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Physics Procedia 22 (2011) 68 – 73

Physics Procedia

2011 International Conference on Physics Science and Technology (ICPST 2011)

The Secondary Development of ABAQUS by using Python and the Application of the Advanced GA

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Abstract

Realizing the secondary development of the ABAQUS based on the manual of ABAQUS. In order to overcome the prematurity and the worse convergence of the Simple Genetic Algorithm (SGA), a new strategy how to improve the efficiency of the SGA has been put forward. In the new GA, the selection probability and the mutation probability are self-adaptive. Taking the stability of the composite laminates as the target, the optimized laminates sequences and radius of the hatch are analyzed with the help of ABAQUS. Compared with the SGA, the new GA method shows a good consistency, fast convergence and practical feasibility.

Keywords: The secondary development; GA; Self-adaptive; Python; ABAQUS; Laminates;

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Selection and/or peer-review under responsibility of Garry Lee.
doi:10.1016/j.phpro.2011.11.010

1. Introduction

ABAQUS[1] can achieve the analysis of complex solid mechanics and structural mechanics, especially it is very convenient to the users because of the visual modeling module. Python[2] is the programming language which is dynamic interpretive execution and Object-oriented. Python is very easy to rookies. The most import is that Python is the script language of ABAQUS[3], so we can control the kernel of ABAQUS by using Python without the GUI module of ABAQUS\CAE. This paper has done much work around the secondary development of ABAQUS.

Now a day, composite is very popular in the development of industry in many countries. While we have a complex model, the optimize design can realize considerable use value and commercial value. Chang Nan has developed some new methods to do buckling analysis of the laminates with reinforced structures[4]. Hsuan-The Hu and Su Su Wang have done some research of laminates with or without cutouts[5]. There are kinds of optimization algorithms, like the Genetic Algorithm (GA), the Ant colony optimization, Particle swarm optimization, the Neural-net algorithm and so on. Tang Wenyan has put forward to add the competition between parents and children in the GA. Lu Dawei has put forward to combine the Immunity algorithm with the GA[6]. The improvement of optimization algorithm mostly is the genetic operators and combination of different algorithms.

2. The secondary development of ABAQUS

The interactive operation between ABAQUS\CAE and Python script: The interactive operation likes following: From top down, PDE interpreter compile and run the Python Script from GUI, commander line or the starting interface, and then build ".rpy" file and "Input" file by transferring the kernel of ABAQUS. At last, ABAQUS will run the "Input" file and build the output database.

The way to access module: When you do an analysis using ABAQUS, the ".rpy" file will record each step in Python, and the different objects will be used to record different modules. For example the "odb…"represents Output database module. When you visit one module, you should abide the hierarchy strictly. For example, you should import "odb.steps.historyRegions.point[i]" if you want to know the history output database on one point. Fig.1 shows the intact visiting ways in Output database module.

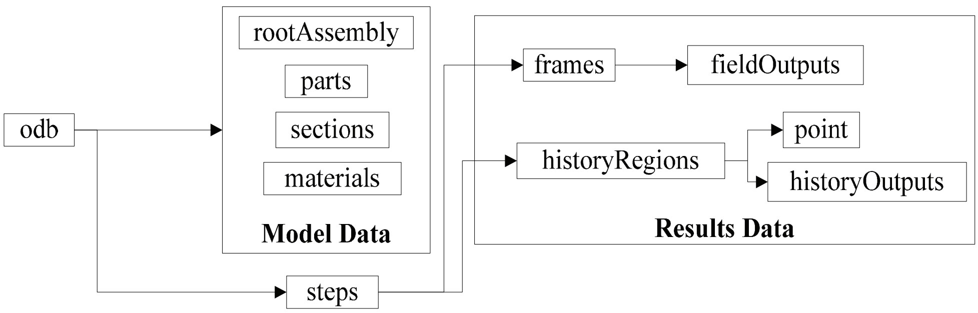


Fig. 1. odb routes

Programming technique: There are three parts program in my paper, they are Parametric Modeling Program (PMP), New Genetic Algorithm Program(NGAP) and Eigen Finding Program(EFP). The process of optimization in Fig.2 will be repeated many times until the most satisfactory result is got. You should be very careful because Python segment the different domain with space. The PMP can be got from the

".rpy" file after you have done the modeling and analysis process. The whole process is without the restart of ABAQUS, this point can save a lot of computer. At the beginning of the analysis, users should input the basic parameters (initial crossover probability and so on) through an interface, then click "OK" to start the analysis. The output will be shown on the main interface of ABAQUS.

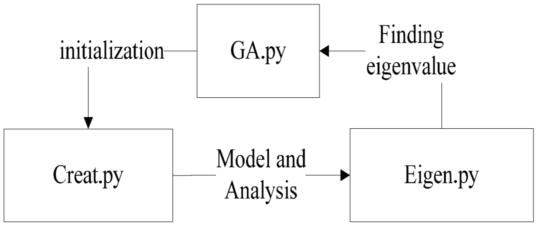


Fig. 2. Relationship of the main parts

3. The New Genetic Algorithm (NGA)

The Simple Genetic Algorithm (SGA): The process of the SGA is: Encoding the design variables according to the coding rules. Then do crossing, mutation and selection, after these we can obtain the new generation. From the fitness formula, we can obtain individual fitness. Repeating the process many times and finding out the individual which has the greatest fitness. At last, Decoding and output the result. Encoding and decoding as well as its fitness are calculated with implicit parallelism. But the SGA itself has some shortcomings, such as convergence is too slow and difficult to produce a higher degree of fitness of the new gene. Those will lead to algorithm converges to local optimum or appear premature. Because of the shortcomings and the arguments in the literature [7], in this literature, some improvements have been done on crossover and mutation probability and decoding mechanism.

Improvement strategies in the NGA: (1) Decoding mechanism: Scheme and Scheme Theorem. Among different coding strings, there are similarities in some position, such as "010" appears in different coding strings, then "010" is a kind of Scheme. When the GA is running, a certain similarity will be maintained between parents and children. This phenomenon is called the Scheme Theorem. When the same layer is located in the different location (the distance between this layer and the neutral surface of the laminates), the laminates will represent different performance. Because of this, in the NGA, we will reverse string which represents the half of the stacking sequence before it is decoded. Then decode the string and the reversed one and compare their fitness, only will the greater one be keep down. Before decoding, another job is judging the validity of these two strings. If the consecutive two strings have the same code, just decode the first string. The purpose of these improvements is to ensure the emergence of good Schemes as much as possible, and enhance the implicit parallelism of the NGA.(2) Children generation mechanism: After repeated calculation and contrast, considering the optimization accuracy and computing time, I have done the following improvements: The total generation is divided into two parts. In the first part, 50% children are from the SGA, another 50% are from the random function. The aim is to produce more schemes in the start of genetic. In the second part, selective retention mechanism is used. According to the fitness, sort the parents in descending, and then select the top 20% parents to be one part of the children. The remaining 80% children will be produced through the simple genetic operation. The aim is to ensure the convergence of the NGA and improve the overall fitness finally. (3) Crossover probability Pc and mutation probably Pm: At the very start, we want to produce more different schemes. So the crossover probability and mutation probability can be given greater. We hope the results of genetic tend to converge latter, so these two parameters should get smaller. Furthermore, children with great fitness should have small these two parameters, so a good scheme will not be destroyed. Moreover, with the genetic generation increases, these two parameters should tend to zero, but not get to zero. In accordance with the above principles, the crossover probability and mutation probability should be multiplied by an impact factor. In order to ensure that the impact factor is not zero, the effective judge should be done before the calculation of the probability. If the difference on the denominator is zero (average fitness has reached the max fitness), take the crossover probability 0.09 and the mutation probability 0.01 directly, it is small enough. Plus 1 to the molecular of genetic impact factor, so that the last generation of the genetic process with a small crossover and mutation probability to proceed. Improved Pc and Pm are shown in Equ.1 and Equ.2(Fi stands for Fitness of the i; Fave stands for the average Fitness; Fmax stands for the Max Fitness; N stands for the whole Generation; j stands for the current Generation.).

$$P_c = \frac{|F_{\max} - F_i|}{F_{\max} - F_{ave}} \frac{N - j + 1}{N} * 0.9 \tag{1}$$

$$P_m = \frac{|F_{\max} - F_i|}{F_{\max} - F_{ave}} \frac{N - j + 1}{N} * 0.1 \tag{2}$$

The Optimization Process of the NGA: The whole Optimization Process likes Fig.3. The parametric modeling and finding eigenvalue parts are added.

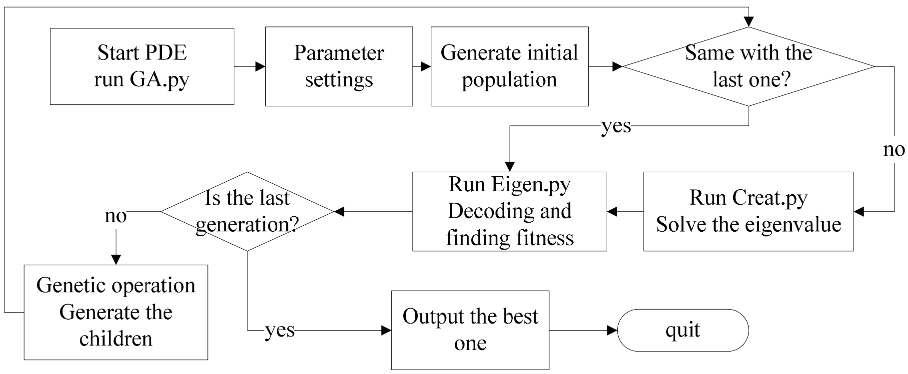


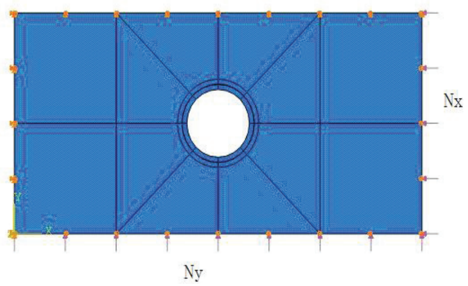
Fig. 3. The process of NGA

4. The optimization of reinforced laminates with hatch

The basic parameter of the model: The simply supported[8] laminates contains 18 layers. Finite element model length is 1000mm, width is 500mm. Boundary conditions are shown in Fig.4(a). Two-way proportional loading is used, Nx=175N/m, Ny = K•Nx. The range of the hatch radius is 50~150mm. Cross-section of the reinforcement is shown in Fig.4(b). Rh : 10~30mm, Rw : 10~30. The material of the reinforcement is BSC durable aluminum[9]. Because all the geometrical dimensions have been limited within a certain range, the weight will also in a certain range, so taking eigenvalue as the target.

Table 1. The optimization results

K	Radius of the hatch	Rh	Rw	The optimized stacking sequence	Eigenvalue
0.125	93.73	12.42	12.80	$[45°/45°/-45°/45°/45°/-45°/-45°/45°/45°]_s$	51.85
0.250	96.73	13.89	11.56	$[-45°/45°/45°/45°/-45°/-45°/-45°/45°/-45°]_s$	35.66



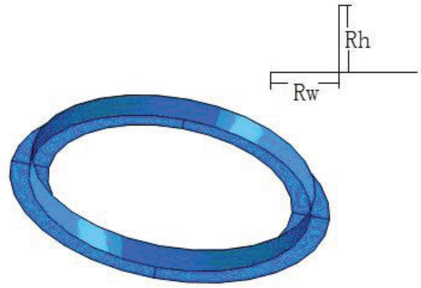
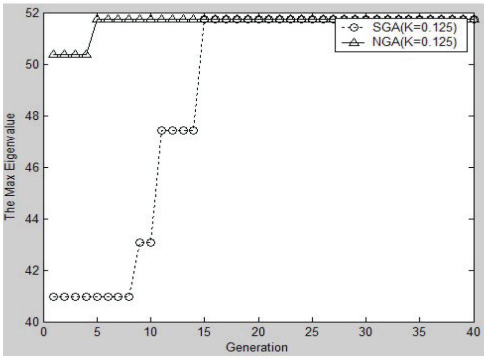


Fig. 4. (a) The laminates with hatch; (b) The reinforcement



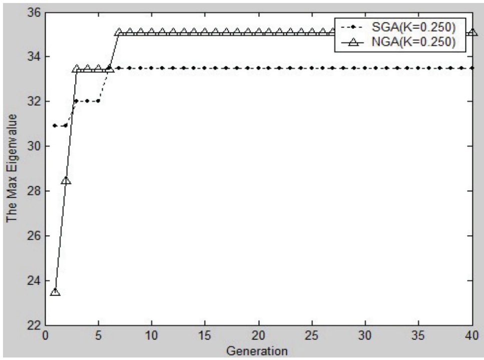


Fig. 5. (a) K=0.125; (b) K=0.250

Table 1 and these two figures show the optimization output. From Fig.5(a) we know that algorithm using the NGA is converging to the optimal in the fifth generation. While algorithm using the SGA is converging to the optimal until the twentieth generation almost. These two algorithms have the same optimization results. In the Fig.5(b), The SGA has a better output at the beginning, but the NGA exceed the SGA in the tenth generation. Because of randomness, the SGA may have a better output than the NGA. But the children from the SGA have very small difference when compared with their parents, so it is difficult to generate new scheme. The NGA can add new schemes through reverse and other improved genetic operation in the latter part of the whole generation. It is easier to generate better output. The Fig.5(b) shows that the SGA is into a local optimum. The above examples confirm the accuracy and validity of the NGA.

5. Conclusions

From the results obtained in this study, the following conclusion can be drawn: The secondary development can reduce the consumption of human and enhance the efficiency of computing greatly. The feasibility and convergence of the NGA with the SGA, the results show the NGA has good stability and convergence. It is possible to develop other modules which contain many aspects of models, algorithms and so on. That will be my next target.

References

[1] Shi Yiping, Zhou Shurong. ABAQUS finite element analysis example explanation [M].Beijing：Machinery Industry Press 2006.1

[2] Zhou Wei, Zong Jie.The development technology of Python [M].Beijing：Machinery Industry Press 2009.8

[3] Abaqus Scripting Users Manual. Dassault Systemes Simulia Corp.

[4] Chang Nan.The optimization of ply reinforced composite laminates and stability [D].Master thesis design. Northwestern Polytechnical University，2007.

[5] Hsuan-Teh Hu, Su Su Wang. Optimization for buckling resistance of fiber-composite laminates shells with and without cutouts [J]. AIAA-90-1069-CP, 1990, 1300~1312.

[6] Lu Dawei, Li Shu. The application of the immune genetic algorithm in the optimization of the laminates stacking sequence[J]. Journals of Beijing University of Aeronautics and Astronautics, 2005.2

[7] Tang Wenyan.The research and application of the genetic algorithm in the structure optimization. PhD thesis. Dalian University of Technology Journal，2001.12

[8] Xiu Yingshu，Cui Degang.The optimization of the layer in composite laminates stability[J]，Engineering Mechanics, 2005,22(6):212~216.

[9] Zhang Fenling, Liao Zilong, Hao Jianwei. China Aeronautical Materials Handbook Volume Ⅵ Composite Adhensive[M], Beijing: Standards Press of China. 147