Two level neural network based shape recognition techniques for structural optimization problem formulation

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1. Introduction

Many practical structural designs are of continuum and discrete nature. The common procedure of designing a continuum structure includes the implementation of a homogenization method to obtain an optimal configuration with a minimum compliance and the subsequent shape optimization to ensure the satisfaction of the important stress and other constraints.

The modeling of such shape optimization problem involves the careful manual conversion of all inner holes with rough boundaries into proper holes defined by variables with proper side bounds, and the zigzag outer boundary into a boundary definable by shape design variables. Lin and Chao [1] proposed a template matching method to classify inner holes into a number of predefined holes of simple geometry. The template matching is based on the signature method often used in computer vision. The interpreted inner hole shapes and the outer boundaries obtained by detecting the first and last pixel of each vertical line in the structure are further used to generate shape models so as to execute a shape optimization in a fully automated manner [2]. The flowchart of the integrated topology optimization and subsequent shape optimization can be seen in Figure 1, where the upper loop describes the procedure on continuum structures.

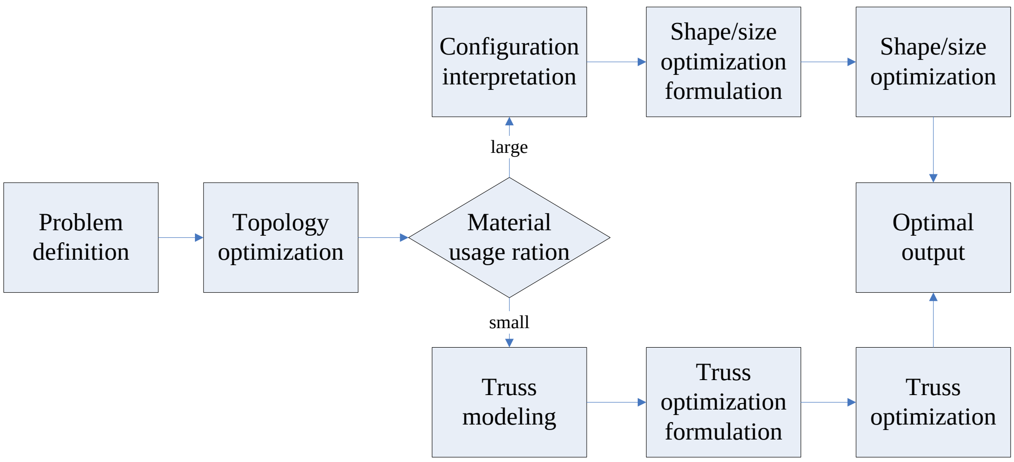

Figure 1 Automated integrated structural optimization procedure

However, the effect of the inner hole recognition by the template matching techniques [1] is not always satisfactory due to limited shape templates and the difficulty of defining matching criteria which are based on the dimensions of a number of key geometric measurement. When the inner hole recognition and modeling is not precise enough, the subsequent shape optimization will not generate satisfactory results.

This paper will propose a two level neural network based hole recognition/classification system which can model the inner hole in a more efficient and accurate manner. The two level neural network hole recognition system contains the first level coarse recognition and the second level fine recognition. In the first level, the principal geometric shape (coarse contour) of the inner hole will be detected. In the second level, the fine geometric shape (detailed contour) of the hole will be defined by selecting the fittest shape model from the same principal geometric shapes. The first level shape template contains 5 principal geometric shapes: circle, semicircle, square, rectangle and triangle. The invariant moment [3] is used to represent the characteristic of each shape template. The seven invariants measured from an identical shape will not change after rotation, translation, mirror reflection, and scale up or down.

The overall procedure of the proposed two level neural network based hole shape recognition and modeling procedure can be seen in Figure 2, where the back propagation method is used in each of the two level of neural network learning. In the final paper, the two level neural network based hole recognition and reconstruction (modeling) system will be tested in a few topology optimization problems. .

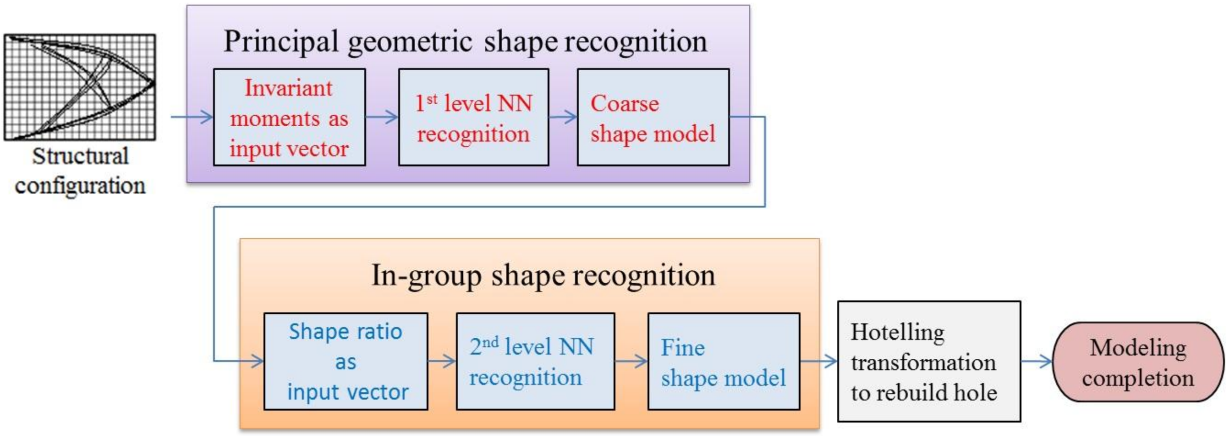

Figure 2 Flowchart of two level neural network hole shape modeling

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