function optimization," in Mathematical Problems in Engineering, Hindawi Publishing Corporation, vol. 2014, 2014.

[7] LihongGuo, Gai-Ge Wang, Heqi Wang and Dinan Wang, "An effective hybrid firefly algorithm with harmony search for global numerical optimization," in The Scientific World Journal, Hindawi Publishing Corporation, vol. 2013, 2013.

[8] Bin Wu, CunhuaQian, Weihong Ni, Shuhai Fan, "Hybrid harmony search and artificial bee colony algorithm for global optimization problems," in Computers and Mathematics with Application, vol. 64, pp. 2621- 2634, 2012.

[9] D. Manjarres, I. Landa-Torres, S. Gil-Lopez, J. Del Ser, M. N. Bilbao, S. Salcedo- Sanz and Z. W. Geem, "A survey on applications of the harmony search algorithm," in Engineering Applications of Artificial Intelligence, vol. 26, p. 1818- 1831, 2013.

[10] Frans van den Bergh and Andries P. Engelbrecht, " A cooperative approach to particle swarm optimization," in IEEE Transactions on Evolutionary Computation, vol. 8, no. 3, 2004.

[11] Zhenyu Yang, Ke Tang, and Xin Yao, "Large scale evolutionary optimization using cooperative coevolution," in Information Sciences, vol. 128, pp. 2985-2999, 2008.

[12] H.-q. Li and L. Li, "A novel hybrid real-valued genetic algorithm for optimization problems," in International Conference on Computational Intelligence and Security, pp. 91- 95, 2007.

[13] Jiali Yang and Jihong Zhu, "A modified harmony search algorithm for optimization problems," in Fifth International Symposium on Computational Intelligence and Design, 2012.

[14] A. Kaveh and S. Talahari,"Paticle swarm optimizer, ant colony strategy and harmony search scheme hybridized for optimization of truss structures," in Computers and Structures, vol. 87, no. 5-6, pp. 267-283, 2009.

[15] Mostepha R. Khouadjia, El- GhazaliTalbi, LaetitiaJourdan, BriseidaSarasola and Enrique Alba, " Multi- environmental cooperative parallel metaheuristics for solving dynamic optimization problems," J Supercomput, no. 63, pp. 836-853.

[16] Chukiat Worasucheep, "A harmony search with adaptive pitch adjustment for continuous optimization," in International Journal of Hybrid Information Technology, vol. 4, no.4, 2011.

[17] HongqingZheng and Yongquan Zhou,"A cooperative coevolutionary cuckoo search algorithm for optimization problem,"inJournal of Applied Mathematics, pp. 9, 2013.

[18] P. Chakraborty, G. G. Roy, S. Das, D. Jain, and A. Abraham, "An improved harmony search algorithm with different mutation operator," Fundamental Information, vol. 95, pp. 401-426, 2009.

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