Nodal Based Evolutionary Structural Optimisation (NESO)

This article may be found at
http://www.soton.ac.uk/~cedc/posters.html

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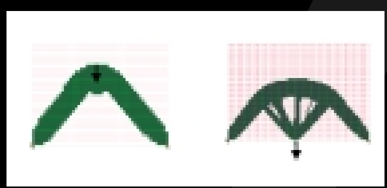
UTP for design

Finite element (FE) analysis is a powerful tool in the field of structural optimisation which designers use to analyse their work. Evolutionary structural optimisation methods may be used to bridge the gap between design and optimisation by efficient use of FEA.
The purpose is to integrate geometry modelling and optimisation into one automated design process.

In a finite element formulation, nodes, elements and material properties define the structure.
Most existing structural optimisation methods such as the classical ESO method, soft-kill and hard-kill methods and the homogenisation methods are based on treating element, material properties or mesh density as design variables.

In all these methods, the use of identical elements in the design domain provides a qualitative measure of the stress distribution in the domain at low cost.
The disadvantage is that the optimised geometry involves "stair-case" effects.
Typical results obtained by treating elements as design variables in this way are shown below:



The optimised geometry is made up of regular identical elements and hence lacks geometric smoothness.

The idea of treating geometry boundary nodes as design variables is not new, but in most early work, the difficulties involved in maintaining boundary smoothness was not overcome. The NESO approach deals with this problem. Two attractive features of this method are that it can optimise using irregular meshes and it also produces smooth designs.
The method is based on treating the boundary nodes as design variables and slowly migrating these nodes from any initially lightly loaded regions towards higher stress zones. During the node-migrating process, element distortion problems occur and re-meshing is used to generate a new set of topology data. We have developed two algorithms that are both based on the NESO approach.

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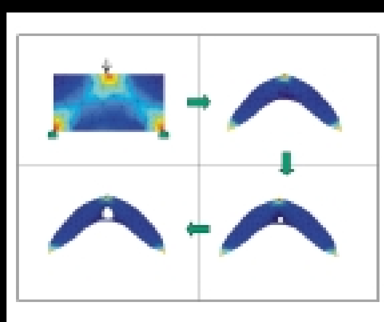
Sequential NESO Algorithm

The first algorithm is termed the sequential NESO algorithm and is capable of performing shape optimisation from a "blank" design domain and then further saves structural weight by introducing cavities within the domain after the external shape has been optimised. These are then optimised by migrating their edge nodes.

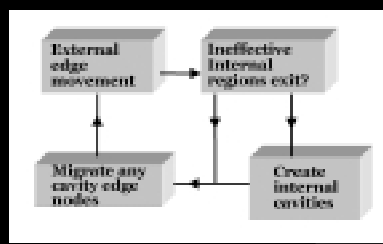
SNESO Application: A Simple Arch Design Problem

Here, the initial oversized domain is chosen to be a rectangle. A point force is applied at the top centre and the lower left and right corners are clamped.

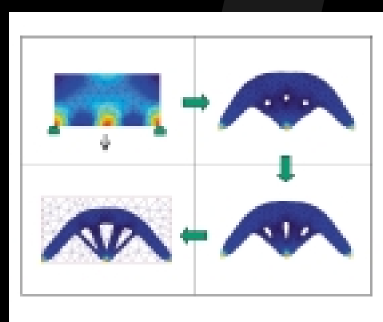


Parallel NESO Algorithm

The second algorithm is termed the parallel NESO algorithm. This algorithm introduces cavities into the domain while the external shape of the boundary is still being optimised.
In addition, once the cavities are introduced into the domain, the edge nodes of cavities are assigned degrees of freedom to move within the inner domain.
The aim is to save more weight. Moreover, by doing this, an efficient topology for the internal domain can be revealed. Hence the PNESO algorithm may be classified as a layout and topology optimisation algorithm.
The schematic diagram of the PNESO algorithm is shown next:



PNESO Application – Benchmark 'Michell Arch' Problem



Here an initial oversized rectangular domain is again used. The bottom left and right corners are rigidly fixed but now a point force is applied at the bottom centre.

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