Metamodeling Framework for Simultaneous Multi-Objective Optimization Using Efficient Evolutionary Algorithms

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Most of the real-world problems are comprised of multiple conflicting objectives and solution to those problems are multiple Pareto-optimal trade-off solutions. The main challenge of these practical problems is that the objectives and constraints do not have any closed functional forms and they are expensive for computation as well. Objectives coming from finite element analysis, computational fluid dynamics software, network flow simulator, crop modeling, weather modeling or any other simulation which involve some partial differential equations are good examples of expensive problems. To provide an efficient search process within limited exact evaluations, metamodel assisted algorithms have been proposed in literature. These algorithms construct a cheap representative model of the problem having the same global optima thereby providing a way to carry out the optimization in model space in an efficient way.

Population-based methods like evolutionary algorithms have become standard for solving multi-objective problems and recently Metamodel-based evolutionary algorithms are being used for solving expensive problems. In this thesis, we would like to address a few challenges of Metamodel-based optimization algorithms and propose some efficient and innovative ways to construct these algorithms. Towards efficient design of Metamodel-based optimization algorithm, one needs to address the choice of metamodeling functions. The most trivial way is to build metamodels for each objective and constraint separately. But we can reduce the number of metamodel construction using some aggregated functions and target either single or multiple optima in each step. We propose a taxonomy of possible Metamodel-based algorithmic frameworks which not only combines most of the algorithms from the literature but also proposes some new ones. We improve each of the frameworks by introducing trust region concepts in multi-objective scenario and present two strategies of building trust region. Apart from the main bottleneck of limited number of solution evaluations, we propose efficient non-dominated sorting methods that further reduce computational time for a basic step of multi-objective optimization. We have carried out extensive experiments over all representative metamodeling frameworks and show that each of them can solve a good number of test and real-world problems. Finally, we have proposed and tested an ensemble-based algorithm that can solve the problems in a much better way compare to each approach.