Supplementary example: validation of 'adjacent individuals' in rigid frame topology optimization

Shuanjun Liu[a]

[a]School of Astronautics, Beihang University, Beijing, 100191, China

ARTICLE HISTORY
Compiled March 1, 2024

This example is used to verify the correctness of applying the concept of 'adjacent individuals' (or θ) to the generation of initial populations. This is a benchmark example of topology and detail size optimization of plane rigid frame structure shown in Fig.1. The material parameters and the model of topology optimization is same as that of Ref.(Huang et al 2018). Finite element model are built by beam element, with total mass of 116854kg and fundamental frequency of 22.17Hz. The objective is to minimize the structure mass and the constraint is that the fundamental frequency $\geq$ 15.76Hz. There have 5 discrete variables and 5 continuous variables. The difference from the solution strategy in Ref.(Huang et al 2018) is only that the method for generating the initial population is based on 'adjacent individuals' in this work.

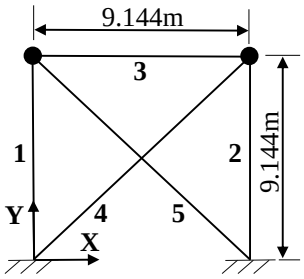

Figure 1. 5-bars frame and the numbering of discrete variable

It should be noted that since there is no damping rod in this example, the discriminant condition of 'whether two individuals are adjacent individuals' needs to be adapted only here to

$$1/2 \sum_{i=1}^{n} |\boldsymbol{\alpha}_1(i) - \boldsymbol{\alpha}_2(i)| \leq \lceil \theta \cdot n \rceil \tag{1}$$

where n is the total number of discrete variable and $n = 5$. Set $\theta = 0.2$ and 0.7 for calculation respectively.

The iteration of the objective function is shown in Fig.2, and the comparison of the optimization results is shown in Table 1. After introducing the concept of 'adjacent individuals' (or θ), the stationarity of iteration is enhanced with no increase in the

CONTACT Email: liushj@buaa.edu.cn

number of structure analysis. Specifically, the structure obtained has the lightest mass and enters the stage of smooth iteration relatively quickly when $\theta = 0.2$. This example suggests that the method of population generation in this paper is correct, and the appropriate value of θ can improve the stability of optimization iteration to a certain extent.

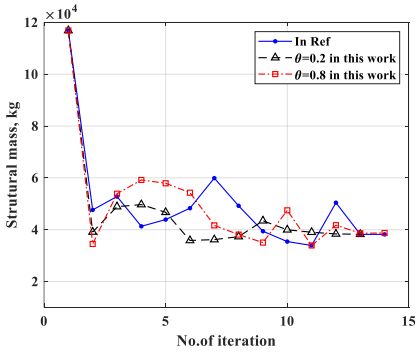

Figure 2. The iteration of the objective in example

Table 1. Optimization results in Ref(Huang et al 2018) and this work

	Huang et al (2018)	This work	
		$\theta = 0.2$	$\theta = 0.8$
R_1, m	0.2744	0.4321	0.2124
R_2, m	0.2394	0.2382	0.419
R_3, m	0.2171	0.2245	0.2714
R_4, m	0.4626	0	0.3577
R_5, m	0	0.3517	0
Mass/kg	38384	38217	38726
Frequency/Hz	15.75*	15.74*	15.72*
No.S	14	13	14

Note: No.S represents the number of structure analysis, and the same below; *The slight violation of constraints is allowed in optimization (Farshi and Alinia-ziazi 2010).

References

Farshi B, Alinia-ziazi A (2010) Sizing optimization of truss structures by method of centers and force formulation. International Journal of Solids and Structures 47(18):2508–2524. doi: https://doi.org/10.1016/j.ijsolstr.2010.05.009

Huang H, An H, Ma H, et al (2018) An engineering method for complex structural optimization involving both size and topology design variables. International Journal for Numerical Methods in Engineering 117(3):291–315. doi: 10.1002/nme.5957