

DT-Tuning: A method based on knowledge representation and inference for self-parameterization of metaheuristics

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ABSTRACT

Although metaheuristics efficiently find high-quality solutions in a shorter time, they still require proper parameterization to ensure good results. Self-parameterization methods focus on automating metaheuristics parameter adjustments during their execution. Good parametrizations improve solution quality, reduce computing time, and provide dynamic adaptation, minimizing manual effort. This work aims to develop a self-parameterization of a metaheuristic for data clustering problems to improve solution quality compared to manual parameter adjustments and other self-tuning methods. We propose a self-parameterization method called DT-Tuning, which uses knowledge representation to adjust the parameter value ranges dynamically. The algorithm randomly generates multiple parameters sets and uses them in the metaheuristic. The performance of each parameter set is evaluated based on objective function and execution time results. The Decision Tree inference's engine classifies the best-performing parameter sets, identifies the most influential parameters, and adjusts their value ranges according to the classification rules. It then generates new parameter sets based on adjusted ranges and repeats this cycle until the stopping criteria are reached. Experiments validated DT-Tuning with well-known datasets to analyze the effectiveness of self-parameterizing the hybrid metaheuristic GRASP with Path-Relinking (GRASP+PR) for the data clustering problem. We compared the proposed with the self-tuning methods BRKGA (Biased Random Keys Genetic Algorithm), I/F-Race, and manually adjusted methods, evaluating the objective function, execution time, and corrected rand index (CRand) as an external measure of clustering quality. The experiments show that DT-Tuning finds good quality clustering, as in the BreastB2 dataset, which achieved the highest CRand (0.531), just like BRKGA. Similar behavior is observed in the DLBCLA dataset, in which among the self-tuning methods, only DT-Tuning obtained the highest CRand (0.855). All methods achieved the maximum CRand value in the Novartis dataset, but DT-Tuning present the highest robustness. DT-Tuning performance varies according to the dataset's characteristics and is generally the most computationally expensive. The exception is the Novartis dataset, where the average execution time is ten times lower than manual methods. The study underscores DT-Tuning as a promising self-parameterization method for GRASP+PR, delivering superior results in clustering quality compared to manual parameterization and, in some cases, other self-tuning methods, particularly in the BreastB2 and DLBCLA datasets. Future research includes exploring alternative rule execution strategies and more robust experiments with larger datasets. The method has the potential to parametrize deep neural networks for Generative Pre-trained Transformers (GPT) to enhance speech recognition and natural language processing.

KEYWORDS. Self-Parameterization. Decision Tree. Data Clustering. GRASP. Path-Relinking.

Topics (13. MH – Metaheuristics, 14. OC – Combinatorial Optimization)