AN EFFECTIVE ALGORITHM FOR DISCRETE OPTIMIZATION WITH STATIC AND DYNAMIC CONSTRAINTS

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1. Introduction

The engineering design consists often in finding the best solution from a finite number of feasible decisions. Designing trusses and frames of minimum weight, the decision has to be made by finding appropriate rolled profiles available on the market, and listed in commercial catalogues. Such a process of searching has been commonly known as "discrete structural optimization"(DSO). The number of all possible combinations entering in almost all problems are very large, and then, solutions by direct enumeration are practically impossible.
The commonly used method in DSO are stochastic algorithms, and among them Genetic Algorithms and Evolutionary Optimization methods. All advantages and disadvantages of GA are rather well known. One of the important disadvantages, from the engineering point of view, is unspecified number of populations which has to be considered. Also, requiring a lot of practice, are coefficients needed to construct the fitness function for problems with constraints.
In the presented paper a problem oriented method of removing from the structure the redundant material is propose. First, attempt to introduce the algorithm into engineering design is presented in [1] and [2]. Here, the extension of the method to multiloading conditions combined with dynamics is presented.

2. Assumptions of the method

Optimized structures (trusses, frames, reinforced plates and shells) of a given topology, are composed of prefabricated rolled profiles, available on the market, and listed in professional catalogues. It is assumed that a structure, is composed of j_0 members. Each j-the member is assumed to have A_j^k cross section area (CSA) and/or moment of inertia, taken from k-th position of the catalogue containing k_0 different values. The structure can be subjected to several static loading conditions and constraints imposed on displacements, and stresses. Additionally a constraint on the first eigenfrequency is imposed. It is assumed that optimized structures are in the linear elastic range of the material.
There are k_0 to power j_0 possible structures of the same topology, made of j_0 members each, and k_0 the number of cross section areas listed in a catalogue. The simple check, mentioned in the introduction, shows that a simple enumeration for finding the optimum cannot be applied due to the enormous computational time needed. It is then assumed that instead of searching for an exact method, it is better to find a simple, approximate approach.

3. A sequential removal of the redundant material

The method for finding minimum weight for a static case was presented in [1]. Now, we add to the discussion the problem of finding minimum weight with a constraint imposed on eigenfrequency. The following main steps of an algorithm are presented (the flow chart is shown on Fig. 1.)

i. Assign to all structural members (SM) the largest, available CSA (A_j^1).
ii. Find the first eigenfrequency end eigenvector for the structure defined in "i".
iii. Find virtual stresses for obtained normalized eigenmode.

iv. Remove the material from a member with the smallest virtual stress, by taking from the catalogue the next smaller value of the CSA. Check whether the constraint imposed on the eigenfrequency is not violated.

v. Repeat “iv” until one or more CSA reach their minimum values in the catalogue.

vi. In the case of a combined problem with static loadings and constraints, the end of the algorithm can be also limited by largest stresses.

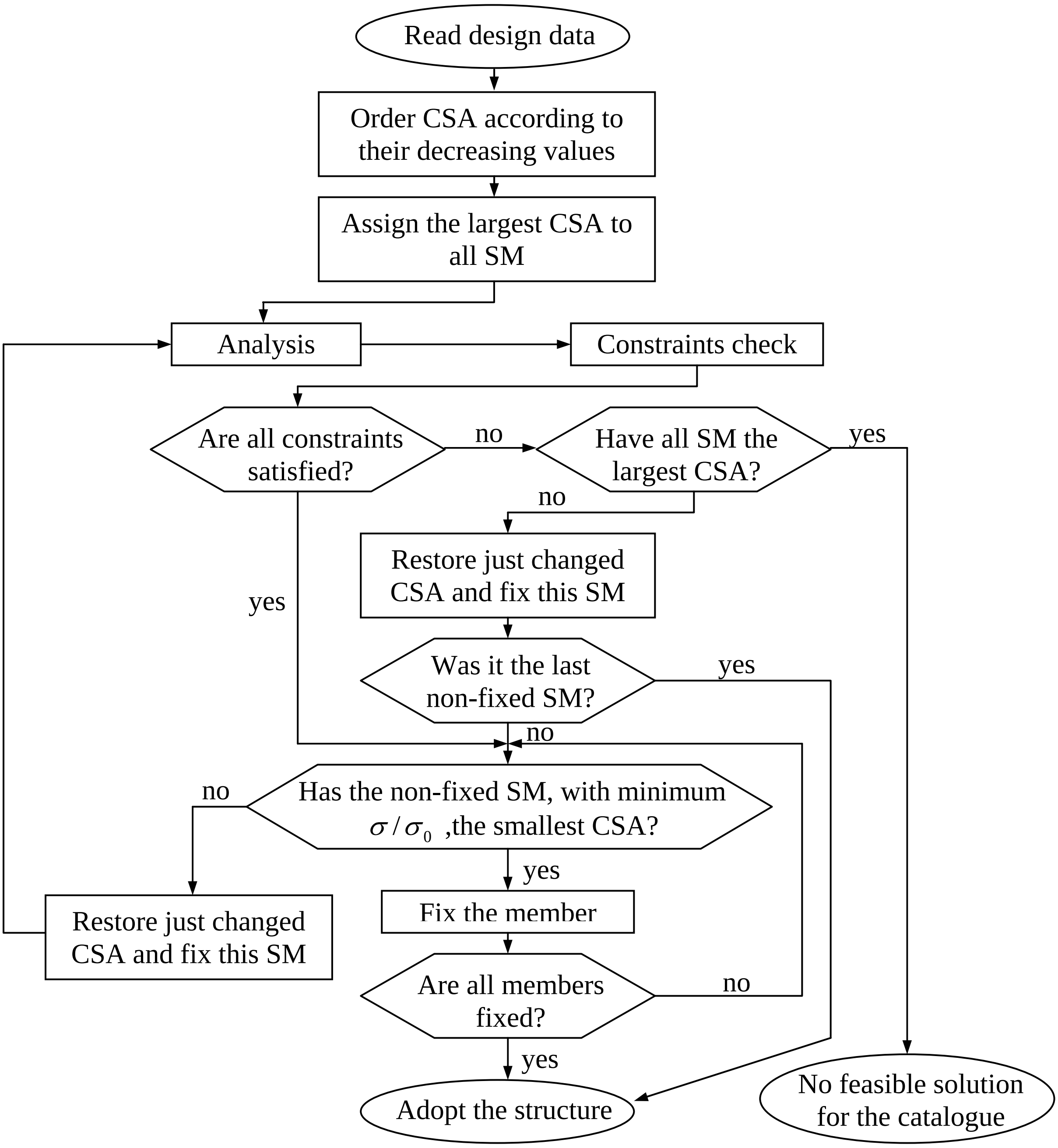

Figure 1.

[1] W.Gutkowski, J. Bauer, J. Zawidzka (2000), An effective method for discrete structural optimization, *Engineering Computations*, **17**, 4, 2000, 417-426

[2] G. Guerlement, R. Targowski,W. Gutkowski, J. Zawidzka and J. Zawidzki.(2001), Discrete minimum weight design of steel structures using EC3 code, *Struct. Multidisc. Optim.* **22,** 322-327.