A Discrete Harmony Search Algorithm

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Abstract. Harmony search (HS), inspired by the music improvisation process, is a new meta-heuristic optimization method and has been used to tackle various optimization problems in discrete and continuous space successfully. However, the standard HS algorithm is not suitable for settling discrete binary problems. To extend HS to solve the binary-coded problems effectively, a novel discrete binary harmony search (DBHS) algorithm is proposed in this paper. A new pitch adjustment rule is developed to enhance the optimization ability of DBHS. Then parameter studies are performed to investigate the properties of DBHS, and the recommended parameter values are given. The results of numerical experiments demonstrate that the proposed DBHS is valid and outperforms the discrete binary particle swarm optimization algorithm and the standard HS.

Keywords: harmony search, binary code, meta-heuristic.

1 Introduction

Harmony Search (HS) algorithm is a recent meta-heuristic algorithm firstly developed by Geem et al. [1] in 2001. It imitates the musician seeking to find pleasing harmony determined by an aesthetic standard, just as the optimization process seeks to find a global optimal solution determined by an objective function.

Due to its excellent characteristics such as easy implementation and good optimization ability, HS has drawn more and more attention and dozens of variants have been proposed to enhance the optimization ability. Pan [2] proposed a harmony search algorithm with ensemble of parameter sets which can self-adaptively choose the best control parameters during the evolution process. Mahdavi [3] developed an adaptive pitch adjustment rate strategy to improve HS. Li [4] proposed a hybrid PSO-HS algorithm where HS was used to deals with the variable constraints. Li and Wang [5] combined the HS with Differential Evolution algorithm and proposed two hybrid algorithms and tested their performance with a set of benchmark functions. Li and Li [6] presented a hybrid HS algorithm combined with particle swarm optimization to solve high dimensional optimization problems and achieve better optimization results. Jang [7] developed a hybrid Simplex Algorithm-Harmony Search algorithm where Simplex Algorithm was used to improve the accuracy and convergence speed. Omran and Mehrdad [8] introduced a new

K. Li et al. (Eds.): LSMS/ICSEE 2010, Part II, CCIS 98, pp. 37–43, 2010.
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global-best harmony search inspired the concept of Particle Swarm Optimization (PSO) algorithm and validated its efficiency on the numerical problem and integer programming problem. In summary, hybrid HS algorithm has been the hotspot, there are other related hybrid algorithm research works such as HS combined with genetic algorithm (GA) [9] and Clonal Selection Algorithm [10]. So far, HS has been successfully applied to various fields, such as slope stability analysis [11], groundwater management model optimization [12], multiple dam system scheduling [13], and energy dispatch problem [14]. The application results promise that HS is a powerful search and optimization technique that may yield better solutions to these problems compared with Genetic Algorithm and PSO algorithm.

As far as we know, all of the previous works on HS concentrated in solving optimization problems in discrete or continuous space expect Greblicki [15] analyzed the properties of HS on the one dimensional binary knapsack problem which is a binary-coded problem. According to his result, HS gains a poor performance in the problem. To make up for it, a discrete binary harmony search (DBHS) algorithm is proposed for solving the binary-coded problems in this paper.

2 Discrete Binary Harmony Search Algorithm

Although the standard HS can be used to tackle the binary-coded problems, the performance is not satisfied, even poor [15]. To extend HS and tackle binary-valued problems effectively, we proposed a novel discrete binary HS algorithm by developing a new pitch adjustment rule.

2.1 Initialization of Harmony Memory

In DBHS, an individual is formed by the binary-string, so HM is initialized as (1):

$$H = \left[h_{1j}\ h_{2j} \ldots h_{ij}\ h_{HMS,M} \right]\ \ h_{ij} \in \{0,1\}, i \in HMS, j \in \{1,2,...,M\} \tag{1}$$

where HMS is the size of HM and M is the length of binary-string, i.e., the dimensionality of the solution.

2.2 Harmony Memory Consideration Rule

The harmony memory consideration rate is of great importance for improvising, it indicates whether the element of new candidate is generated from the HM or randomization. Imitating the standard HS, the HMCR is the probability of picking up a value from HM in DBHS, while the (1-HMCR) is the rate of randomly choosing a feasible value not limited to HM, that is, it is re-initialized stochastically to be “0” or “1”.

Here we propose a refined harmony memory consideration rule called individual selection strategy. In this strategy, all the elements of a solution are only selected from one HM vector. The individual strategy operation is defined in (2-3)