Evaluation of the quality of the "Montecarlo plus K-means" heuristics using benchmark functions

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Abstract. The evaluation in terms of quality of the results obtained from the use of a heuristic method is necessary to, first, verify the obtained results since heuristic methods do not guarantee to reach the optimum because all the possibilities are not fully explored. Secondly, it becomes interesting to validate such method, thus granting a high-quality index. Through our proposal, starting on the analysis of the literature survey on many optimization test functions, we are proposing the evaluation of a heuristic method based on Montecarlo approaches in conjunction with K-means clustering. Besides this, we aim to evaluate the results obtained through the use of some complex optimization test functions. Also, we seek to add a defined quality index to the original heuristic method relying on the consequent improvement in the results. As a side-work, we would aim to validate the heuristic mentioned above and optimize the algorithm in terms of scalability and quality.

Keywords: Heuristic method, Montecarlo, K-means, Benchmark functions.

1 Introduction

Optimization is a complex process defined as the process of finding the best solution to a given problem under certain conditions.In engineering, the objective of optimization could be to maximize the performance of a system using the minimum resources and the minimum execution time[1]. Heuristics are methods that help decide from a set of possible solutions to examine. Probabilistic methods typically consider the elements of the search space in further computations that have been selected by the heuristic. The Montecarlo-based approaches[2], usually trading the solution for a shorter runtime, which doesn't mean that the result is incorrect, just not the global optimal.

To the purpose of this work, we will analyze a problem that requires the simultaneous optimization of more than one objective, that is, a multi-objective optimization. There are extensive works dedicated to the operation of this type of methods[3] [4] [5]. Montecarlo plus K-means methodology was defined and a process was developed for improving the operation of Emergency Departments [6], based on the assumption that this it is a complex system, difficult to characterize and naturally dynamic.

Our proposal develops from the idea of evaluating the Montecarlo plus K-means heuristic method using optimization test functions to evaluate the quality of the solutions provided by this heuristic. To prove the quality of optimization algorithms, optimization test functions are designed to mimic different types of workload[3]. They have many vital characteristics, such as its relevance, repeatability, scalability, transparency, and cost-effectiveness.

The heuristic method Montecarlo plus K-means[6] is explained through the next sections. Then, our proposal is delimited. In the methodology, we explain how we will proceed. Finally, in the last section, we present the conclusions and future work.

2 Related Work

The computational optimization techniques include a variety of optimization algorithms[1]. In terms of probabilistic methods, we find the heuristics which are a part of an optimization algorithm that uses information gathered by the algorithm to help decide which solution between the candidates should be tested.

The Montecarlo methods use randomness to solve problems, useful when it becomes difficult to apply other approaches. These methods are used for simulating the behaviour of many different types of systems that rely on repeated random sampling to obtain numerical results and incorporates random numbers. It is used primarily in three problem cases: optimization, numerical integration and generating draws from a probability distribution.

Emergency Departments, as described by Cabrera et al.[6], comprise a very complex system; there are a large number of possible configurations with the capacity to provide urgent medical attention and care for a certain amount of patients. Their objective is to find the best setting to minimize patient waiting times, reduce saturation and improve the use of resources. Optimization via simulation with heuristic approaches offers the best option to solve this problem, since it is difficult to experiment in real-time with the different existing parameters.

Optimization test functions[3], by its inherent properties, are convenient to evaluate and improve our proposed methodology, delimit the area of interest and perform iterations. Since we expect that the results are more accurate, the idea is to carry out the least number of iterations.

3 Proposal Methodology

The initial proposal of this work is to evaluate the quality of the Montecarlo plus K-means heuristic through the use of complex optimization functions, first delimiting a wide area of interest.

In this case, our proposed heuristic is a two-phase method: The first phase would be a coarse-grained approach consisting of a global exploration stage over the entire search space to find promising regions for optimization identified on a neighbourhood structure of the problem. This phase uses the Montecarlo heuristics plus the K-means method, returning a collection of promising regions. The second phase is a fine-grained approach, involving the search for the best solution,

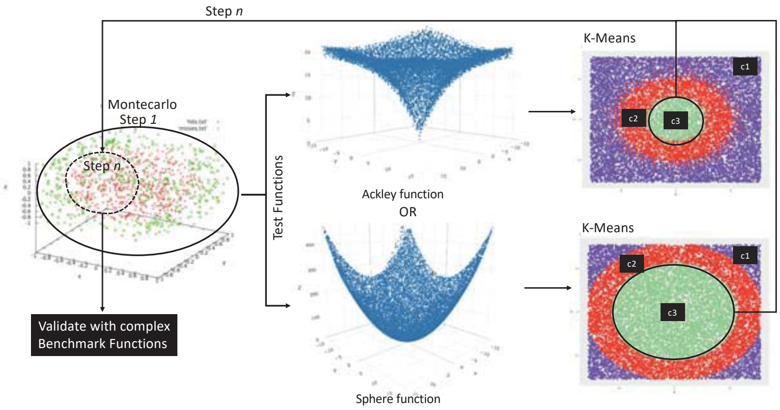

Fig. 1. Overview of the proposed methodology

be it optimal or sub-optimal, through a recursive application of our heuristics narrowing an exhaustive search within the promising regions.

To carry out the evaluation proposal, we selected the optimization test functions to assure that we find the minimum configuration value, which would be assimilated to the configuration obtained through the application of heuristic methods. This process would open up the possibility of adding a high-quality index to the heuristic method procedures carried out in addition to establishing a better value for the use of resources.

Our methodology focuses on evaluating the quality of the heuristic method. By adjusting the functions to Montecarlo methods, as illustrated in Fig.1, where we show the whole process, we apply Montecarlo to obtain a random sampling defining the domain of possible inputs. Afterwards, through the functions Ackley and Sphere, we bound an area containing a certain number of samples. These random samples represent the area where we will find the optimum value. As seen in the same Fig.1, when we apply k-means, the graphed functions seen from above show the area in which we are looking for our result. In the first case, when we use the Ackley function, we can locate a slightly smaller area in the centre containing a smaller number of values; while the second example, the Sphere function returns a broader area in the centre. These values would be similar to the one we are looking for. In this case, we can also observe that there are two different types of minimum, depending on the function.

Once we have delimited this area, we perform another iteration following the same process, and so on. After a few iterations, we will confirm that there are no variations in the returned values so we will stop iterating.

We aim to increase the quality of the results obtained and improve our heuristics using the optimization functions as evaluation benchmarks. The parameters resulting from the Montecarlo methods that we introduced within the function will allow us to locate the area of interest more precisely. By doing this, we would be on the path that leads us to an improvement of the heuristic method and also be on the road to add a quality index to the whole process.

4 Conclusions and Future Work

Concepts such as optimization have been analyzed.The proposed methodology includes the use of the Montecarlo plus K-means heuristic method and the optimization functions as evaluation benchmarks since we are seeking to improve the quality of this heuristic method taking into account that there are some scenarios that can not be solved linearly due to its characteristics and because it would require too many resources and time.

Our proposal originates from the idea of evaluating the heuristic method applied in order to find an optimal configuration. We are proposing to analyze the quality of the Montecarlo plus K-means heuristic developed to find the best possible scenario and to analyze its quality. Through the use of optimization test functions, we are trying to obtain the best solution (be it optimal or sub-optimal) in a more accurate and sophisticated way.

The heuristic method described sets us on the road to a good strategy when looking for an optimal configuration, and it is also applicable to different areas. Our idea is to finally validate the heuristic method through the use of complex optimization functions, analyze its quality and be able to add a high-quality index to the whole configuration. In the future, we will work on improving the algorithm, making it scalable, and further improving the quality index.

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