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Literature Survey on Harmony Search for feature selection

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Abstract— A new HS (Harmony Search) meta-heuristic algorithm has been conceptualized using the musical process of searching or a perfect state of harmony. Musical performances seek to find pleasing harmony (a perfect state) as determined by an aesthetic standard, just as the optimization process seeks to find a global solution (a perfect state) as determined by an objective function. The pitch of each musical instrument determines the aesthetic quality; just as the objective function value as determined by the set of values assigned to each decision variable. The new HS (Harmony Search) meta-heuristic algorithm has been derived based on natural musical performance processes that occur when a musician searches for a better state of harmony, such as during jazz improvisation. In this paper, the concept of harmony search algorithm has been used in feature selection and based on it; literature survey for the recent few years has been done.

Keywords— Harmony search, feature selection, optimization, pitch adjustment, bandwidth and harmony memory

I. INTRODUCTION

A new HS (Harmony Search) meta-heuristic algorithm has been conceptualized using the musical process of searching or a perfect state of harmony. Musical performances seek to find pleasing harmony (a perfect state) as determined by an aesthetic standard, just as the optimization process seeks to find a global solution (a perfect state) as determined by an objective function. The pitch of each musical instrument determines the aesthetic quality; just as the objective function value as determined by the set of values assigned to each decision variable. The new HS (Harmony Search) meta-heuristic algorithm has been derived based on natural musical performance processes that occur when a musician searches for a better state of harmony, such as during jazz improvisation. In music improvisation, each player sounds any pitch within the possible range, together making one harmony vector. If all the pitches make a good harmony, that experience is stored in each player's memory, and thereafter they will try to make a good harmony in increased time. Similarly in engineering optimization, each decision variable initially chooses any value within the possible range, together making one solution vector. If all the values of decision variables make a good solution, that value is stored in the memory of each variable, and the possibility of making a good solution is also increased in the next time. Harmony search meta-heuristic algorithm imitates natural phenomena, i.e., physical annealing in simulated annealing, human memory in tabu search, and evolution in evolutionary algorithms.

Rest of the paper is organized as follows, Section I contains the introduction of the harmony search meta-heuristic algorithm, Section II contain the literature survey of the feature selection using harmony search, Section III contains the flowchart and algorithm of the new harmony search algorithm, Section IV contains the description of the steps of modified harmony search algorithm, section V gives the concluding remarks.

II. RELATED WORK

Koti et al have proposed a hybrid HS algorithm that utilizes Correlation-based Feature Selection (CFS) for heart disease prediction with levi distribution in [1]. In this work they have designed an intelligent algorithm for heart disease prediction by using hybrid models for efficient local search procedure. They have shown that their algorithm generates better results than other existing meta-heuristic optimization algorithms by validating against several datasets and comparing the results with and without the feature selection.

Lomoush et al have performed a comprehensive review on the development of harmony search and its applications in [2].In their work they have explained how the parameters of the harmony search affect its performance and they have discussed the variants of the HS algorithm in detail. Also included in their work is a study on the strengths and weakness of the HS algorithm & how further improvements can be made.

Pattern recognition requires a large computational effort and support vector machine is a popular technique but the classifier requires extensive training for parameter optimization which can be used for successful data classification. L. A. M. Pereira et al in their work [3] have used the harmony search & its variants for finding optimal parameters & their result shows that their harmony search based approach is robust in comparison to exhaustive search and a Particle Swarm Optimization-based implementation.

A Catfish effect inspired harmony search algorithm has been proposed by Zhang, L., Xu, Y., Xu, G., et al in [4]. They have compared the result of their new algorithm with other harmony search algorithms on standard benchmark optimization problems from CEC2005 and deduced that their algorithm has generated promising results. They have used two equal size harmony memories and then the New Harmony is generated from the possible solution set. Furthermore the New Harmony will better the weak harmony and the process will continue until the near-optimal solution vector is obtained.

A four-bar mechanism path-generation technique for planar parallel robot synthesis using improved Harmony Search Algorithm has been discussed by B. Aboulissane et al in [5].Their work focuses on finding the optimum dimension of the mechanism and minimize the error between the generated trajectory and the desired one, taking into consideration constraints such as: Grashof condition, transmission angle, and design variables constraints. They have also given a comparison of their work with results found by other evolutionary algorithms.

Ouyang, H. Et al have proposed a competition harmony search algorithm with dimension selection for continuous optimization problems in [6]. The algorithm includes a parallel search mechanism for increasing the search speed and a new dimension selection strategy is used for improving efficiency of the search. They have demonstrated that the result of their algorithm has better performance compared to other latest Harmony search algorithms.

Toğan et al have applied the harmony search algorithm for Optimization of trusses under uncertainties in [7]. The minimum weight of a space truss is obtained under the uncertainties on the load, material and cross-section areas with harmony search using reliability index and performance measure approaches. Their work shows that the harmony search method is more efficient compare to reliability index approach in terms of the convergence rate and iterations needed.

Salcedo-Sanz et al have discussed a One-way urban traffic reconfiguration using a multi-objective harmony search approach in [8]. In this intelligent two-objective optimization method; reconfiguration of one-way roads in a city after the occurrence of a major problem in order to provide alternative routes that guarantee the mobility of citizens is described. They have tested their work on several possible dummy scenarios and a real scenario in a city near Madrid and shown that their results are promising.

A New Harmony search algorithm for solving the optimal reactive power dispatch problem (ORPD) has been proposed by Lenin et al in [9]. The proposed algorithm has been tested on IEEE 30 bus system consisting 6 generators. They have formulated the ORPD problem as a nonlinear constrained single-objective optimization problem where the real power loss and the bus voltage deviations are to be minimized separately. Their results show that the proposed Harmony search algorithm is efficient compared to other algorithms for solving the single-objective ORPD problem.

Kumar et al have described a method for feature selection in face recognition using Harmony Search in [10].They have used the Principal Component Analysis for feature extraction and utilized the harmony search algorithm for feature selection. They have used the ORL face database for simulation and show that their method obtains better their results than standard Eigen-faces method for face recognition.

Geem et al have proposed an Improved Optimization for Wastewater Treatment and Reuse System
Using an evolutionary algorithm called a parameter-setting-free harmony search algorithm in [11]. This work involves improving the existing optimization model by minimizing the economic expenditure of life cycle costs while satisfying the public health standard in terms of groundwater quality through pinpointing the critical deficit location of dissolved oxygen sag curve by using analytic differentiation. It is shown in the study that this improved model successfully finds optimal solutions while conveniently locating the critical deficit point.

Gao et al have discussed a modified harmony search method which uses pareto-dominance-based ranking as a variant of the harmony search meta-heuristic optimization method in [12]. In addition their paper also focuses on the essentials of the theoretical harmony search algorithm along with its applications. A brief review of the variants of the original harmony search is also discussed.

Tuo et al have proposed a novel Novel Harmony Search Algorithm Based on Teaching-Learning Strategies for 0-1 Knapsack Problems in [13]. A method has been presented for adjusting the dimension dynamically for selected harmony vector in optimization procedure. To improve the performance of their algorithm four strategies namely harmony memory consideration, teaching-learning strategy, local pitch adjusting, and random mutation have been employed. Finally they have concluded that their novel harmony search algorithm based on teaching-learning is an efficient alternative based on simulation experiment with different types of knapsack problems.

A harmony search algorithm (HSA) with multiple pitch adjustment operators have been proposed by Sabar et al for the portfolio selection problem in [14].Their work emphasizes that different operators are appropriate for different stages of the search and using multiple operators can enhance the effectiveness of HSA. They have used portfolio selection benchmark instances for validating their results & demonstrated that the proposed method is capable of producing high quality solutions for most of the tested instances when compared with state of the art methods.
Manjarres et al have performed a survey on applications of the harmony search algorithm in [15]. In their survey paper they have focused on the diverse application areas of harmony search algorithm. They have described the strengths of the algorithm which ultimately has led to its wide application in a variety of applications & increase in the number of research contributions. A meaningful insight to future applications is also given in this paper.

Citing the problems faced by engineering optimization algorithms Lee et al have proposed a new harmony search (HS) meta-heuristic algorithm-based approach for engineering optimization problems with continuous design variables in [16]. Their algorithm uses a stochastic random search instead of a gradient search so that derivative information is unnecessary. They have applied their algorithm to various engineering optimization algorithms and the results demonstrate that their approach is a powerful search and optimization technique that may yield better solutions to engineering problems than those obtained using current algorithms.

Scalabrin et al have described a new evolutionary algorithm based on the standard harmony search strategy, called population-based harmony search PBHS in [17]. Protein structure prediction experiments with the AB-2D off-lattice model were done using a benchmark of a hard scientific problem. They have employed graphical processing units GPU for multiple function evaluations at the same time thus providing a parallelisation method for the proposed PBHS. Their results demonstrate that quality of solutions and speed-ups achieved by the PBHS is significantly better than the HS after comparison of their approach with standard harmony search & other implementation running on the CPU.

Clustering genes reveal hidden gene expression patterns and natural structures to find the interesting patterns from the underlying data that in turn helps in disease diagnosis and drug development. Particle Swarm Optimization (PSO) technique has been used widely but it reduces clustering efficiency. Samraj et al have described a novel meta-heuristic optimization algorithm called Harmony Search Particle Swarm Optimization (HSPSO) clustering algorithm for producing clusters with better compactness and accuracy in [18].They have applied their technique to Brain Tumor, Colon Cancer, Leukemia Cancer and Lung Cancer gene expression datasets for clustering. Better results were obtained in comparison to K-means clustering, PSO clustering (swarm clustering) and Fuzzy PSO clustering.

Al-Betar et al have in [19] defined more pitch adjustment procedures for the university course timetabling problem (UCTP), where each is controlled by a specific PAR value range to further enhance the ability of Harmony Search algorithm to connect the UCTP search space more efficiently. Also the acceptance rule of these procedures is changed to accept the local change on the New Harmony, if the objective function is not negatively affected.

Bagyamathi M. & Inbarani have proposed in [20] a new feature selection algorithm that combines the Improved Harmony Search algorithm with Rough Set theory for Protein sequences to successfully tackle the big data problems. The proposed algorithm is compared with the two prominent algorithms, Rough Set Quick Reduct and Rough Set based PSO Quick Reduct. The experiments are carried out on protein primary single sequence data sets that are derived from PDB on SCOP classification, based on the structural class predictions. The feature subset of the protein sequences predicted by both existing and proposed algorithms are analyzed with the decision tree classification algorithms.

Yadav et al have described the optimal scheduling of the generators to reduce the fuel consumption in the oil rig platform [21]. The accurate modelling of the specific fuel consumption is significant in this optimization. HS algorithm has been used for optimal scheduling of the generators of both equal and unequal rating. Subsequently an Improved Harmony Search (IHS) method for generating new solution vectors that enhances accuracy and convergence rate of HS has been employed. This paper also focuses on the impacts of constant parameters on Harmony Search algorithm. Numerical results show that the IHS method has good convergence property.

Zhao et al have presented a dynamic multi-swarm particle swarm optimizer (DMS-PSO-SHS) by hybridizing Particle Swarm Optimization and a sub-regional harmony search (SHS) [22]. It is shown that effective diversity maintaining properties of the dynamic multiple swarms and strong exploitative properties of the HS with multi-parent crossover operation strengthen the overall search behaviour of the proposed DMS-PSO-SHS.

A novel global harmony search algorithm (NGHS) has been proposed by Zou et al to solve reliability problems in [23]. The proposed algorithm includes two important operations: position updating and genetic mutation with a small probability. The former has enabled the worst harmony of harmony memory to move to the global best harmony rapidly in each iteration while the latter has effectively prevented the NGHS from trapping into the local optimum.

III. FLOWCHART & ALGORITHM

The flow chart has been shown in figure1.

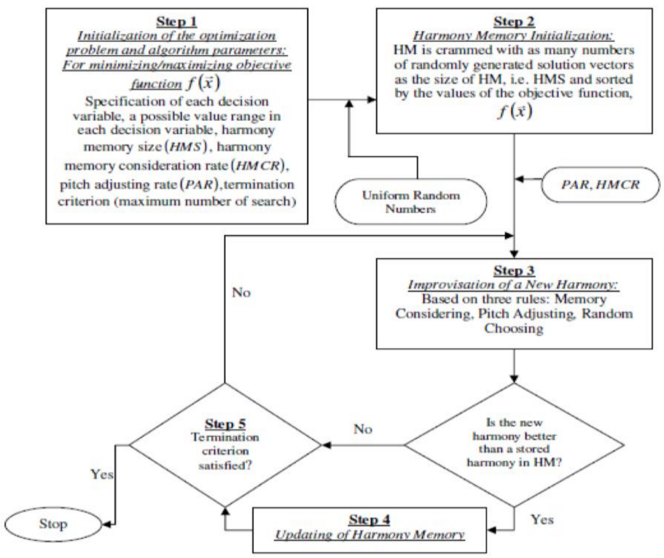

Figure 1. Flowchart of New Harmony search

Optimization Procedure of the Improved Harmony Search Algorithm

Step 1 Initialize the optimization problem and algorithm parameters.
Step 2 Initialize the harmony memory (HM).
Step 3 Improvise a new harmony from the HM.
Step 4 Update the HM.
Step 5 Repeat Steps 3 and 4 until the termination criterion is satisfied.

IV. METHODOLOGY

The essential step of the New Harmony search algorithm is described below:

Initialize the Problem and Algorithm Parameters

The optimization problem is specified as follows:
Minimize f (x) subject to $x_i \in x_i$ =1, 2. . . N, where f (x) is an objective function, x is the set of each decision variable x_i, N is the number of decision variables; x_i is the set of the possible range of values for each decision variable that is $L^{x_i} \leq x_i \leq U^{x_i}$, L^{x_i} and U^{x_i} are the lower and upper bounds for each decision variable. The HS algorithm parameters are the harmony memory size (HMS), or the number of solution vectors in the harmony memory; harmony memory considering rate (HMCR), pitch adjusting rate (PAR), and the number of improvisations (NI) for using stopping criterion.

The harmony memory (HM) is a memory location where all the solution vectors (sets of decision variables) are stored. Here, HMCR (Harmony Memory Considering Rate) and PAR (Pitch Adjusting Rate) are parameters that are used to improve the solution vector.

Initialize the Harmony Memory

The HM (Harmony Memory) matrix is filled with as many randomly generated solution vectors as the harmony memory size (HMS). In this step each component of each vector in the parental population (Harmony Memory), which is of size HMS (Harmony Memory Size) is initialized with a uniformly distributed random number between the upper and lower bounds $[L^{x_i}, U^{x_i}]$, where $1 \leq i \leq N$. This is done for the i^{th} component of the j^{th} solution vector using the following equation:

$$x_j^i = L^{x_i} + \text{rand}(0, 1) \times (U^{x_i} - L^{x_i}),$$

where j = 1, 2, 3, …HMS and rand (0, 1) is a uniformly distributed random number between 0 and 1 and it is instantiated a new value for each component of each vector.

$$\text{HM}= \begin{bmatrix} x_1^1 & \cdots & x_N^1 \\ \vdots & \vdots & \vdots \\ x_1^{HMS} & \dots & x_N^{HMS} \end{bmatrix}$$

Improvise a New Harmony

A new harmony vector $x' = (x_1', x_2' \dots, x_N')$ is generated based on three rules: (1) memory consideration (2) pitch adjustment and (3) random selection. Generating a new harmony is called 'improvisation'.

In the memory consideration, the value of the first decision variable x_1' for the new vector is chosen from any of the values in the specified HM range ($x'^1_1 - x'^{HMS}_1$). Values of the other decision variables ($x_2' \dots, x_N'$) are chosen in the same manner. The HMCR (Harmony Memory Considering Rate), which varies between 0 and 1, is the rate of choosing one value from the historical values stored in the HM (Harmony Memory), while (1 - HMCR) is the rate of randomly selecting one value from the possible range of values.

$$x_i' = \begin{cases} x_i' \in, \{x_i^1, x_i^2 \cdots, x_i^{HMS} & \text{with probability HMCR} \\ x_i' \in X_i & \text{with probability } (1 - \text{HMCR}) \end{cases}$$

For example, a HMCR (Harmony Memory Considering Rate) of 0.85 indicates that the HS (Harmony Search) algorithm will choose the decision variable value from historically stored values in the HM (Harmony Memory) with an 85% probability or not from the entire possible range with a (100–85) % probability. Every component obtained by the memory consideration is examined to determine whether it should be pitch-adjusted. This operation uses the PAR (Pitch Adjusting Rate) parameter, which is the rate of pitch adjustment as follows:

$$\text{Pitch adjusting decision for } x_i' \leftarrow \begin{cases} \text{YES with probability PAR} \\ \text{NO with probability } (1-\text{PAR}) \end{cases}$$

The value of (1 - PAR) sets the rate of doing nothing. If the pitch adjustment decision for x_i' is YES, x_i' replaced as follow:

$x_i' \leftarrow x_i' \pm$ rand ( ) × bw, where bw is an arbitrary distance bandwidth rand ( ) is a random number between 0 and 1.

HM (Harmony Memory) consideration, pitch adjustment or random selection is applied to each variable of the New Harmony vector in turn.

Update Harmony Memory

If the new harmony vector, $x' = (x_1', x_2' \dots, x_N')$ is better than the worst harmony in the HM (Harmony Memory), judged in terms of the objective function value, the new harmony is included in the HM (Harmony Memory) and the existing worst harmony is excluded from the HM (Harmony Memory).

Check Stopping Criterion

If the stopping criterion (maximum number of improvisations) is satisfied, computation is terminated. Otherwise, instructions needed for improvising New Harmony memory and updating harmony memory are repeated.

V. CONCLUSION

From the literature survey, it has been observed that harmony search play a vital role in many optimization field and use of harmony search in feature selection is new. Most of the authors have used it for the real optimization problem and in this paper; we have used it for the feature selection from the set of real world attributes. After the feature selection of attributes, we will form the knowledge base which will predict the value of new data based on the previous knowledge.

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