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Harmony Search Algorithm and performance on Rastigin function

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ABSTRACT: The heuristic optimization technique is used to find optimal solution of complex large-scale nonlinear realistic based problems. Harmony search algorithm is one of that optimization technique founded by W.H. Geem and then applied successfully in different practical problems.The theoretical and functional aspects are discussed here in details. The performance is tasted on benchmark function i.e. Rastigin function. The optimal solution is found satisfactory and number of iteration is also analyzed.

KEYWORDS: Optimization Technique, Harmony Search Algorithm, population, dimension, rastrigin function

I. INTRODUCTION

Harmony Search Algorithm (HSA) is music enlivened public type optimization strategy. The way toward making the best music is similar to searching the ideal answers for given target work. In one side, bit of music is created with flawless harmony whose standard is controlled by sound tasteful norm. Thus on opposite side best arrangement accessible to the issue is discovered under the given goals and restricted by limitations. The music is formed by utilizing the instrumental tune whose quality is changed utilizing distinctive melodic note. Distinctive melodic note is made by utilizing pitch alteration in existing note, which is done to improve the music quality. Thus in optimization method, there are factors of given issues, which framed the ideal arrangement. The modification in these factors is done so acceptable arrangement can be discovered. There exists a relationship among music and optimization: every instrument compares to every choice variable; melodic note relates to variable worth; and harmony compares to arrangement vector [1].

Most importantly W.H. Geem et al. had discovered the connection among music and optimization and proposed another optimization method known as HSA in 2001. From that point forward HSA has been effectively applied in different optimization issue, for example, benchmark work optimization, building optimization, structure of water dispersion systems, groundwater displaying, vitality sparing dispatch, support plan, vehicle steering and so forth. Hybridization of HSA with other meta-heuristic cycle, for example, molecule swarm optimization, hereditary algorithm and so on has been accounted for in different research work.

II. TERMS OF HSA

The various terms associated with HSA are discussed in following sub sections. The importance and the function of these terms in HSA are also explained.

A. HARMONY MEMORY (HM)

The memory area putting away the arrangement vectors and the wellness of target work is called HM. Utilization of HM is critical in HSA on the grounds that it guarantees that great arrangement is a piece of new arrangement. The existed arrangement put away in HM might be best arrangement or not. In the event that the arrangement isn't ideal, at that point the arrangement vector is changed by utilizing pitch modification rate and data transfer capacity so the put away arrangement combines to best one. For the compelling use of HM, a boundary harmony memory considering (or tolerating) rate (HMCR) is taken, which is examined later. All the existed arrangement put away in HM and with evolving these, ideal arrangement can be discovered.

B. HARMONY MEMORY SIZE (HMS)

Total number of solution vectors in HM is known as Harmony Memory Size (HMS). With increasing the number of solution the possibility of finding the best solution is increases. But when the value of HMS is high then the time taken for iteration will be more.

HARMONY MEMORY CONSIDERATION RATE (HMCR)

Application of perfect already made harmony is very important in composing best music. In harmony search the already made harmonies or solution vectors are stored in HM. The solution vector whose fitness is better than the current solution should be taken into account. The number of solution vectors would take into account is decided by HMCR. The more the value of HMCR more solution vectors are taken from HM and vice-versa. The range of this parameter is taken from 0 to 1. When the value of HMCR is near about 0 that's mean the only few solution is taken from HM and the result converge too slowly. If this value is near about 1 then the almost all value is taken from HM. But the other ones solutions from HM are not explored well, leading immature solution and thus good solution may not found out. The solution can stuck into local optimal point. Generally the value of this parameter is taken from 0.7 to 0.95. HMCR improves the rate of convergence for the optimization.

C. **PITCH ADJUSTING RATE (PAR)**

The second significant part in HSA measure is pitch modification which is finished by utilizing parameters transmission capacity go (bw) and pitch changing rate (PAR). The significance of contribute modification music is to change the recurrence for example make a somewhat extraordinary music. For search the best music there is change in existing music with the goal that the nature of music improves. Also in HSA there is little worth included or deducted from existing worth so the enormous pursuit zone will be looked with the goal that best arrangement discovered.

In HSA the new arrangement component is made by including and taking away some incentive as indicated by data transfer capacity taken exposed to models which is characterized by PAR. In other word how much component ought to be pitch balanced is characterized by PAR and how much worth is included and deducted is characterized by data transmission. PAR is relegated to control the level of the alteration. A low pitch altering rate with a restricted data transmission can hinder the intermingling of HS in light of the impediment in the investigation of just a little subspace of the entire inquiry space. Then again, a high pitch-altering rate with a wide data transfer capacity may make the arrangement spread around some potential optima as in an arbitrary hunt. Normally the estimation of PAR taken in many applications is from 0.1 to 0.5 [2]. Both direct and nonlinear change should be possible in principle, yet by and by straight alteration is utilized.

D. BANDWIDTH

The value included and deducted from existing arrangement is called transmission capacity (bw) in HSA. Little the estimation of bw little changes in existing arrangement vectors will happen. Thus in like manner change will occur in wellness. Also, consequently, all potential purposes of the pursuit space are examined. Yet, when its estimation is high then the all conceivable arrangement territory may not looked and consequently the arrangement could trap in nearby minima.

E. NEW HARMONY VECTOR (NHV)

All the arrangement vectors are put away in HM. In act of spontaneity measure the arrangement vectors are changed by the rationale of HSA. The changed arrangement vectors are put away in NHV. At the point when the put away arrangement is better than the as of now existed arrangement vector then the arrangement vector will put away in HM in any case not. During the creation of HM from NHV, there is change in arrangement vectors which is put away in D3 variable. Actually in pitch adjusting process some solutions of problem are added and subtracted and so new solution is stored in D3.On the off chance that the limit conditions are fulfilled by arrangement vector put away in D3, at that point this arrangement is put away in NHV in any case some alteration is done so the limit condition will be satisfied. So the satisfactory pitching is done here and the perfect harmony can be found.

III. STEPS OF HSA

The steps involve in HSA process are explained below.

A. INITIALIZE THE PROBLEM AND ALGORITHM PARAMETERS

In this progression the target work and the parameters of calculation are characterized. The enhancement issue is characterized as follows:

Limit $f(x)$ …(1)

Subject to $x_i \in X_i$, $I = 1, 2\ldots, N$ …(2)

Where $f(x)$, x_i, X_i are the goal work, estimation of every choice factors and all conceivable arrangement set separately. N is number of choice factors. With characterizing the target capacity and limitations the parameters of HSA are likewise indicated in this progression. The primary parameters of HSA are HMCR, HMS, PAR and number of cycle (NI). These parameters are talked about above.

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B.FORMATION OF HARMONY MEMORY

In this progression the factors of target work are created arbitrarily inside their cutoff points. The quantity of lines of lattice is equivalent to the HMS and segment equivalent to number of factors. These factors with relating yields are put away in the framework supposed concordance memory lattice as demonstrated as follows.

$$HM = \begin{bmatrix} x_1^1 & x_2^1 & \dots & x_M^1 \\ x_1^2 & x_2^2 & \dots & x_M^2 \\ \vdots & \vdots & \dots & \vdots \\ x_1^{HMS} & x_2^{HMS} & \dots & x_M^{HMS} \end{bmatrix} \quad \dots(3)$$

C. IMPROVISE A NEW HARMONY

In the act of spontaneity measure the new amicability vectors, x'= (x1',x2'… … , xN') are shaped dependent on the accompanying three guidelines: (1) memory thought, (2) pitch change and (3) randomization. Hence by utilizing these three cycles extemporization is finished.

In the memory thought, the estimation of first new factor (x1') is browsed any estimation of first section (x11 to x1HMS) of HM. Estimation of other new harmonies (x2' to xN') are picked in comparative way. New factor esteem is taken from HM or not is chosen by HMCR. The HMCR, which differs somewhere in the range of 0 and 1, is the pace of picking one incentive from the verifiable qualities put away in the HM, while (1 − HMCR) is the pace of arbitrarily choosing one incentive from the conceivable scope of qualities [3],

$$x_i' \leftarrow x_i' \in \{x_i^1, x_i^2, \dots, x_i^{HMS}\} \text{ w.p. HMCR}$$
$$x_i' \in X_i \quad \text{w. p. (1-HMCR)}$$

For example when the value of HMCR is 0.8 then 80% of already existed variable value in HM is taken and remaining (1 - HMCR) i.e. 20% is generated randomly within possible range. These 80% taken is examined further for pitch adjustment which is decided by PAR parameter.

Pitch adjusting decision for

$$x_i = \begin{cases} \text{Yes w. p. PAR} \\ \text{No w. p. } (1 - \text{PAR}) \end{cases} \quad \dots(5)$$

In the event that the pitch modification condition is fulfilled, at that point the new worth will be the somewhat not the same as existed an incentive as follow:

$$xi' = xi \pm bw*\varepsilon \quad \dots(6)$$

Where xi is the current arrangement of target work in HM and xi' is the new conceivable arrangement after pitch change. Here ε is the irregular number from 0 to 1 with uniform appropriation inside its range. In the event that the pitch alteration condition isn't fulfilled, at that point previously existed an incentive in HM will be taken. For instance, on the off chance that the estimation of PAR is 0.3, at that point the 30% of taken an incentive as per HMCR is pitch balanced with half of expansion and deduction. In other word the level of pitch modification is given by

Level of pitch modification = HMCR*PAR (7)

for instance on the off chance that the estimation of HMCR and PAR are 0.7 and 0.3, at that point 0.21 (0.7*0.3) is the likelihood of pitch change. In other word it very well may be said that 21% of HM will be pitch balanced.

Along these lines in this progression HM thought, pitch alteration and randomization measures are applied to every factor. The HMCR and PAR parameters presented in this progression help the calculation find all around and privately improved arrangements, separately [3].

D. UPDATE THE HM

Subsequently new vector arrangement x' (x1', x2',…, xN') is framed by previously mentioned advances. In the event that the wellness, which is assess by target work is better than the current arrangement in HM than there will trade between old arrangement and new arrangement. In this manner refreshed HM is shaped which contain preferable arrangement over effectively made arrangement and the outcome will be meets at ideal point.

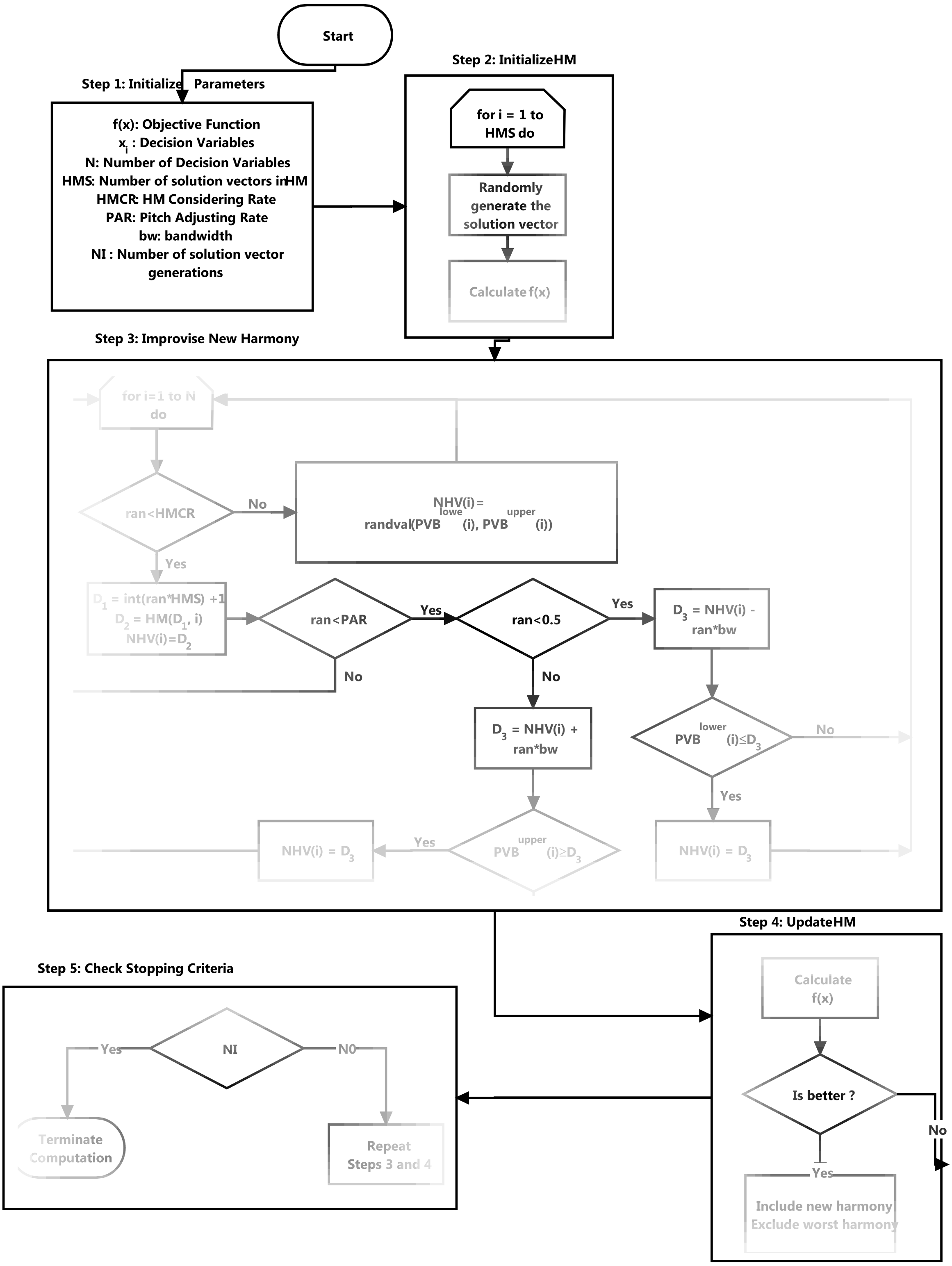

FIG: 1.0 FLOW CHART OF HSA

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E. CHECK THE STOPPING CRITERION

Steps 3 and 4 will be repeated till the stopping criteria will not satisfied. The stopping criterion is number of iteration (NI) or all solution vectors have same fitness. The flowchart of HSA is shown in Fig.1.0.

IV. SIMULATION RESULT

Above all else HSA is tried on Rastrigin work for testing the adequacy and proficiency of it. The outcomes acquired by applying HSA on the Rastrigin function for different components of capacity factors for 100 preliminaries are organized in Table 1. The estimations of best wellness, most exceedingly terrible wellness, mean and standard wellness are acquired for populace size equivalent to the component of capacity variable. HMCR and PAR parameters of HSA for 10 measurements are 0.7 and 0.3 separately. These parameters for 20 and 30 measurements are 0.8, 0.25 and 0.9, 0.2 separately. The data transmission for all measurements is 0.01. The calculation is created on MATLAB, and reenacted on a PC with Intel Core 2 Duo, 2.20 GHz, 4 GB RAM. Rastrigin capacity can be portrayed as:

F(x) = 20 + x12 + x22 – 10(cos2πx1 + cos2πx2); where x ∈ [–5, 5]. (8)

The table shows that the created calculation is working agreeably on Rastrigin work. Result got is compared with Bat Algorithm (BA). From the table it is effortlessly presumed that aftereffect of HSA is awesome compared to BA. Best wellness just as deviation from it for example mean of best wellness decide by HS is extensively acceptable compare to BA. As the component of variable increment, more emphasis is required for intermingling. 2000 cycle is taken for 20 measurement and likewise 3000 for 30 measurement. The best wellness in 20 measurements is slightly below average on the grounds that the emphasis and populace size is fixed by result acquired by BA. Anyway the outcome is comparable acceptable as for BA.

TABLE – 1: RESULT OBTAINED BY HSA ON RASTRIGIN FUNCTION.

Dimension	Iterations	Value	HS
10	1000	Best fitness	0
		Worst fitness	4.706
		Mean of fitness	0.504
		Median of fitness	0.019
		Standard Deviation	0.858
20	2000	Best fitness	5.074
		Worst fitness	20.151
		Mean of fitness	11.896
		Median of fitness	11.841
		Standard Deviation	2.571
30	3000	Best fitness	32.405
		Worst fitness	73.768
		Mean of fitness	53.854
		Median of fitness	53.779
		Standard Deviation	7.682

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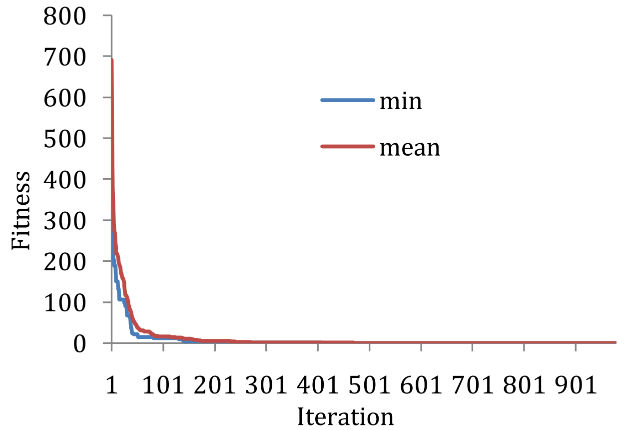

FIG.2.0. FITNESS VS ITERATION

The convergence characteristic of HSA for 10 dimensions and 1000 iteration is shown in Fig. 2. Both minimum and mean of fitness is shown in figure. The termination criterion adopted is when all fitness of objective function will be equal then algorithm will be terminated. This termination condition occurs at iteration 977 in figure below. From figure, it can be concluded that HSA has fast convergence. Nearby 400 iterations all population converges to optimal for 10 dimensions and 10 population size.

V. CONCLUSION:

This optimization technique is applied on Rastrigin function with different dimensions and found satisfactory result. This technique is emerged as robust and effective optimization techniques among different optimization techniques. The result for 10 dimensions is shown above. It can be concluded that HSA has fast convergence as discussed above. The parameters of this optimization technique is adjusted and concluded that for different dimensions different values of parameters are suitable.

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