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Geometry optimization with PDE constraints and applications to the design of branched sheet metal products.

München: Dr. Hut; Darmstadt: TU Darmstadt, Fachbereich Mathematik (Diss.) (ISBN 978-3-86853-474-0/pbk). 163 p. (2010).

In different industries a variety of sheet metal products is used, where roll forming is an important manufacturing process for their volume production. The present doctoral thesis introduces algorithms for the solution of optimization problems which arise in the shape design of steel profiles. In these optimization problems, partial differential equations act as constraints.
After an introduction in Chapter 1, Chapter 2 describes the optimization model, the choice of the design parameters and the considered design constraints. Two simple examples show the restrictions of simplified NLP models. Motivated by the latter, the linear elasticity equations are studied in their weak formulation, and implementation details of a finite element approximation with quadratic tetrahedral elements are given.
Chapter 3 first shows reliability and efficiency of an a posteriori error estimate, even in the case of an inexact solution of the finite element formulation. Adaptive mesh refinement and the transformation of some reference mesh depending on the shape given by the design parameters are described. The chapter closes with an outline of the employed multigrid approach.
Chapter 4 proves differentiability of the PDE constraint and the objective function under mild assumptions. This allows to use the adjoint approach for computing the gradient of the objective. For the computation of the necessary derivatives of the finite element approximations an explicit approach and automatic differentiation are compared. Results of an SQP algorithm using several quasi-Newton updates are presented.
In Chapter 5 an inexact SQP algorithm, along with a convergence proof, is given, where special attention is paid to the convergence of the inexact SR1 update to the true Hessian. Three suitable stopping criteria for a nested iteration of successively better finite element approximations are presented, again together with convergence proofs.
Chapter 6 illustrates the performance of the algorithm for an example problem, and Chapter 7 concludes the thesis with a summary and an outlook.
The text is accompanied by 21 figures, a glossary of notation, and 56 references.

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