Calculation of Coating Area of AM Hull Structure Based on Distributed Method

Xue Cao

Bohai Shipbuilding Vocational College, Liaoning, Huludao, 125000, China

Keywords: Distributed; AM hull structure; Painting area calculation

Abstract: This paper aims to solve the problem of efficiency and accuracy in the calculation of coating area of hull structure, and puts forward a calculation method of coating area of AM hull structure based on distributed computing. By constructing three-dimensional model, task decomposition and distribution model and painting area calculation model, this method realizes efficient and accurate calculation of painting area of hull structure. The experimental results show that the calculation accuracy of AM hull structure painting area based on distributed calculation is obviously improved compared with the traditional method, and it can reflect the actual painting requirements of hull structure more accurately. At the same time, in terms of calculation efficiency, this method significantly shortens the calculation time and improves the work efficiency by parallel processing. In addition, this method also shows good scalability and can adapt to different scale computing tasks. The calculation method of coating area of AM hull structure based on distributed computing proposed in this paper provides a new and effective way to solve the problem of coating area calculation of hull structure. This method has obvious advantages in improving calculation accuracy and efficiency, and it is of great significance to promote the automation and intelligence of ship manufacturing and maintenance process.

1. Introduction

In the process of shipbuilding and maintenance, the painting of hull structure is a crucial link [1]. Painting can not only protect the hull from corrosion and wear, but also improve the aesthetics of the ship [2]. However, the accurate calculation of painting area has always been a difficult point in hull structure painting [3]. The traditional calculation method of painting area is often based on manual measurement and estimation, which is not only inefficient, but also difficult to guarantee the accuracy [4]. With the development of shipbuilding industry, higher requirements are put forward for the accuracy and efficiency of painting area calculation [5]

In recent years, distributed computing technology has been widely used and developed. Distributed computing can decompose large and complex computing tasks into multiple small tasks and distribute them to multiple computing nodes for simultaneous processing, thus significantly improving computing efficiency [6]. The application of distributed computing technology to the calculation of hull structure painting area is expected to solve the problems of low efficiency and insufficient accuracy of traditional methods [7]. Therefore, the purpose of this paper is to study the calculation method of coating area of AM hull structure based on distribution, so as to improve the accuracy and efficiency of coating area calculation and provide strong support for ship manufacturing and maintenance.

2. Overview of calculation of coating area of hull structure

2.1. Hull structure characteristics

Hull structure is an important part of a ship, which has complex three-dimensional shapes and various structural forms. Hull structure is usually composed of many parts, including bottom, side and deck [8]. These parts have different shapes and sizes, and they are interconnected to form an integral structure. In addition, there are many detailed features such as holes and grooves in the hull structure, which makes the calculation of painting area more complicated.

In the process of painting, it is necessary to consider all parts of the hull structure and their

  DOI: 10.25236/icmmct.2024.025

connection relations [9]. At the same time, it is necessary to pay attention to the uniformity and continuity of painting to ensure the protective effect of the coating. Therefore, it is necessary to fully consider the complexity and particularity of the hull structure when calculating the painting area.

2.2. Traditional calculation method of painting area

The traditional calculation method of painting area is usually based on manual measurement and estimation. Surveyors use measuring tools (such as tape measure, range finder, etc.) to measure each part of the hull structure one by one and record the measurement results [10]. Then, the area required for painting is estimated according to the measurement results. Although this method is simple, it has obvious limitations. First of all, manual measurement is easily influenced by human factors, such as the experience and skill level of surveyors. Different surveyors may get different measurement results, which makes it difficult to guarantee the accuracy of painting area. Secondly, manual measurement is inefficient and cannot meet the needs of large-scale shipbuilding. In addition, it is often difficult to accurately obtain the surface area data of hull structural components with complex shapes by manual measurement.

3. Distributed computing technology

Distributed computing is a computing method, which decomposes large and complex computing tasks into several small tasks and distributes them to multiple computing nodes in the network for parallel processing. Each computing node has certain computing power and storage resources, and can independently complete the tasks assigned to it, and return the calculation results to the central node for summary and integration. Through distributed computing, the computing tasks that originally needed a single high-performance computer can be distributed to multiple ordinary computers for parallel processing, thus significantly improving the computing efficiency and scalability.

In distributed computing, task decomposition and assignment are key links. Task decomposition refers to dividing a large computing task into several independent small tasks that can be processed in parallel. Task assignment refers to assigning these small tasks to computing nodes in the network for processing. In order to achieve effective task decomposition and allocation, it is necessary to design reasonable algorithms and strategies to make full use of computing resources in the network and improve computing efficiency. The obvious advantages of distributed computing are shown in Table 1:

Table 1 Advantages of distributed computing

Superiority	Describe
High efficiency	By decomposing the computing task into multiple small tasks and distributing them to multiple computing nodes for parallel processing, parallel computing is realized, which significantly shortens the computing time and improves the computing efficiency.
Expandability	It has good scalability. When it is necessary to deal with larger-scale computing tasks, the computing power can be expanded by adding computing nodes to meet the actual needs flexibly and economically.
Reliability	By introducing data backup and fault-tolerant mechanism, even if a computing node fails or loses data, it can be restored through the backup data of other nodes to ensure the continuity and stability of the computing process.
Resource sharing	Realize the sharing of computing resources in the network, and multiple computing nodes can share each other's computing power and storage resources to avoid resource waste and repeated investment.

4. Calculation method of coating area of AM hull structure based on distributed computing

4.1. Method principle

The basic principle of AM hull structure painting area calculation method based on distributed

computing is to decompose the painting area calculation task of hull structure into multiple small tasks and distribute them to multiple computing nodes in the network for parallel processing. Each calculation node is responsible for calculating the painting area of a part of the hull structure and returning the calculation results to the central node for summary and integration. By this method, the efficiency and accuracy of painting area calculation can be significantly improved.

Specifically, this method first needs to model the hull structure in three dimensions, and divide the hull structure into several small calculation units. Then, these computing units are distributed to computing nodes in the network for processing by using distributed computing technology. Each computing node calculates the painting area of the computing unit by using the corresponding algorithm according to the received data of the computing unit, and returns the calculation result to the central node. Finally, the center node summarizes and integrates the calculation results of all the calculation nodes to get the painting area of the whole hull structure.

4.2. Computational model construction

In order to realize the calculation method of coating area of AM hull structure based on distributed computing, it is necessary to construct the corresponding calculation model. The calculation model includes three parts: three-dimensional model of hull structure, task decomposition and distribution model and painting area calculation model.

(1) Three-dimensional model of hull structure: The shape and size information of hull structure can be accurately described by three-dimensional modeling of hull structure. The three-dimensional model can be modeled by CAD software, or by using laser scanning and other technologies to obtain the actual data of the hull structure. After the modeling is completed, the 3D model needs to be divided into several small computing units for distributed computing.

(2) Task decomposition and allocation model: Task decomposition and allocation model is the key link to realize distributed computing. The model needs to decompose the painting area calculation task into several independent and parallel tasks according to the characteristics and calculation requirements of the hull structure, and design reasonable algorithms and strategies to assign these small tasks to the calculation nodes in the network for processing. The task decomposition and allocation algorithm needs to consider the load balance of computing nodes, communication overhead and other factors to achieve efficient task processing.

(3) Painting area calculation model: The painting area calculation model is an algorithm and formula used to calculate the painting area of each calculation unit. The model needs to choose a suitable calculation method to calculate the painting area according to the characteristics of hull structure and painting requirements. This paper adopts the calculation method based on geometric shape. In the calculation process, the influence of coating thickness, uniformity and other indicators on the coating effect is considered. Wherein the formula for calculating the painting area of the unit is:

$$A - B \times h \times (1 + k) \tag{1}$$

Where A is the coating area, B is the bottom area of the calculation unit, h is the coating thickness, and k is the coating uniformity coefficient. The calculation formula of hull surface coating area is:

$$A_{total} = \sum_{i=1}^{n} A_i \tag{2}$$

Among them, A_{total} is the total painting area of the hull surface, A_i is the painting area of the i th calculation unit, and n is the total number of calculation units.

The specific implementation steps of the AM hull structure painting area calculation method based on distributed computing proposed in this paper are as follows:

(1) Carrying out three-dimensional modeling on the hull structure and dividing it into a plurality of small calculation units;

(2) Building a task decomposition and distribution model, decomposing the painting area calculation task into a plurality of small tasks, and distributing them to the calculation nodes in the network for processing;

(3) Implementing a painting area calculation model on each calculation node, and calculating the painting area of the calculation unit according to the received data of the calculation unit;

(4) Summarizing and integrating the calculation results of all calculation nodes to obtain the painting area of the whole hull structure;

(5) Verify and analyze the calculation results to ensure the accuracy and reliability of the calculation results.

5. Experiment and analysis

In order to verify the effectiveness and superiority of AM hull structure painting area calculation method based on distributed computing, it is necessary to design the corresponding experimental scheme. The experimental scheme should include experimental objects, experimental environment, experimental methods and evaluation indicators. The experimental object chooses a representative hull structure model to carry out the experiment; A distributed computing platform with multiple computing nodes is built in the experimental environment. The experimental method adopts the method of comparative experiment, and compares and analyzes the traditional calculation method of painting area with the method based on distributed calculation; The evaluation indexes include calculation accuracy, calculation efficiency and expansibility. Through experiments, the experimental results of the calculation method of coating area of AM hull structure based on distributed computing can be obtained.

In terms of calculation accuracy, this paper analyzes the accuracy of the distributed calculation method by comparing with the traditional calculation method of painting area; In the aspect of computing efficiency, this paper evaluates the computing efficiency based on distributed computing method by counting the computing time; In the aspect of scalability, this paper tests the scalability based on distributed computing method by adding computing nodes. Among them, the calculation accuracy is shown in Figure 1.

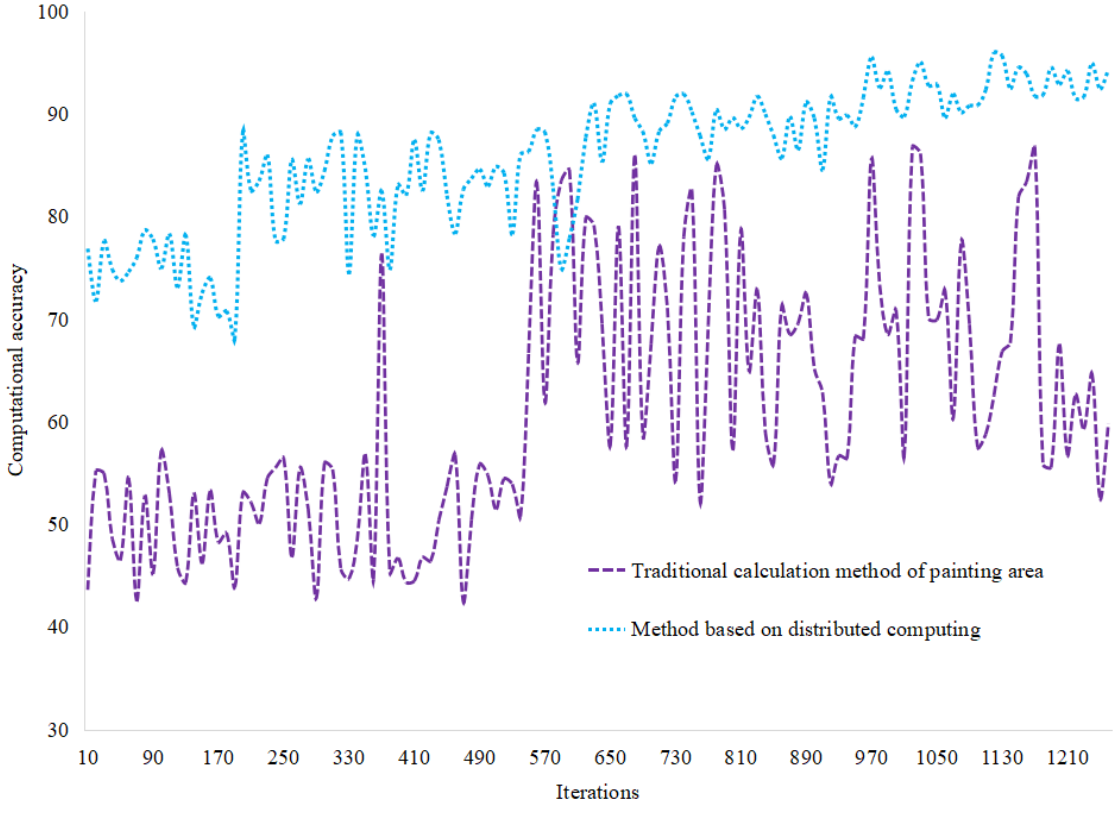

Figure 1 Computational accuracy

The calculation efficiency is shown in Figure 2.

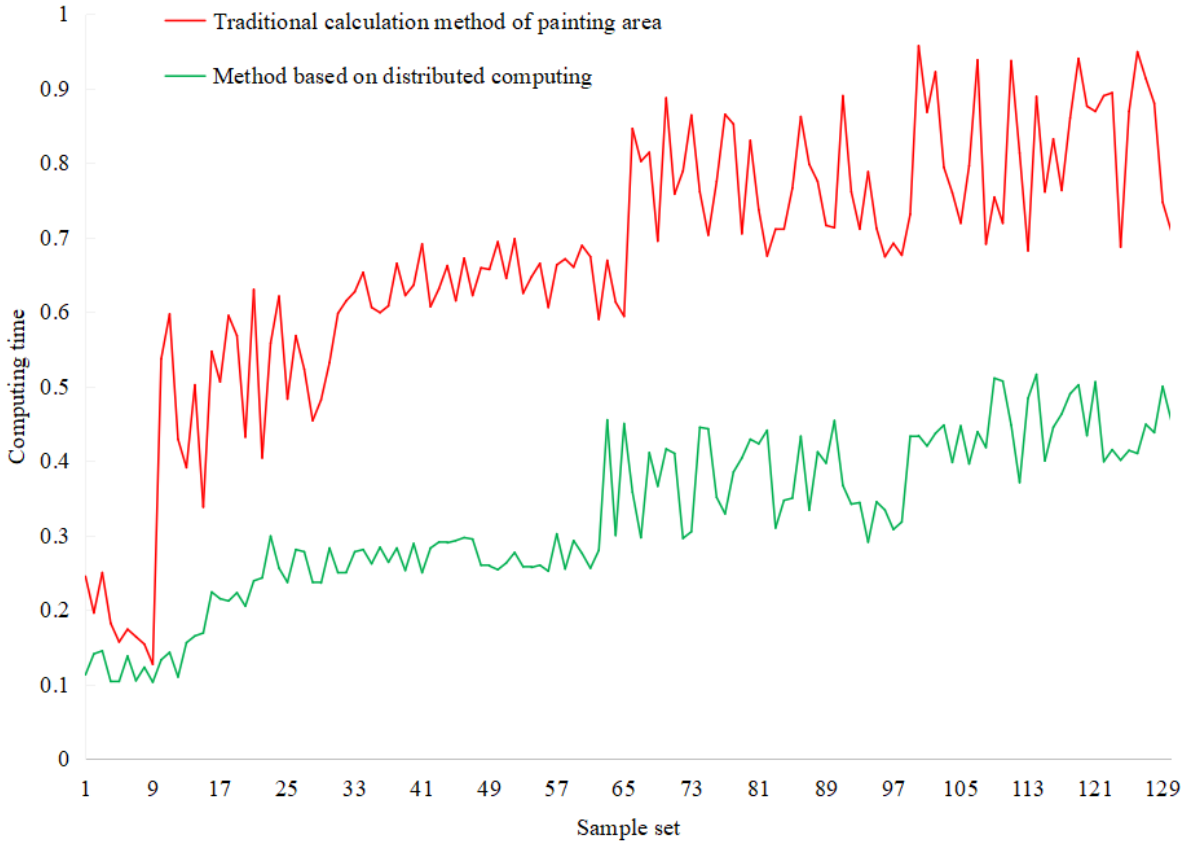

Figure 2 Computational efficiency

The scalability is shown in Table 2.

Table 2 Scalability situation

Calculate the number of nodes	Task Completion Time (seconds)	Extensibility evaluation
1	120	Basic performance
2	65	The performance is improved by about 46%
4	35	Significant performance improvement of about 71%
8	20	Significant performance improvement of about 83%
16	12	Excellent scalability, performance improvement of about 90%

Through the analysis and discussion of the results, the effectiveness and superiority of the calculation method of coating area of AM hull structure based on distributed calculation can be obtained, and it can provide useful reference for further research and application.

6. Conclusions

Aiming at the problem of calculating the coating area of ship structure, this paper puts forward a method for calculating the coating area of AM ship structure based on distributed computing. Through in-depth analysis of the characteristics of hull structure and painting requirements, combined with the advantages of distributed computing technology, the corresponding calculation model is constructed and the specific calculation steps are realized. The experimental results show that this method has good performance in terms of calculation accuracy, calculation efficiency and scalability.

Compared with the traditional calculation method of painting area, the method based on distributed calculation can significantly improve the calculation accuracy and efficiency. By decomposing the computing task into multiple small tasks and distributing them to multiple computing nodes for parallel processing, the computing resources are fully utilized and the

computing time is shortened. At the same time, this method has good scalability and can adapt to different scale computing tasks. Therefore, the calculation method of coating area of AM hull structure based on distributed computing has a wide application prospect in the process of shipbuilding and maintenance. However, due to the limitation of experimental conditions and time, this study only carried out experimental verification on a limited hull structure model, which failed to cover all types of hull structures. Therefore, it may be necessary to adjust and optimize the calculation model according to the specific situation in practical application.

References

[1] Jia Qikang, Zhang Weidong, Wang Jinchuan, et al. Research on synchronous control strategy based on distributed hydraulic lifting system [J]. Engineering Machinery, 2023 (12): 67-72,9

[2] Lu Ping. Research on Ship Structure Design Based on Digital Twin Technology [J]. Ship Science and Technology, 2023, 45 (14): 41-44

[3] Wang Xiaoqiang, Liu Yuning, Zhang Xiaodong, et al. Application of Hull Shafting Coupling Model in Direct Calculation of Hull Structures [J]. Journal of Wuhan University of Technology: Transportation Science and Engineering Edition, 2023, 47 (3): 484-487

[4] Zhu Wenmin, Shan Xiaofen. Finite element modeling method for ship structures oriented towards CAD/CAE integration [J]. New Industrialization, 2024 (1): 87-92

[5] Chen Fukang, Yang Jun, Yuan Yuchao, et al. Analysis of Structural Strength Characteristics of Hull Beams under Ship Ice Riding Accidents [J]. China Shipbuilding Research, 2023, 19 (2): 1

[6] Ding Jianliang, Kang Yuhan, Zhang Liang, et al. Optimization Design of Ultimate Strength of Ship Hull Structures [J]. Journal of Wuhan University of Technology: Transportation Science and Engineering Edition, 2023, 47 (4): 639-643

[7] Zhu Anqing, Sheng Zhengshan, Yao Biao. BOM based task package decomposition for ship structure construction [J]. Journal of Jiangsu University of Science and Technology: Natural Science Edition, 2023, 37 (3): 1-6

[8] Yao Jing, Zheng Jianli, Yang Hao. Research on the Structural Strength of Polyethylene Fishing Boat Hull Based on Direct Calculation Method [J]. Fisheries Modernization, 2023, 50 (1): 89-96

[9] Liu Yuchao, Ren Huilong, Feng Guoqing, et al. Simplified method for direct calculation of fatigue assessment of ship structures [J]. Journal of Huazhong University of Science and Technology: Natural Science Edition, 2021, 49 (12): 6

[10] Hu Wen. Research on Direct Calculation Method for Local Structural Strength of Ship Hull Based on ANSYS [J]. China Water Transport, 2023 (4): 80-81