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Platform Structure and Topology Optimization Design in Marine Engineering Based on Divide-and-Conquer Algorithm

Pushpitari Ijazen*

The University of Sydney Business School, Australia

**corresponding author*

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Abstract: In the research of modern intelligent algorithms, divide and conquer algorithms are also widely used. The divide-and-conquer algorithm has the characteristics of coping with the increase in the amount of data in large-scale data sets and high data dimensions. Combined with the research of platform structure topology optimization design, it is very important to improve the algorithm of design results under complex working conditions, which has important guiding significance for the research of platform structure and topology optimization design in marine engineering based on divide and conquer algorithm. In the experiment, the ten-bar plane pestle is taken as the research object, and the reliability optimization problem with stress as the limit state function under a single working condition is considered through numerical examples. The experimental results show that the reliability optimization method is feasible and reliable.

1. Introduction

With the in-depth development of information technology, more and more data are acquired and stored, and many problems can be described and characterized more accurately. In this context, new optimization problems also take on more diverse and complex forms [1]. The evolutionary algorithm based on divide and conquer provides a channel for simplifying complex problems and increases the possibility of solving complex problems. Focusing on single-objective optimization and multi-objective optimization, a large number of evolutionary algorithms based on divide and conquer have been designed and applied, and related research results have shown that evolutionary algorithms based on divide and conquer can improve the optimization effect, reduce the optimization time, and process Problems with special properties have significant effects.

Divide-and-conquer-based evolutionary algorithms and topology optimization have many advantages, which have led to many related studies. Gupta DK has studied on recent multi-resolution topology optimization (MTO) methods involving the division of finite elements into multiple density elements, allowing for a finer design description compared to the traditional FE mesh-based design domain. However, such formulations produce discontinuous intra-element material distributions, similar to QR patterns. The stiffness of these discontinuous features is overestimated, depending on the polynomial order of the finite element shape function employed. Although this phenomenon has been observed before, it is important to understand the occurrence of QR patterns in order to be able to realize the full potential of multi-resolution topology optimization. The formation and properties of these QR patterns are investigated and provide a basis for the definition of effective countermeasures. We investigate in detail the fact that continuous shape functions used in multi-resolution topology optimization cannot model the discontinuous displacement fields required to describe the separation of disconnected chunks of material within an element. The effect of filtering on QR pattern formation is also investigated and a low-cost method is proposed to determine the minimum filtering radius to avoid these artifacts [2]. Simonetti HL's research aims to explore the application of evolutionary optimization techniques to multi-objective optimization problems, with the Von Mises maximum stress minimization and the maximum growth minimization of the internal strain energy of the structure as criteria. To assess the global impact on the optimal design setup by removing inefficient material, regions of relatively small magnitude of stress or strain energy from the structure, an objective weighting scheme is employed in which weighting factors emphasize and balance stress and strain energy criteria. The global criterion method for multi-objective optimization and the concept of Pareto optimality are also considered. Therefore, the use of linear static analysis by the finite element method has contributed to the study of these two methods in the process of structural optimization [3]. However, the introduction of divide and conquer also brings new problems for this type of algorithm. How to decompose the optimization process and how to deal with the relationship between each sub-problem are factors that have an important impact on the optimization effect, and are also necessary for this type of algorithm. unique problems faced.

This paper studies the research status of divide-and-conquer algorithm, the research status of structural optimization, the research on platform structure and topology optimization design in marine engineering based on divide-and-conquer algorithm, including reliability-based structural topology optimization design, and the establishment of structural optimization design flow chart . In the experiment, the ten-bar plane pestle was taken as the research object, and the design variables and optimization objectives of the problem were studied by using ANSYS software and topology optimization method. The reliability optimization problem with stress as the limit state function under a single working condition is considered through numerical examples. The experimental results show that the reliability optimization method is feasible and reliable.

2. Research on Platform Structure and Topology Optimal Design in Ocean Engineering Based on Divide and Conquer Algorithm

2.1. Research Status of Divide and Conquer Algorithms

In the study of modern intelligent algorithms, divide and conquer strategies are also widely used. Divide and conquer strategies are used in the study of data clustering. In order to cope with the increase of data volume and high data dimension in large-scale data sets, researchers divide the data set into several subsets, cluster each subset, and then combine the clustering results of the entire data set to overcome the distance trend. The effect of zero is zero, and good experimental results are obtained; the divide and conquer method is used to design the knowledge reduction of rough sets, a decision table decomposition method based on divide and conquer is proposed, and a knowledge reduction control process based on divide and conquer method is constructed. , which effectively improves the performance of the data processing method based on rough sets; uses the divide-and-conquer strategy to solve the 0-1 knapsack problem, and develops a parallel algorithm based on the divide-and-conquer strategy. Both the effect and the running time have better performance. The divide and conquer strategy is used to solve the path planning problem [4-5]. The problem is modeled as an optimization model. In this paper, an ant colony system based on stored information is constructed. Multiple agents share the population memory and heuristic information, jointly construct a feasible solution to the optimization problem, and continuously update the population memory and heuristic information. Push the algorithm to search for the optimal path. Use the divide and conquer idea to construct an abstract frame to achieve effective extraction of video content [6-7].

2.2. Current Situation of Structural Optimization Research

The optimization design mainly improves the performance indicators of products and structures by selecting the variable parameters of the structure and selecting the numerical values or model categories of the design parameters within a given range and according to certain optimization ideas and rules, so that the design optimization can achieve the optimal purpose. Structural optimization design can be mainly divided into traditional optimization design methods and optimization design methods based on mathematical analysis [8-9]. The traditional optimization design method is the initial prototype of the optimization design. According to the specific use requirements, through a large amount of experience and practice as the reference design basis, the optimization model is compared and the best design scheme is selected. This scheme is also called empirical design. Optimization method, however, this method needs to consume time and cost, and constantly tries to find the optimal target. The cost is high and it is not suitable for more complex structural design. It has considerable limitations, so it has been gradually eliminated. The optimization design method based on mathematical analysis is an optimization design method based on the establishment of a mathematical optimization model, based on theory, and combined with structural numerical analysis and computer technology. At the same time, the optimization design method based on mathematical analysis has many advantages that other optimization designs do not have, and can approach the objective function more accurately. Because of its solid theoretical foundation, the optimization structure has authenticity and rationality in checking and checking. In recent years, more and more scholars use optimization design for research [10-11].

2.3. Research on Platform Structure and Topology Optimal Design in Marine Engineering Based on Divide and Conquer Algorithm

(1) Reliability-based structural topology optimization design

In marine engineering problems, the optimization design process of structures is usually full of various uncertain factors, such as material properties, load properties, geometric characteristics, boundary conditions and uncertainties caused by some human factors. The structural performance of traditional topology optimization design results may not meet the initial design requirements under the interference of various uncertain factors, resulting in structural failure [12-13]. Therefore, in the process of topology optimization design of the structure, a reasonable mathematical model should be used to quantitatively analyze the uncertain factors, predict the impact of the uncertain factors on the structural design requirements, reduce the sensitivity of the design results to the uncertain factors, and then improve the structural reliability. Robustness and reliability [14-15].

(2) Flow chart of structural optimization design

With the continuous progress of modern social science and technology, in the fields of engineering design such as aviation, aerospace, machinery, construction and automation control, the engineering demand for high-performance structures and lightweight design is increasing. Therefore, structural optimization design has become an engineering structure. An indispensable link in the design [16]. Structural optimization design refers to the design method of finding the optimal solution of engineering structure according to the predetermined objective under the condition of satisfying the constraints [17-18]. The general process of structural optimization design is shown in Figure 1:

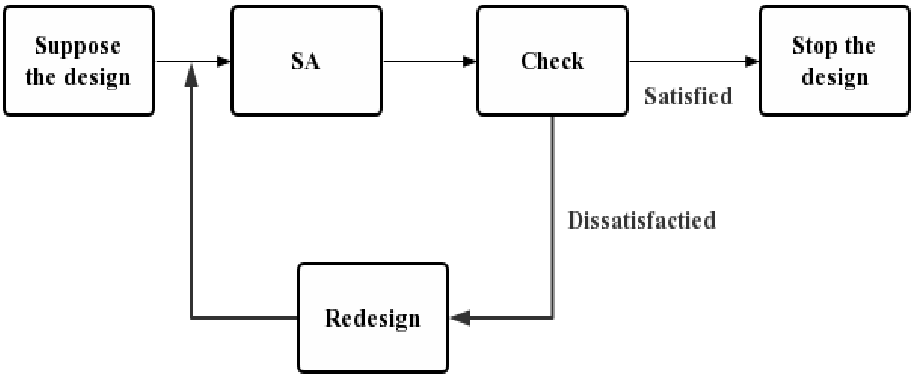

Figure 1. Flowchart of the traditional structure optimization design

3. Investigation and Research on Platform Structure and Topology Optimal Design Based on Divide and Conquer Algorithm in Ocean Engineering

3.1. Research Content

Taking the ten-bar plane pestle as the research object, the design variables and optimization objectives of this problem are studied by using ANSYS software and topology optimization method.

3.2. Topology Optimization Method

As the main structure of offshore oil exploitation, the offshore platform is complicated in structure and expensive. In this paper, the dimension design variable is selected as the member wall thickness t_i under the condition of constant inner radius. which is:

$$T = (t_1, t_2, ..t_k) \tag{1}$$

k is the number of groups of conduit components

The platform weight is selected as the objective function of structural optimization, because the manufacturing cost of the platform (approximately proportional to the weight of the platform) is often the primary factor to be considered in the design stage. In the formula, W is the total weight of the support structure of the jacket platform, the outer diameter of the ith unit D_i, the wall thickness of the ith unit t_i, the density of the ith unit ρ_i, kg/m'; l_i the ith unit length, m; g gravitational acceleration, N/kg. The specific formula of the topology optimization method is as follows:

$$W=\sum_{i=1}^{n}\pi\rho_i l_i g\left[\frac{\pi}{4}D_i^2-\frac{\pi}{4}(D_i-2t_i)^2\right] \tag{2}$$

4. Analysis and Research of Platform Structure and Topology Optimal Design Based on Divide and Conquer Algorithm in Ocean Engineering

4.1. Numerical Example

Consider a reliability optimization problem with stress as the limit state function under a single operating condition. The calculation results and the comparison with the optimization method of determining parameters are shown in Table 1 and Figure 2:

Table 1. Optimization Result of 10-bar Truss

Pole number	1	2	3	4
This law optimization	9.124	9.102	8.361	8.326
Direct optimization	9.235	8.142	9.471	9.142
Relax the algorithm	9.000	9.205	9.304	9.158
Weight	1675.2	1694.2	1702.5	1724.3
Reliability analysis	4.251	4.362	4.215	4.325

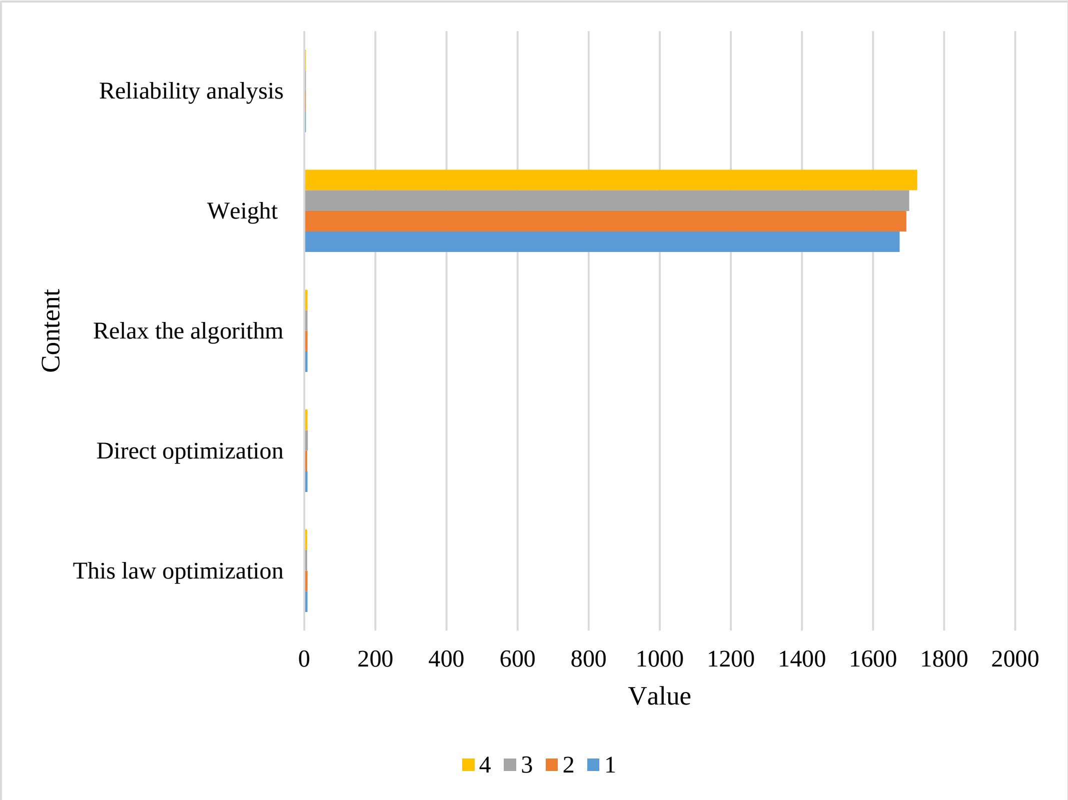

Figure 2. Reliability analysis data in figure

The optimization results show that the structural reliability analysis method integrated with ANSYS software is very close to or even better than the results given by the optimization algorithm. It can be verified that the reliability optimization method based on this method is feasible and reliable. However, the frequent call of ANSYS procedure causes a lot of waste of computing time, which is also a major factor affecting the computing efficiency.

4.2. Optimization Results

The optimization results of design variables and objective function values are shown in Table 2 and Figure 3:

Table 2. Number of iterations and data tables

Iterations	1	2	3	4	Original design
1	28.5	28.0	26.1	25.3	27
3	27.8	26.2	16.1	14.2	26
5	24.9	25.4	19.5	12.4	20
7	16.1	18.2	20.1	19.3	16
9	24.3	23.9	19.7	20.0	23

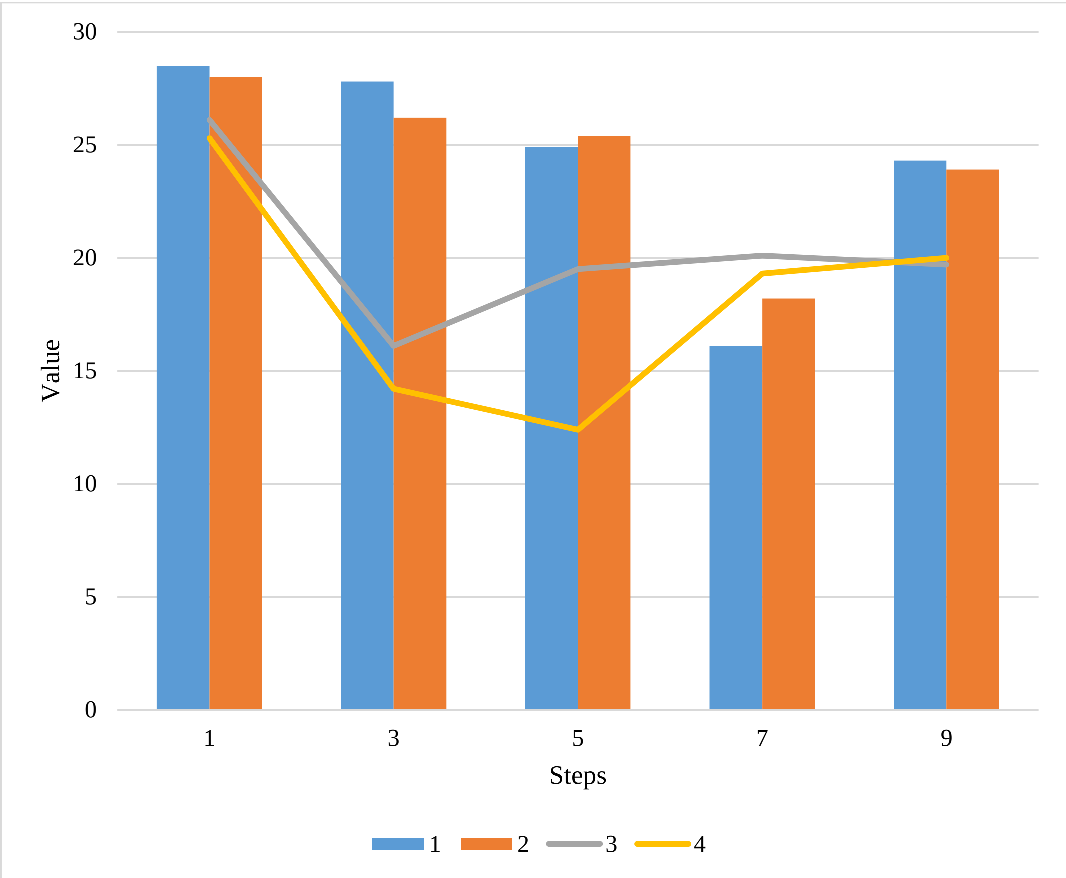

Figure 3. Iteration process and optimization results diagram

In the initial design of the platform, the structure was in an unreliable state. In the early stage of the optimization process, the structure strengthens the design variables to meet the constraints, the wall thickness of the components increases, and the weight of the structure increases significantly.

Reliability indicators have also improved at the same time. At the end of the optimization process, the distribution of components gradually tends to be reasonable, and the weight of the platform is redistributed, which reduces the weight of the structure.

5. Conclusion

As an important tool in the structural optimization design process, topology optimization technology makes up for the defects of the designer's experience design, and integrates the conceptual theoretical design into the structural optimization design, so that it has a higher degree of design freedom and obtains better structural performance. In order to avoid structural failures, such as dynamic response failures and reliability failures of structures, based on the divide-and-conquer algorithm, this paper takes the platform structure in marine engineering as the research object, and deeply and systematically studies the platform structure and topology optimization and design in marine engineering.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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