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Level set-based optimization using automated solutions of partial differential equations

Atsushi Kawamoto[1], Tsuyoshi Nomura[1], Tsuguo Kondoh[1] and Shinji Nishiwaki[2]

[1] Toyota Central R&D Labs., Inc. Nagakute, Aichi, Japan, atskwmt@mosk.tytlabs.co.jp
[2] Kyoto University, Kyoto, Japan, shinji@prec.kyoto-u.ac.jp

Abstract

The present paper deals with level set-based optimization in terms of practical implementation utilizing automated solutions of partial differential equations (PDE). A level set-based approach is not only preferable to promote black-and-white solutions in standard topology optimization, but also, using a signed distance function, advantageous to incorporate a boundary tracking mesh generation scheme. Another interesting but less familiar way of using the signed distance function is to define the orientation of non-isotropic material as the gradient of the function. One drawback of the level set-based approach is the extra re-initialization steps that interrupt the optimization process from time to time. In this paper, we propose a way to implement these level set-based optimization methods including re-initialization procedures within the time evolution of diffusion equations. All programs are implemented in COMSOL Multiphysics. From an agility point of view, the proposed methods are advantageous because all of the necessary elements are already included in the software package. Therefore, the proposed methods can be implemented by simply describing equations. The effectiveness of the proposed methods is confirmed through numerical examples.

In multiscale heat conduction design problems, the orientation angle distribution of the anisotropic material (macro variable) is designed [1]. As a micro expression, for instance, one can use a texture pattern, such as flow lines. In that case, from the manufacturing point of view, it is desirable to make the flow line density as uniform as possible (ideally equal intervals). For generating a line and space pattern, Line Integral Convolution [2] and a reaction-diffusion model [3] can be used. In this study, when a vector field is given in a plane, using the above mentioned time evolution equation, we propose a method for generating an approximate equal interval streamlines along the vector field.

References

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