Accepted Manuscript

An explicit optimization model for integrated layout design of planar multi-component systems using moving morphable bars

Xuan Wang, Kai Long, Van-Nam Hoang, Ping Hu

PII: S0045-7825(18)30365-7
DOI: https://doi.org/10.1016/j.cma.2018.07.032
Reference: CMA 12004

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 13 January 2018
Revised date : 17 July 2018
Accepted date : 22 July 2018

Please cite this article as: X. Wang, K. Long, V. Hoang, P. Hu, An explicit optimization model for integrated layout design of planar multi-component systems using moving morphable bars, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.07.032

An explicit optimization model for integrated layout design of planar multi-component systems using moving morphable bars

Xuan Wang[a], Kai Long[b], Van-Nam Hoang[c], Ping Hu[a,*]

[a]*State Key Laboratory of Structural Analysis for Industrial Equipment, School of Automotive Engineering, Dalian University of Technology, Dalian 116023, China*
[b]*State Key Laboratory for Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Beijing 102206, China*
[c]*Department of Mechanical Engineering, Vietnam Maritime University, Hai Phong 484, Vietnam*

Abstract

Layout design of multi-component systems has received ever-increasing attention over recent years. However, most of the current literature on the layout design of multi-component systems conducted are all carried out in an implicit way. In this paper, an explicit optimization model based on the moving morphable bars method is proposed. To this aim, topology description functions are used to describe the geometrical shapes of embedded components, while moving bars act as supporting structure that connects these embedded components. Different from traditional optimization methods, the geometric parameters used to describe the size, shape, location and orientation of the moving bars and embedded components are considered as design variables in this work. To avoid remeshing the grids and improve the efficiency of computation, the moving bars and embedding components are mapped into two density fields on a fixed grid using a smoothed Heaviside function. A discrete material interpolation scheme developed for orientation optimization problem is extended for the first time to the material parameterization of multi-component systems. Moreover, a single explicit constraint based on the volume and perimeter of embedded components is proposed for avoiding overlaps between the embedded components, and between each component and the design domain boundary. Several numerical examples are performed to show the effectiveness and flexibility of the presented optimization model in handling layout optimization of structures with multi-phase embedded components.

Keywords: Topology optimization, Multi-component systems, Moving morphable bars, Explicit model, Layout optimization

1. Introduction

Since the landmark work of Bendsøe and Kikuchi [1], topology optimization, which aims to find the best possible structural topology or layout for achieving the best structural performance, has become a powerful conceptual design tool for wide range of engineering fields and disciplines in the critical early stage of the design process, from agricultural engineering, civil engineering to mechanical engineering. Substantial and fundamental research efforts have devoted to the development of efficient and reliable computational methods for various optimization problems, including the homogenization method [1], the solid isotropic material with penalization (SIMP) method [2, 3], evolutionary structural optimization (ESO) method [4], level set method [5, 6]. The available state-of-the-art reviews on the latest developments in this field can be found in [7–11] and the references therein.

It is seen that most of the topology optimization methods and published researches have focused on the topology design of single-component structures [7–11]. However, as stated in [12], most real-world engineering design problems involve multiple components, which is a relatively new topic of great significance and still not extensively researched. Thus, the focus of this paper is on integrated layout design of multi-component systems using an explicit optimization model.

*Corresponding author
Email addresses: xuanwang@mail.dlut.edu.cn (Xuan Wang), pinghu@dlut.edu.cn (Ping Hu)