6th German-Japanese Workshop on Computational Mechanics,
RWTH Aachen University, December 04-05, 2023

Applications of Semi-Implicit Sensitivity Analysis for Path-Dependent Topology Optimization

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Extended Abstract

Topology optimization is a method of optimal design that can find a free optimal shape with extremely high shape representation performance. The characteristic of this method is that it describes the design space with thousands to tens of thousands of design variables. This makes the sensitivity analysis process for updating design variables using the gradient of the objective function and constraints unique. Specifically, this is a formulation called the adjoint variable method, which is well suited to the nature of topology optimization, where the number of design variables is enormous.

The adjoint variable method becomes complicated when solving mechanical problems with history dependence, such as material nonlinear problems and dynamic problems. This is because the forward problem constructs a complex implicit function in which global equations such as equilibrium equations and local equations of material constitutive laws are nested. The adjoint variable method for such problems requires solving adjoint equations that backtrack many incremental steps, which tends to increase computational costs such as memory usage and iteration count.

For such problems, sensitivity analysis can be semi-implicitly formulated under the condition of limiting the form of the objective function [1]. This method can sequentially update the sensitivity history of internal variables of nonlinear constitutive laws without solving global adjoint equations. It can be applied to topology optimization problems that are generally considered to have high computational costs using elasto-plastic analysis, dynamic analysis, and multiscale analysis. This presentation introduces a research example of topology optimization applying the semi-implicit sensitivity analysis method.

References

1. J. Kato, H. Hoshiba, S. Takase, K. Terada, T. Kyoya, *Analytical sensitivity in topology optimization for elastoplastic composites*, Structural and Multidisciplinary Optimization, 52(3) (2015), 507-526.