METAMODEL BASED MULTI-OBJECTIVE OPTIMIZATION WITH FINITE-ELEMENT APPLICATIONS

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AKADEMISK AVHANDLING

för filosofie doktorsexamen i informationsteknologi
som enligt beslut av den internationella kommittéen för den fjärde internationalen
kommer att försvaras offentligt
Fridaydagen den 25 May 2018 kl. 10:00, Portalen, Insikten,
Högskolan i Skövde

Avhandling försvaras på engelska

Opponent: J. Ölvander, Linköping University

ISBN 978-91-984187-4-3

ABSTRACT

As a result of the increase in accessibility of computational resources and the increase of computer power during the last two decades, designers are able to create computer models to simulate the behavior of complex products. To address global competitiveness, companies are forced to optimize the design of their products and production processes. Optimizing the design and production very often need several runs of computationally expensive simulation models. Therefore, integrating metamodels, as an efficient and sufficiently accurate approximate of the simulation model, with optimization algorithms is necessary. Furthermore, in most of engineering problems, more than one objective function has to be optimized, leading to multi-objective optimization (MOO). However, the urge to employ metamodels in MOO, i.e., metamodel based MOO (MB-MOO), is more substantial.

Radial basis functions (RBF) is one of the most popular metamodeling methods. In this thesis, a new approach to constructing RBF with the bias to be set a priori by using the normal equation is proposed. The performance of the suggested approach is compared to the classic RBF and four other well-known metamodeling methods, in terms of accuracy, efficiency and, most importantly, suitability for integration with MOO evolutionary algorithms. It has been found that the proposed approach is accurate in most of the test functions, and it was the fastest compared to other methods. Additionally, the new approach is the most suitable method for MB-MOO, when integrated with evolutionary algorithms.

The proposed approach is integrated with the strength Pareto evolutionary algorithm (SPEA2) and applied to two real-world engineering problems: MB-MOO of the disk brake system of a heavy truck, and the metal cutting process in a turning operation. Thereafter, the Pareto-optimal fronts are obtained and the results are presented. The MB-MOO in both case studies has been found to be an efficient and effective method.

To validate the results of the latter MB-MOO case study, a framework for automated finite element (FE) simulation based MOO (SB-MOO) of machining processes is developed and presented by applying it to the same metal cutting process in a turning operation. It has been proved that the framework is effective in achieving the MOO of machining processes based on actual FE simulations.