FITNESS LANDSCAPE ANALYSIS AND ALGORITHM PERFORMANCE FOR SINGLE- AND MULTI-OBJECTIVE COMBINATORIAL OPTIMIZATION

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On the one hand, computationally-hard combinatorial problems are common in practice, and many evolutionary and general-purpose heuristic algorithm classes have been proposed for both single- and multi-objective optimization. On the other hand, fitness landscape analysis is a well-established field for understanding the relation between the problem search space structure and the algorithm paradigm and components in evolutionary computation. Starting by presenting state-of-the-art tools from single-objective fitness landscapes, we identify the main differences and additional issues to be addressed for a deep understanding of multi-objective fitness landscapes. We expose and contrast the impact of fitness landscape characteristics on the performance of optimization algorithms for single- and multi-objective black-box combinatorial optimization problems. A sound and concise summary of features characterizing the structure of an arbitrary problem instance are identified and related to the expected dynamics of a number of algorithm classes to be introduced during the tutorial. Their intercorrelation and their association with algorithm performance are also analyzed. This allows us to assess the individual and the joint effect of problem features on algorithm performance, and to highlight the main difficulties encountered by optimization algorithms. By providing effective tools and practical examples for both single- and multi-objective fitness landscape analysis, further insights are given on the importance of ruggedness and multimodality to characterize the difficulty of an instance for combinatorial optimization problems and algorithms. At last, we conclude with guidelines for the design of randomized search heuristics based on the main fitness landscape features, and we identify a number of open challenges for the future of fitness landscapes and evolutionary algorithms.