A Hybrid Design Optimization Strategy for The Field of Structural Dynamics

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Introduction

The occurrence of dynamic problems during the operation of machinery may have devastating effects on a product. Employing design optimization techniques may help to ensure the safety and the reliability of the product.

Objective & Approach

The objective of this project is to develop a hybrid design optimization strategy that can be benefited for solving dynamic problems of structures.
The developed strategy is presented in Figure 1.
Keywords: Design of Computer Experiments (DOCE), Component Mode Synthesis (CMS), Neural Networks (NN), Genetic Algorithms (GA), Sequential Quadratic Programming (SQP).

Application

To demonstrate the strategy, a structure illustrated in Figure 2(a) is considered. The thicknesses of the struts are selected as the design parameters and the struts which have $n\frac{\pi}{2}$, $n = 0,\ldots,3$ rotational distance between each other are assigned to have the same thickness values. The model of the complete structure is generated by modeling only one repeating component. The initial design is shown in Figure 2(b). The optimization problem is formulated as:

$$\begin{aligned} \min_{\text{thck}_i} \quad & \rho V(\text{thck}_i) \\ \text{sbj. to} \quad & f_5 = 750 \\ & \text{MAC}_5 \geq 0.9 \\ & 0.1 \leq \text{thck}_i \leq 0.5 \qquad i = 1,\ldots,6. \end{aligned}$$

The results are summarized in Table 1 and the final design is shown in Figure 2(c).

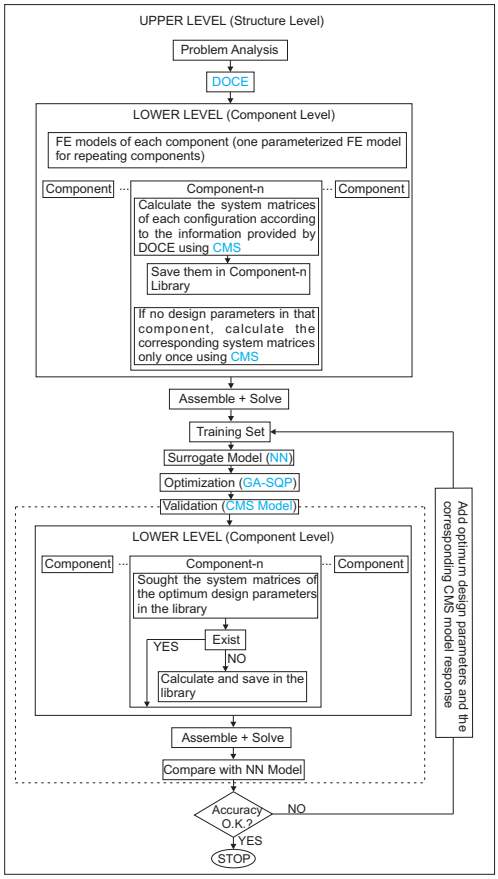
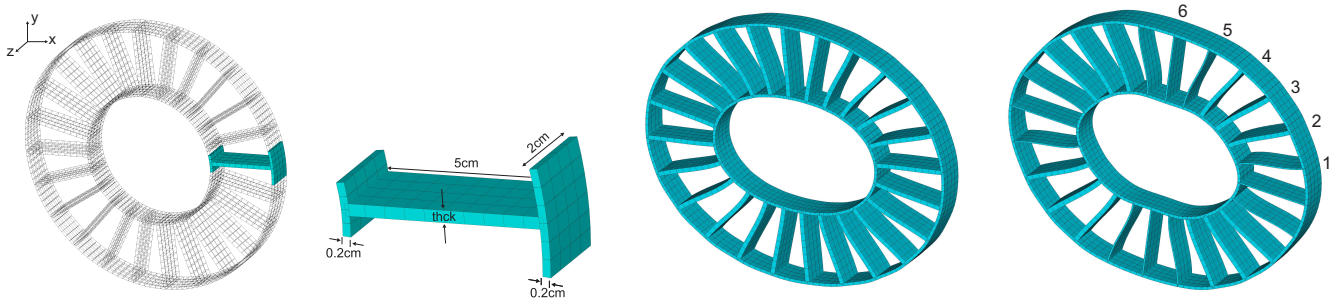


Figure 1 : The developed hybrid design optimization strategy.

Initial Design Parameters	[0.3 0.3 0.3 0.3 0.3 0.3]
Optimum Design Parameters	[0.1 0.298 0.329 0.297 0.1 0.1]
# of designs in the Library (Initial)	60
# of designs in the Library (Final)	349
Total # of iterations	89
Initial Mass	0.4936 kg.
Optimum Mass	0.3899 kg.
MAC_5(NN)	0.9866
MAC_5(CMS)	0.9817
Final f_5(NN)	750 Hz.
Final f_5(CMS)	749.33 Hz.

Table 1 : Summary of the optimization problem.



(a) The structure and its repeating component *(b) Initial Design-Mode 5* *(c) Final Design-Mode 5*

Figure 2 : Application