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FULLY INTEGRATED DESIGN OPTIMIZATION FOR ENGINEERING STRUCTURES WITH BENCHMARKING

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Abstract

This paper introduces a computer based, fully integrated design optimization (FIDO) system to allow engineers to produce efficient engineering structural designs for a set of loading conditions. The basic problem may be summarised as follows: given the loading and support conditions, what is the optimal structure? To solve such a problem, a three stage process is developed involving: (a) preliminary optimal layout design, (b) structural model redefinition with parameterization and (c) refined optimal shape and sizing design.

1 Introduction

There has been a growing worldwide interest in structural optimization stimulated by the increasing availability of very powerful yet inexpensive computers as well as stress analysis tools of improved robustness and reliability. Research activity in structural optimization at Swansea began in the early seventies [1] and has been extended in more recent years by the ADOPT (adaptivity and structural optimization) group, led by the first author [2-32]. For structures which may be represented by 2D and shell models, the group has developed and implemented a series of procedures for optimal structural design integrating CAD/CAM geometry description tools based on parametric cubic splines and Coons patches with adaptive FE analysis.

However, while this research was being carried out the limitations of pure shape or sizing optimization became more and more apparent. For example, for conventional shape or sizing optimization of structures represented using 2D models, only the boundaries of a given topology can be varied in order to obtain an optimized solution. Consequently, the solution found in this way might not be optimal and it would appear advantageous to develop techniques which allow the designer to perform a preliminary layout optimization of the structure prior to further design.

Two groups of procedures for carrying out layout or topology optimization have emerged: the more intuitive evolutionary methods [2] and the more mathematically rigorous homogenization methods [33]. In the evolutionary method, for example, the design domain is divided into a mesh of finite elements and a finite element analysis is carried out in which each element is assumed to have an identical elastic modulus. Subsequently, the elastic moduli of the lightly stressed elements are reduced to a low value and the structure is reanalysed. This procedure is continued iteratively until an optimal layout is obtained: the elements with low elastic moduli being ignored. During this process the stress path is gradually attracted to the stiffer elements. Other approaches make use of homogenization and related procedures.

In this paper, we introduce a fully integrated design optimization (FIDO) system to allow engineers to produce efficient engineering structural designs. Figure 1 shows the three stage process involving (a) preliminary optimal layout (or topology) design, (b) structural model redefinition and parameterization and (b) refined optimal shape and sizing design.

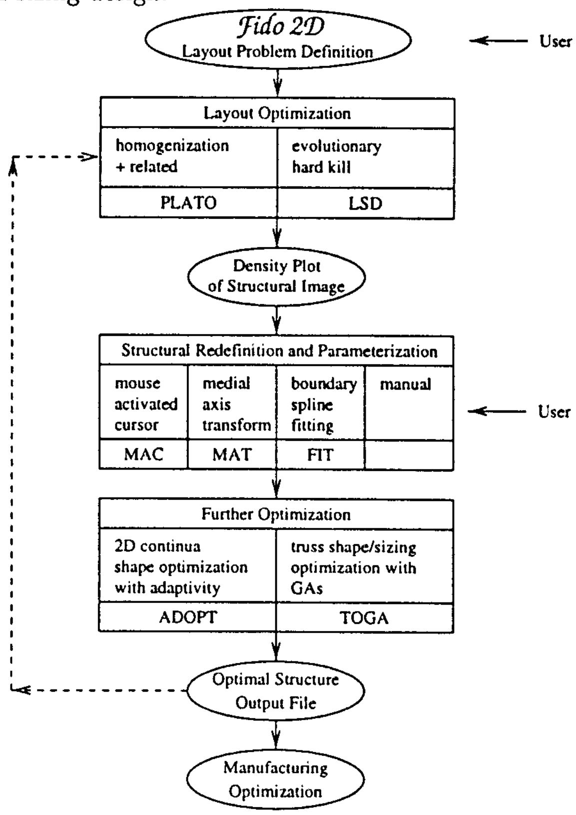

Figure 1 *Fully integrated structural optimization package FIDO-2D.*