Impact of Fuzzy Logic in the Cooperation of Metaheuristics

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Summary. Algorithm selection problem is a common problem when we solve optimization problems. To cope with it we have proposed a hybrid system of metaheuristics that intelligently combines different strategies using a coordinator based on Fuzzy Logic. In this paper we study the impact of Fuzzy Logic in the behaviour of this hybrid system. In order to do that we perform some tests to study the impact of an important parameter, the $\alpha$--cut, used in the fuzzy engine of the system, demonstrating how the variations on this parameter may change the performance of the system with different kind of instances.

Keywords: Meta-heuristic, Cooperative System, Fuzzy Rules, Data Mining.

1 Introduction

Optimization problems have focused the interest of the research community for a long time. For that reason a large amount of strategies have been developed in order to solve them in a reasonable period of time finding solutions with a near optimum quality. However, when we try to solve different instances of an optimization problem we can find algorithm selection problem [14], which tries to decide which algorithm has to be used to solve an instance of a problem, trying to maximize a measure of performance. This problem is undecidable [7], and the most common approach to solve it is to measure the performance of a set of algorithms over a set of instances and use the one with the best performance. Nevertheless, this approach seems to be too rigid and it would be more interesting to search for more tolerant strategies that adapt better to the changing conditions of the problems.

An interesting way of obtaining flexible mechanisms is using hybrid systems, which allow us to solve complex problems, very hard to solve using less tolerant approaches. Consequently, combining intelligently different strategies using a hybrid system we can tackle the algorithm selection problem. But to obtain an “intelligent” combination of strategies that achieves good results for all type of instances and problems we need a tolerant approach, as the one provided by “Soft Computing”, specially by Fuzzy Logic. On the other hand this increase in tolerance may produce some precision loss, but we can sacrifice it in order
to obtain a more robust system which could face the changes of the problems and instances. The use of different strategies together with the methodologies provided by Fuzzy Logic for building hybrid systems, will give us reasoning mechanisms and search methods which will allow us to combine domain knowledge with experimental data in order to obtain new computation tools to solve complex problems that are very difficult to solve with less tolerant approaches. In [9], Kuncheva shows a study and comparative of combination methods of fuzzy and odd nonfuzzy classifiers. The work demonstrates that better results are obtained with fuzzy combination methods and, though Kuncheva does not want to establish that the fuzzy methods are better in general, she wants to clarify that the fuzzy alternatives must not be forgotten.

In this paper, we study the impact of Fuzzy Logic in the behaviour of a hybrid system developed with the aim of solving optimization problems. In section 2, we present the design of this hybrid system, which is based on a Data Mining and Knowledge Discovery. As we use Fuzzy Logic to model some components of the system, in section 3, we show the impact of these components in the improvement of the found solutions. To finish, in section 4, we present the conclusions and work to develop.

2 A Cooperative Meta-heuristic System

2.1 Related Works

Several studies have shown that heuristics and meta-heuristics are successful tools for providing reasonably good solutions (excellent in some cases) using a moderate number of resources. An interesting trend in this area is to obtain hybrid strategies which cooperate in a parallel way in order to solve a problem, and two fields that follow this approach are parallel meta-heuristics and hybrid meta-heuristics, where the same or different metaheuristics are parallelized in order to reduce its execution time or even improve its results.

Many efforts have been focused on these fields, and we can find different implementations. First appeared synchronous implementations, where information is shared in regular intervals, such as [11]. More recently asynchronous implementations showed up, such as [6], and, according to the reports provided in [6], they obtain better results than synchronous. It has been pointed out that these approaches obtain better results than independent methods, but previous studies, [6], show that if the access to shared information is not restricted they can experiment premature convergence problems. This seems to be owe to the stabilization of the shared information produced as a result of the intense exchange of the best solutions. Trying to cope with this problem in [13] is proposed a cooperative strategy that uses memory to control this effect. Here a coordinating agent, modeled by a set of fuzzy rules defined by the user, monitors a set of solver agents and sends orders to them about how they have to continue, implementing each agent the same meta-heuristic.