Structural Optimization and Free form Design

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Summary

Free form design is an important trend in contemporary architecture which aims to overcome the geometric limits of traditional architecture. With the advent of free form design topics like structural efficiency and reliability play a central role in the design process. The adoption of uncommon geometry (often extended in 3D space) make difficult the adoption of classical methodologies for structural analysis. New techiques based on optimization methods can bring a useful contribution in both the architectonic and structural design. In this paper an optimization method based on genetic algorithm is presented and several practical applications are shown and discussed. The complexity due to the large amount of calculations needed by this kind of approach have been exceeded by the adoption of parallel computing strategies that seems to be powerful, scalable with the size of the problem and also valuable from the economic point of view [1].

The present technique can be successfully adopted for sizing and topology optimization of truss structures in real size.

Keywords: structural optimization; genetic algorithms.

1. Introduction

Over the years a large number of optimization techniques has been introduced. Historically the importance of structural optimization has been first recognized by the aerospace industry that is particularly interested in the reduction of structural weights.

Nowadays the interest is still high because of the growing demonad for lightweight, efficent and low cost structures.

In general terms a generic optimization problem can be expressed as a minimization of an objective function $f(x)$ subject to constraints in its own variables x:

$min\ f(x),\ \forall x \in \Re^n$ subject to $c_i(x) = 0,\ c_j(x) \geq 0$

with $i \in \Upsilon, j \in \Xi$ where c_i and c_j are functions in x and represent the constraints [2].

In structural optimization the variables are often related to stresses, displacements, vibration frequencies or others. From a structural point of view, many authors agree on the following classification about different levels of optimization [3]:

- **size** optimization deals with minimization of one ore more response variable (tension, deformation or others) acting on one ore more design variables (such as thickness for a plate or cross section of a bar) while respecting some conditions (equilibrium, restraints and so on);
- **shape** optimization aims to find the optimal shape of a domain which is a design variable;
- **topology** optimization for continuum structures deals with the number, position, shape of holes and topoology of the domain.

Commonly used objective functions are weight, displacements or stresses.

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