Including Modal Improvisation and Music-Inspired Components to Improve Harmony Search*

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Abstract. In this paper we present new components to be included in harmony search algorithms. These components are inspired from music improvisation. The Modal improvisation uses musical modes rather than chord progressions as a harmonic framework. We also include the notion of tone scales that allows the algorithm to visit different parts of the search space. We evaluate our approach solving instances of the Multidimensional Knapsack Problem instances. We compare our results with those obtained by the former harmony search algorithm, and with the well-known state-of-the-art results.

Keywords: Harmony Search, Discrete Optimization.

1 Introduction

Harmony Search has been introduced as a new metaheuristic inspired from jazz music improvisation to solve hard problems, [1]. This technique has been successfully applied to solve various well-known problems, [2]. Because the idea of using a technique based on music looks very promising, we propose in this paper to include components inspired from music into harmony search algorithms. These components allow the search of the standard harmony search algorithm to improve. Moreover, because of the great presence of musical components, our approach is much different from classical metaheuristics. The goal of our research is to improve the search of harmony search algorithms by including new inspired musical components. We find the best parameter values for our algorithms using EVOCA [3], a recently proposed tuner for metaheuristics. We also report a statistical analysis for comparison. In the next section, we briefly describe the classical harmony search algorithm. This is followed by a description of the Multidimensional Knapsack Problem (MKP), which we use to evaluate our approach. The musical based components and mechanisms incorporated on the harmony search structure are introduced in Section 5. Section 6 presents the experimentation, statistical analysis and comparison using well-known MKP instances, and finally, Section 7 gives the conclusions of our work and ideas for future work.

* This work is partially supported by FONDECYT Project 1120781 and Centro Científico Tecnológico de Valparaíso (CCT-Val) FB0821.

F. Castro, A. Gelbukh, and M. González (Eds.): MICAI 2013, Part II, LNAI 8266, pp. 105–117, 2013.

2 Standard Harmony Search Algorithm

[4] introduces the Harmony Search (HS) metaheuristic inspired in the jazz music improvisation. Roughly speaking, the idea comes from musicians who search to improve harmonies in order to obtain aesthetic melodies. Thus, HS is a population-based metaheuristic. From the optimization point of view, each harmony represents a candidate solution which is evaluated using an evaluation function. The changes are inspired by music improvisation that are randomly applied to previous candidate solutions in memory. The HS algorithm uses a population of candidate solutions or Harmony Memory (HM). At the beginning a HM is randomly generated. At each iteration a new solution is either generated from memory information, or randomly. Two parameters guide the generation of the new solution. The Harmony memory considering rate (HMCR) and Pitch adjusting rate (PAR) correspond to the rate of randomly updated solutions. For each variable, its value in the new solution is either obtained from a direct copy of a selected value in the memory, or from a selected value from the memory that goes through a small perturbation, or randomly generated. The new solution is evaluated and replaces the worst candidate solution in the population if it obtains a better evaluation value. This process is repeated, until a termination criterion is reached. The pseudocode is presented in algorithm 1. At step (5) in this figure, the variable value comes from the memory. Different strategies can be applied. The most popular are to randomly select a value for this variable from the memory. Another strategy is to select the value from the best evaluated harmony the memory. At step (7) a little perturbation using equation 1 is made to the previously selected value using a bandwidth (BW) value. When the algorithm does not use the value in memory (step (10)), a new value belonging to the variable domain is randomly generated. Finally, after the evaluation, if the new solution is better than the worst one, it takes its place in the memory (step(15)).

$$new\_solution[i] = new\_solution[i] + random(0, 1) * BW \tag{1}$$

This algorithm has been applied to solve various problems with continuous domains, [5]. Some modifications have been proposed to solve discrete problems, [6] , [7], as well as to include an on-line tuning strategy in order to control the parameters HCMR and PAR during the search, [8].

Before describing the new musical inspired components, we briefly present the Multidimensional Knapsack Problem (MKP) in the following section. We use MKP to illustrate our new components, and also to evaluate the algorithm in the experiments section.

3 Multidimensional Knapsack Problem

The 0-1 Multidimensional Knapsack Problem (MKP), defined as a knapsack with multiple resource constraints. It consists in selecting a subset of n objects or items in such a way that the total profit of the selected objects is maximized while a set of m knapsack constraints are satisfied.