

PhD. Subject: Strategies to Design Life-Long Learning Heuristic Based Algorithms

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Nowadays combinatorial optimization problems arise in many circumstances, and we need to be able to solve these problems efficiently. Unfortunately, many of these problems are proven to be NP-hard, but problems can be related in some way. Analysing different combinatorial problems we can see some similarities between them. If we work with this similarities, we could improve the search process of an algorithm, because there exists some concurrent knowledge about solving a problem that could be exploited. For example, if an algorithm can solve an instance X for Sudoku puzzle ensuring uniqueness in blocks before rows and columns, this strategy can be useful for another instance Y when the algorithm is in a local optimum. In other words, some heuristics that can find interesting candidate solutions can be reused in future during the execution of an algorithm. To do this, an algorithm should learn over time to determine how, when and which heuristic apply. The idea of this investigation is to create strategies to design life-long learning heuristic based algorithms. There have been some investigations in this area applied to 1-D Bin Packing problem [6], for Traveling Sales Problem [3] and the most important thing, is that can be applied in different kinds of problem.

Heuristic methods guarantees certain solution quality and the polynomial running time. Unfortunately, this nice theoretical property is usually achieved at the cost of relatively poor performance. In other words, a simple heuristic is often faster and yields better solutions than an approximation algorithm, though a simple heuristic does not guarantee any quality and in certain cases it yields very bad solutions. The importance of design a life-long learning heuristic system lies in the need of finding better quality solutions in less time. Create a system like this can be very expensive and if it doesn't solve a considerable set of instances (or it doesn't work like we wanted to), the system must be redesigned. So we are interested in designing a framework that gives the necessary tools to solve complex problems, using heuristic strategies. We understand that the immediacy of get a solution, in some cases, it's more important than quality. This research aims to design new strategies to try to make algorithms more efficient too. At the beginning of this research, we decided to work with the Harmony Search algorithm. This algorithm was selected because I had a close relationship with the Musical Composition (apart from my interest in work with Metaheuristics). We improved Harmony Search for one binary problem, but using more time than the original algorithm. So the next step it's trying to improve our algorithms, changing the design with the objective of making them more efficient. This kind

of systems are in field of machine-learning and meta heuristic methods, that can inspire ideas to design an algorithm. So I will study different approaches of life-long learning algorithms using machine-learning. Heuristics are the heart of this investigation, so it's really important to study different kinds of heuristics that can be useful to this project. Techniques for performance prediction, automatic algorithm construction, knowledge representation and ideas taken from the field of hyperheuristics may be used to attain a higher level of generality. Applications in planning and scheduling in production and health care will serve as validation domains. During the year 2013, this research focused on seeing how to improve Harmony Search, an heuristic algorithm based on the musical improvisation in Jazz. Harmony Search (HS) was presented in 2001 by Zong Woo Geem [2], and there's a lot of variants and applications in many areas¹. The first improvements were related with how HS explore and exploit the search space, without losing potential good solutions. These ideas converged in three new algorithms, based on a HS variant for binary problems called Adaptive Binary Harmony Search [7], implemented to solve some instances of the Multidimensional Knapsack Problem. The comparison between this algorithms and their details are presented in [4]. A dynamic control strategy was created using two of these new algorithms [5]. After testing these new algorithms in a problem with binary variables, the algorithms were implemented in a HS variant for solving Sudoku [1]. During this work, a problem with the evaluation function presented in [1] was found. A new evaluation function will be presented, for any heuristic algorithm based on solving Sudoku (paper in progress).

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¹ Harmony Search Publications and Books: <https://sites.google.com/a/hydroteq.com/www/>