 ICCES, vol.16, no.2, pp.51-51

Shape optimization of nonlinear structure using adjoint variable approach and gradient-based Kriging method

Zhenhan Yao and Yintao Wei

Summary

Shape optimization is very important in many engineering fields. As conventional engineering design, the shape optimization is generally based on the finite element analysis. Because many engineering strutures are related to different nonlinear problems in their working state, the analysis for each design sample is quite time consuming. For example for the shape optimization of automotive tires, it is related to the geometrical, material nonlinearity, and boundary nonlinearity caused by the contact problem. Therefore, the finite element analysis combined with sensitivity analysis to get more information for each design sample is a strategy usually adopted. For the sensitivity analysis, the adjoint variable approach can be applied to enhance the efficiency, provided the number of design parameters is much less than the number of degrees of fredom. The sensitivity of the objective functions with respect to the shape parameters are derived considering the nonlinarity. Based on the results of the sensitivity analysis for each design sample, the gradient-based Kriging method is a matched choice to construct the response surface for the shape optimization. The Latin hypercube method can be applied to reduce the number of design samples.

For the shape optimization based on the finite element analysis, the accuracy of the finite element analysis should be guaratteed. To the element selection and mesh generation should pay much attention. If the characteristic stress or strain obtained for the objective function is affected by the unreasonable mesh, the sensitivity obtained will be instable, which will cause the optimization invalid. Considering the error of finite element analysis, the Latin hypercube method shoul be revised, to reduce the effect of the error of finite element analysis, some more design samples should be adopted.

For the objective function of nonuniformity of the contact pressure, the sensitivity directly obtained from the finite element analysis is instable, even if much attention is paied for the finite element mesh. To obtain the reasonable nonuniformity of the contact pressure, an adaptive postprocess approach has been presented, but the sensitivity cannot be obtained based on one design sample only. In such case, only the conventional Kriging method can be adopted rather than the gradient-based Kriging method.