

Retraction

Retracted: A New Method for Optimizing the Cabin Layout of Manned Submersibles

Complexity

Received 23 January 2024; Accepted 23 January 2024; Published 24 January 2024

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] W. Wang, S. Zhang, C. Ye, D. Chen, and H. Fan, "A New Method for Optimizing the Cabin Layout of Manned Submersibles," *Complexity*, vol. 2020, Article ID 6626602, 11 pages, 2020.

Research Article

A New Method for Optimizing the Cabin Layout of Manned Submersibles

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Received 20 October 2020; Revised 17 November 2020; Accepted 19 November 2020; Published 4 December 2020

Academic Editor: Zhihan Lv

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In order to reduce the misoperation of submersible pilots in the complex environment of deep sea and improve human reliability, it is a very important method to optimize the cabin space of manned submersible. In this paper, manned submersible Jiaolong is taken as an example to describe the breakthrough of traditional modes for optimizing the cabin layout of manned submersible with an aesthetic perspective of deconstruction and reconstruction thinking; the layout is optimized based on deconstruction and reconstruction from the cultural perspective of interdisciplinary. The experimental results show that the layout of manned submersible cabin is optimized by combining the theory of deconstruction and reconstruction aesthetics and human factors engineering, and the feasibility and effectiveness of this method are verified by multiobjective genetic algorithm. Deconstruction and reconfiguration layout optimization improves the human reliability of divers. It is a new method for the optimization of manned submersible cabin layout and also provides a reference for studies on the layout of similar small space.

1. Introduction

Since the 21st century, human beings have entered a new era of ocean exploration. Currently, the “blue territory” with deep-sea resources and military strategic significance is being developed, utilized, and protected by numerous coastal countries. The first choice for ocean exploration is manned submersible, which is called “an important cornerstone of oceanographic research.” Manned submersible refers to a type of diving device with the capacities of underwater observation and operation, which can be mainly used to carry out the tasks such as deep-sea investigation, exploration, development, and salvage, and is usually taken as a base for underwater activities by submersible pilots. Deep-sea manned submersible, as the forefront and commanding height of ocean exploitation, will reflect the comprehensive strength of a country [1]. However, in the complex deep-sea environment over thousands of meters

deep, several submersible pilots shall perform the high-intensity and high-precision scientific investigation for more than ten hours in a manned submersible cabin with an inner diameter of about only 2 meters, which is almost an impossible mission. Therefore, the matter of how to optimize the space layout of a manned submersible cabin and improve the human reliability of submersible pilots has always been a hot topic in maritime powers [2].

The manned submersible cabin layout has been performing better and better through continuous upgrading and transformation by means of function orientation, ergonomics, space segmentation, and algorithm based on the preliminary design [3]. Foreign and domestic manned submersibles, such as Ross/Consul and Peace I/II of Russia, Alvin and Nadir/Deep Rover of the United States, Deep Sea 6500 of Japan, Nautilie of France and Jiaolong, Deep Sea Warrior, and Fendouzhe of China, as shown in Table 1, have been transformed as planned in recent years; they have

TABLE 1: Main technical parameters of domestic and foreign manned submersibles.

Item	Country	Depth (m)	Length (m)	Height (m)	Width (m)	Total weight (t)	Manned cabin material	Cabin inner diameter (m)
Peace I/II	Russia	6000	7.8	3.0	3.6	18.6	Nickel steel	2.1
Ross/Consul	Russia	6000	8.0	3.7	3.7	24	Ti alloy	2.1
Nautile	France	6000	8.0	3.8	2.7	19.5	Ti alloy	2.1
Deep Sea 6500	Japan	6500	9.5	3.2	2.7	25.8	Ti alloy	2.1
Alvin	The United States	4500	7.1	3.7	2.6	17	Ti alloy	1.98
Jiaolong	China	7000	8.2	3.4	3.0	23.5	Ti alloy	2.1

accepted continuous and planned upgrades in aspects of cabin layout, and all have achieved great success [4].

The optimized layout of manned submersibles, aerospace, and aircraft enclosed cabins usually takes the operator as the center to build simulators to optimize the layout. For example, Boeing's BOEMAN, NASA's A3I program, and NATO's AGARD Aircraft Cockpit program all use simulators to study how to optimize space layout and reduce the misoperation caused by human factors. The space layout of manned submersible cabin adopts the traditional cut-and-trial manner; later, they turned to adopt 3D modeling with computer software for layout cut and trial, which was not materially different from a model and could not reach a satisfactory result either. The layout based on ergonomics, such as muscle fatigue of submersible pilots, would also cause a series of problems; therefore, it is a trend to optimizing cabin layout with multiple technologies oriented by manned submersible functions and ergonomics. With the increase of diving depth of manned submersibles, the cabin space will be smaller and smaller, the interference between equipment and equipment becomes greater and greater, the working hours of submersible pilots become longer and longer, and the multidisciplinary optimization design system will be highlighted during the research of cabin layout. In this system, visual simulation, virtual reality technology, and mathematical algorithm model will be introduced [5].

The optimization of manned submersible cabin layout has been continuously explored to seek new design methods and means to optimize the layout, thus improving human reliability. In this paper, the manned submersible cabin layout is optimized based on deconstruction and reconstruction thinking from the cross-disciplinary cultural perspective and then verified in combination with multi-objective genetic algorithm. It will provide a new method for the research on cabin layout of manned submersibles and also provide a reference for the research on the layout of small cabins of aircraft, ships, and space ships [6].

2. Application of Deconstruction and Reconstruction Thinking in Optimization of Cabin Layout of Manned Submersible Jiaolong

2.1. Deconstruction and Reconstruction Thinking. Deconstruction (structural decomposition) is a term proposed by Derrida, a French poststructuralist philosopher,

which was derived from "deconstruction" in Sein Und Zeit. Reconstruction refers to the rationalization of design pattern and architecture through adjusting and improving quality and performance, thus improving the scalability and maintainability. In short, deconstruction is the decomposition of the original structure into basic units, while reconstruction is the restoration of such basic units to parts for recombination, thus obtaining a brand new and different structure.

Deconstruction and reconstruction thinking is a way of thinking for getting new objects by recombination in a new way based on representative elements taken from the basic units decomposed from a specific object, such as overall appearance, local morphology, or microfeatures. Basic deconstruction methods include planarization, geometrization, symbolization, and abstraction. Reconstruction has the following types and methods: reconstruction of the concrete form: reality and superreality; and reconstruction of the abstract form: geometric abstraction (cool abstraction) and free abstraction (hot abstraction).

2.2. Symbolic Deconstruction of Static Space in the Cabin of Manned Submersible Jiaolong. The cabin of the manned submersible Jiaolong is approximately an oval sphere with an inner diameter of 2.1 m, which can accommodate three people, including an operator and two scientists, as well as the corresponding seats, monitors, manipulators, batteries, and the related electronics. First, qualify the ergonomic parameters of people and facilities, and evolve the objects in the spherical cabin into simple symbols based on the tasks to be performed, as shown in Table 2; later, take these symbols as the constituent elements of space layout, which is the symbolic expression of deconstruction and reconstruction thinking, as shown in Figure 1; three submersible pilots (⊙round) are arranged in the middle of the cabin, with the grey dotted circle and rectangular boxes as their range of activity; workbenches (∟lines), monitors, and maneuvering devices (□square) are arranged around, for taking full advantage of the spherical cabin wall.

As shown in Figure 1, the objects in the cabin are symbolically deconstructed, and the displays and monitors are combined with the spherical wall. As shown in Figure 2(a), the operating table and monitoring equipment shall be reconstructed in combination with Figure 2(b) by making full use of spatial features of the spherical wall

TABLE 2: Objects in the spherical cabin and occupied area.

Name	Parameters	Quantity	Occupied area A (m ²)	Area	Symbolization
Submersible pilots	50% sample population	3	0.25 (50% sample)	Activity area	⊙round
Seats	600 × 400 × 350 (mm)	3	0.252	Working area	□square
Monitors and other devices	/	Several	/	Cabin wall	□square
Console	/	1	/	Wall edge	□square
Batteries	500 × 400 × 1200 (mm)	1 set	0.24	Cabin bottom	□square
Storage and food containers	20 L for normal use; 50 L for emergency use	1 each	0.02; 0.05	Cabin bottom	□square
Life support area	500 × 400 × 1200 (mm)	1	0.24	Cabin top	□square

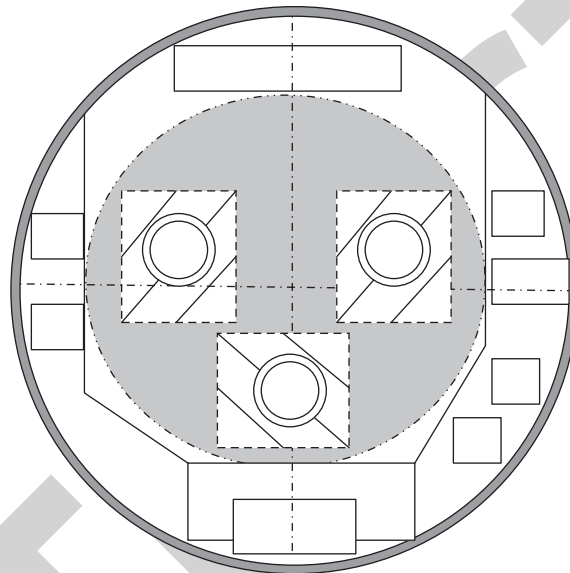


FIGURE 1: Symbolic expression in the spherical cabin.

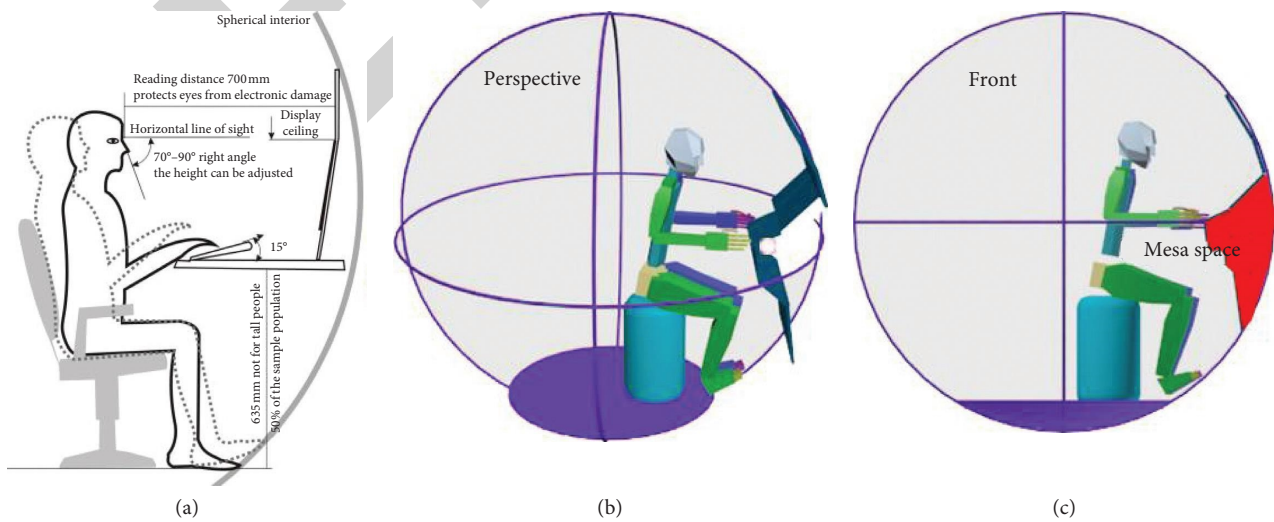


FIGURE 2: Reconstruction and optimization of the working table and display system of manned submersible cabin.

according to the ergonomic requirements for submersible pilots under the conditions of meeting the strong constraint requirements of visibility, accessibility, and comfort and then form the red space as shown in Figure 2(c), to place electronic devices and personal belongings of submersible pilots.

2.3. Geometric Deconstruction of Active Regions in the Cabin of Manned Submersible Jiaolong. The manned submersible cabin consists of the master control area, display area, life support area, working area, and area of other facilities. Its spatial relation can be decomposed into several geometric planes, which may be taken as basic modeling elements for performing geometric deconstruction combining with the tasks of manned submersible, the underwater environment, and working area in the cabin [7].

The layout of objects in the cabin can be divided into three parts, and most destructive collisions would be concentrated in the front and lower parts of manned submersible, so it is suggested placing energy and electronic devices in the lower part of manned submersible and back area of the cabin with great structural strength. In addition, according to the tumbler principle, the batteries shall be placed at the bottom for easy maintenance and maintain the balance of manned submersible. Due to few collisions on the top of the cabin, the upper part is relatively safe, so it can be taken as the last line of defense for the safety of submersible pilots and the place for storing life support materials, as shown in Figure 3(a). The active region mainly refers to the working area of the three submersible pilots in the middle of the spherical cabin, as shown in Figure 3(b). Through geometric deconstruction and reconstruction for submersible pilots and objects in the cabin, the display and monitoring devices shall be fixed on the spherical inner wall, so as to ensure the visibility and the operability within the control range of upper limbs, thus ensuring the accessibility of control [8].

The seats are usually reconstructed in a similar manner, which may be set as the integrated or folded geometry with geometric construction surface as the basic modeling element. The integrated seat can increase the storage space, while the folded one can increase the activity space after being folded and allow 3 people to seat after being unfolded. In this case, the integrated seat is adopted. Through graphic reconstruction of the storage space shown in Figure 3 in combination with the seats for 3 submersible pilots, the lower storage space is increased as much as possible while meeting the seating requirements of submersible pilots, as shown in Figure 4. While designing the integrated seat, the man-machine ergonomic parameters such as visibility and comfort of submersible pilots, the accessibility, and comfort of manned submersible equipment shall be constrained in strict accordance with the ergonomic requirements, so as to construct the model of the integrated seat and working table for submersible pilots as shown in Figure 4.

2.4. Reconstruction and Optimization of Overlapping Area in the Cabin of Manned Submersible Jiaolong. The operation of manned submersible can be simplified into five stages:

diving, sitting on the sea bed, cruising, operating, and ascending, which involve the tasks of photo taking, camera shooting, surveying, and sampling [9]. Surveying, sampling, and manned submersible manipulation would basically overlap in pairs; therefore, we should freely and abstractly reconstruct the overlapping work area and arrange movement areas for submersible pilots undertaking the overlapping tasks, thus meeting the requirements for simultaneous working by submersible pilots without interference, as shown in Figure 5. Take sampling; for example, reconstruction and optimization of overlapped areas can save the activity space for one submersible pilot and ensure that the operation and observation space are sufficient for two operators without mutual interference, and another scientist may only need to stand in front of the monitor and direct the operations while monitoring.

The working areas of the three submersible pilots are overlapped, with the activity space in the front, as shown in Figure 5. Their activities are concentrated in the front, one may perform operations, the second one may provide observation and assistance, and the third one may monitor the working status. The weight of space overlapping is the lowest at the wall and the rear half, as shown in Table 3. After deconstruction, the rear part of the cabin is used to place equipment, and through optimization and reconstruction of the integrated seat, the seat and rear space can be designed in a model conforming to ergonomics. The lower part in the rear is provided with a certain space for a submersible pilot to lie down and relax (for they will work for more than ten hours in the cabin with a diameter of only 2.1 m). The upper part of the spherical cabin is separated, the middle part is vacated, and the top is set with a passageway, thus obtaining the space layout as shown in Figure 6.

3. Establish the Optimization Model of Cabin Layout of Manned Submersible Jiaolong under the Deconstruction and Reconstruction Thinking

In this paper, we consider the basic elements of the reconstruction as modules and seek the sources of manned submersible cabin module, the function of each part of the cabin represented by the module, and the form of each module in the cabin by the deconstruction and reconstruction thinking, so as to reconstruct the space layout of the cabin module system under different thinking [10].

The abstract module system is a logical system with coherent design, so there is a close relationship between task decomposition modules, and the matching of different modules may have different meanings. The module elements applying deconstruction thinking are qualified (sample population is selected for submersible pilots), as shown in Figure 2; as for cabin layout, the space of each qualified module has an exact range, and the modules can be freely replaced under the condition that the occupied space does not exceed the maximum range of activity. The overlapping weight grade is set between modules, as shown in Table 3, to further optimize the layout of cabin space.

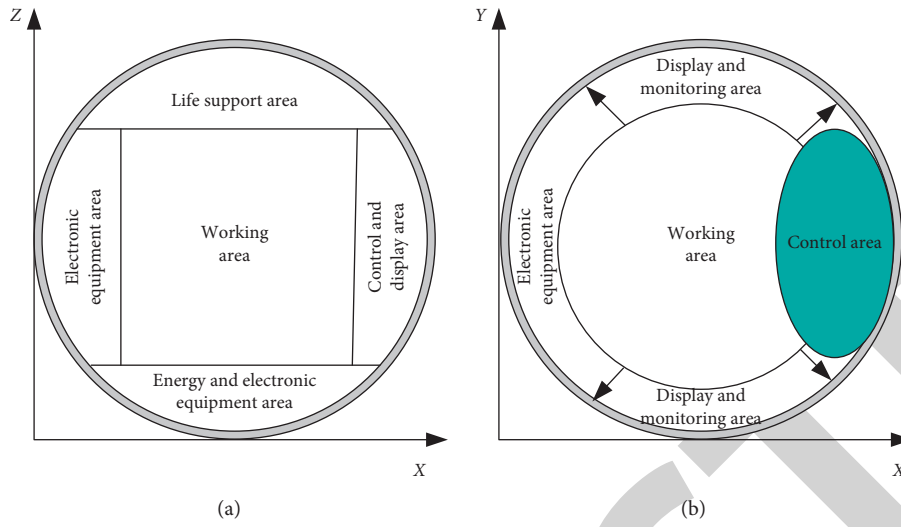


FIGURE 3: Geometric deconstruction of space in manned submersible cabin.

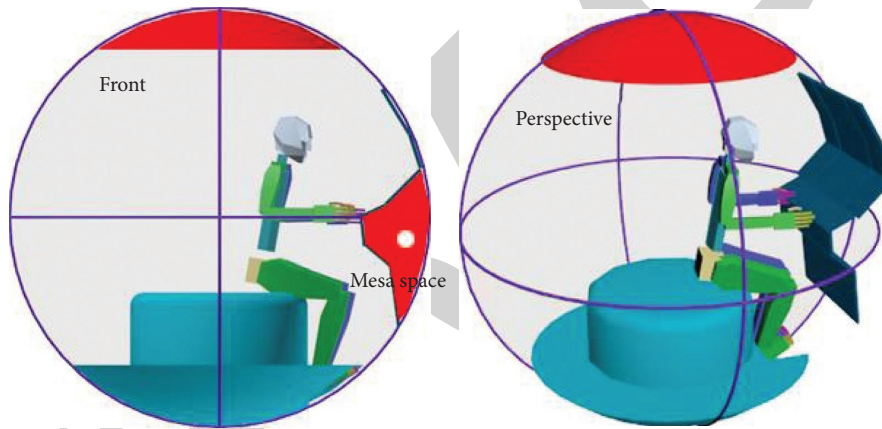


FIGURE 4: Reconstruction and optimization of the seat for three submersible pilots.

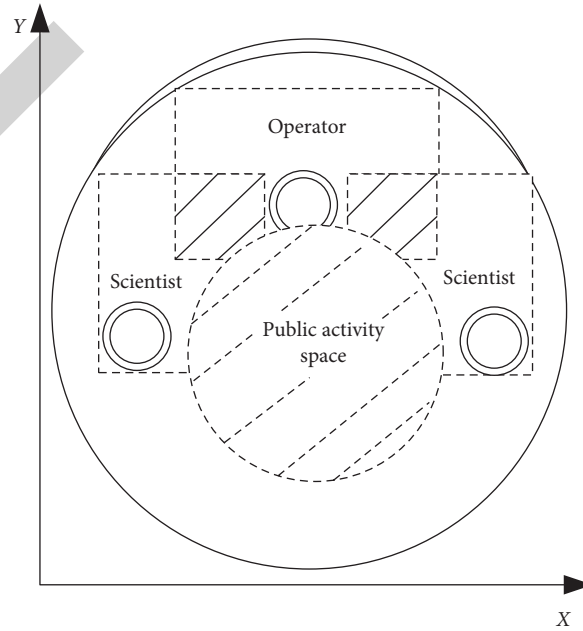


FIGURE 5: Reconstruction optimization of overlapping working areas in manned submersible cabin.

TABLE 3: Overlapping weight grade and definition of coefficients.

Grade	Weight	Meaning
1	1	Regional overlap demand is quite high or the regions must be overlapped
2	0.7	Overlap demand is relatively high
3	0.4	Overlap demand is general
4	0.1	Overlap demand is relatively low

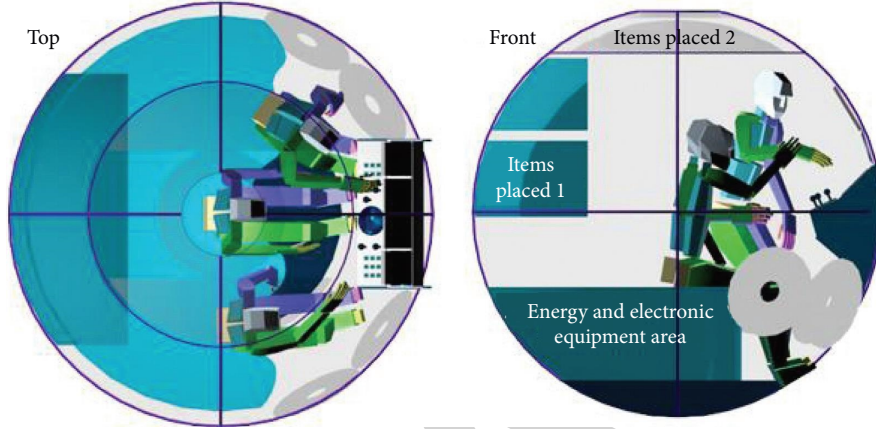


FIGURE 6: Abstract reconstruction and optimization of overlapped space for submersible pilots in the spherical cabin.

3.1. Cabin Layout Optimization Model of Manned Submersible Jiaolong. Suppose that m target objects (including 3 submersible pilots) shall be placed in the spherical cabin; the design variable of m objects is $X = (x_1, x_2, \dots, x_m)^T$, representing the spatial position of each object; F refers to the objective function, representing the design requirements of each object; r refers to the radius of the spherical cabin; v_i refers to the space occupied by objects in the spherical cabin; v_j refers to the space occupied by objects during movement; i refers to the variable of objects occupying space in the spherical cabin; j refers to the variable of objects with mutual interference of active space; and k refers to the equipment overlapping weight coefficient, as shown in Table 3:

$$\left\{ \begin{array}{l} \max F = \{f_1(X), f_2(X), \dots, f_m(X)\}, \\ \text{Vol}_F = \sum_{i=0}^m V_i + \sum_{j=0}^m kV_j, \\ \text{s.t. } 0 \leq i, j \leq m, \\ \text{Vol}_F \leq \frac{4}{3}\pi r^2. \end{array} \right. \quad (1)$$

According to the ergonomic quantitative data of the cabin model, we perform preliminary deconstruction and reconstruction of the targets in the cabin and get the model of cabin layout (Figure 7) according to the requirements of noncollision between objects in manned submersible cabin, between equipment and equipment, and between equipment and cabin wall.

3.2. Optimization of Cabin Layout under Noninterference Constraint. Noninterference refers to the zero probability of collision between equipment and equipment in the cabin and between the equipment and cabin wall, which is the first condition for the optimization of cabin layout [11]. According to calculation formula (2), the metrics can be used to measure noninterfering collisions, where f_I refers to the total interference of space layout in the cabin, $I_1(x)$ refers to the interference amount between the equipment and cabin wall, and $I_2(x)$ refers to the interference amount between equipment and equipment. In summary, the mathematical model can be expressed as follows:

$$\left\{ \begin{array}{l} \max F = \{f_1(X), f_2(X), \dots, f_m(X)\}, \\ f_I = \sum I_1(x) + \sum I_2(x), \\ \text{s.t. } |X_i| \leq R, \quad i = 1, 2, \dots, m, \\ f_I = 0. \end{array} \right. \quad (2)$$

4. Pareto Multiobjective Optimization Genetic Algorithm

Optimization refers to getting better items through certain rules or algorithms. In a given area, the optimization of multiple numerical targets is called the multiobjective optimization. In this paper, the genetic algorithm, combined with the parallel selection strategy, is mainly used to solve the multiobjective optimization in the cabin of manned submersible Jiaolong after deconstruction and reconstruction [12].

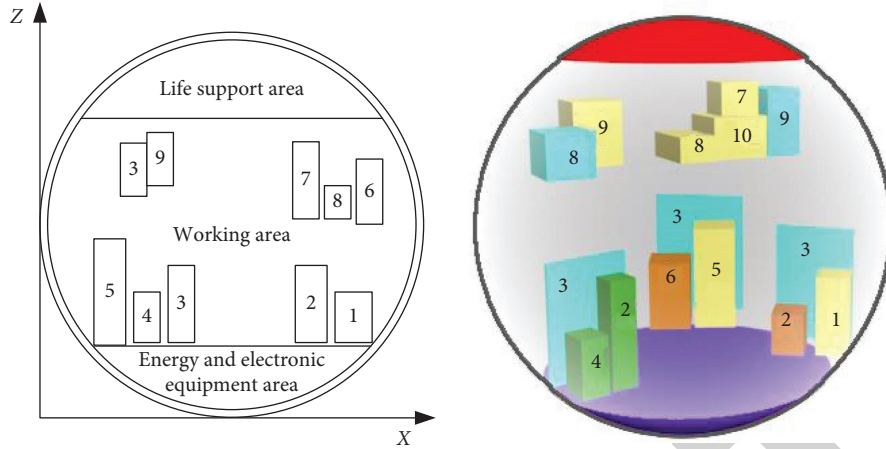


FIGURE 7: Model of space layout of equipment in the cabin.

4.1. Improved Genetic Algorithm. The manned submersible cabin group (all kinds of equipment) is divided into different subgroups based on the number of objective functions of cabin layout category after deconstruction and reconstruction, and the corresponding objective function is provided for each subgroup; later, the optimal subfunctions are independently selected under the constraint conditions of cabin layout and formed into the corresponding new subgroups, thus combining into new groups; and then the cross-mutation operation is performed; finally, the group of the next generation is generated, and the Pareto optimal solution will be obtained after cycling [13], as shown in Figure 8. The flowchart of parallel selection genetic algorithm after deconstruction and reconstruction is shown in Figure 9.

After deconstruction and reconstruction, the genetic algorithm can be improved from the following aspects: maintain the Pareto optimal items in the subgroups of the next generation, without participating in crossover calculation and mutation calculation. The area to be searched, such as the integrated seat and the rear item placement area after deconstruction and reconstruction, can be taken as the final search result, as shown in Figure 10; the search trajectory of Figure 10(a) improved genetic algorithm is more effective than that of Figure 10(b) random search, based on which, the fitness function value is established for guiding the fast and stable search.

4.2. Coding and Fitness Function. The solution variable is the coordinate of each of the types of equipment in the cabin of manned submersible Jiaolong, which can be taken as the chromosome for coding. X refers to a certain layout scheme. x_{ic} , y_{ic} , and z_{ic} refer to the center-of-mass coordinate of each equipment:

$$X = (x_{1c}, y_{1c}, z_{1c}, x_{2c}, y_{2c}, z_{2c}, \dots, x_{mc}, y_{mc}, z_{mc}). \quad (3)$$

Fitness function value is usually used to evaluate the individual performance and guide the search in genetic algorithm, and it directly determines the stability and speed of the genetic algorithm. Take the space layout in the cabin of

manned submersible Jiaolong as an example; R of the spherical cabin is 2,000 mm, so in order to find an optimal layout scheme of the cabin of manned submersible Jiaolong, the first condition is that the devices cannot collide with each other (i.e., $f_I = 0$). The fitness function is

$$F(p) = k \times \sum_{i=1}^m Q_i \times f_i(p), \quad (4)$$

where P refers to the layout scheme of manned submersible cabin; Q_i refers to the prior layout index of the cabin after deconstruction and reconstruction; $f_i(p)$ refers to the optimal individual value of the equipment in manned submersible layout scheme; k refers to the equipment overlapping weight coefficient.

4.3. Main Parameters of the Optimization Algorithm. The manned submersible group size $N=50$. According to formula (3), n is 10; crossover probability $P_c=0.8$; mutation probability $P_m=0.1$; generation gap of subgroup $GGap=0.8$ (each generation has 20% of outstanding individuals inherited into the next generation); the maximum number of evolution generation $G_{max}=500$. The initial individuals are randomly arranged and automatically optimized during the operation of the algorithm. The objective function values of the subgroups are all subject to dimensionless and normalization processing [14].

4.4. Analysis of Case Results. In this case, the results of 20 calculations are basically consistent, verifying that the optimized layout of manned submersible cabins constructed after deconstruction and reconstruction has a better stability. A set of calculation results (only part of the results) is extracted for analysis, as shown in Figure 11.

As for Figure 11(a), optimization of equipment with low overlapping weight in the cabin, the initial objects are randomly arranged, the movement trajectory of equipment in the cabin is chaotic, and there are many collisions in the activity space, which are mainly the collisions between equipment and inner wall of the spherical cabin and between

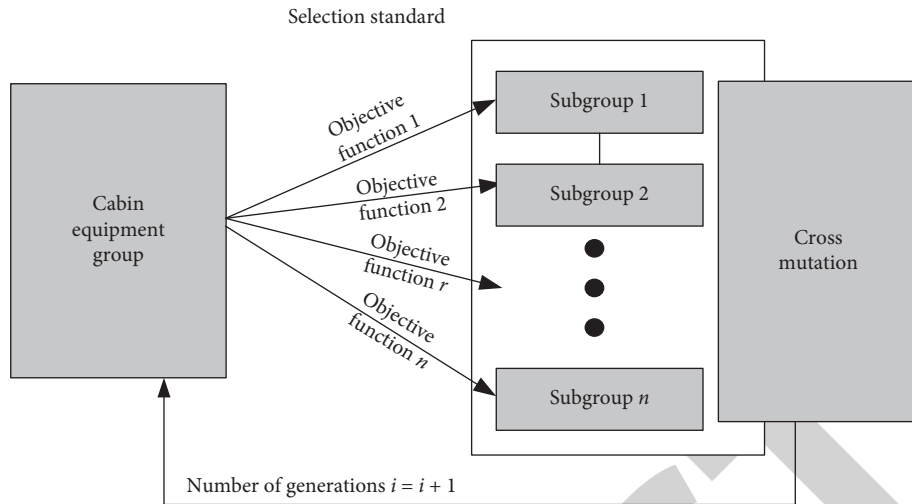


FIGURE 8: Diagram of parallel selection genetic algorithm after deconstruction and reconstruction.

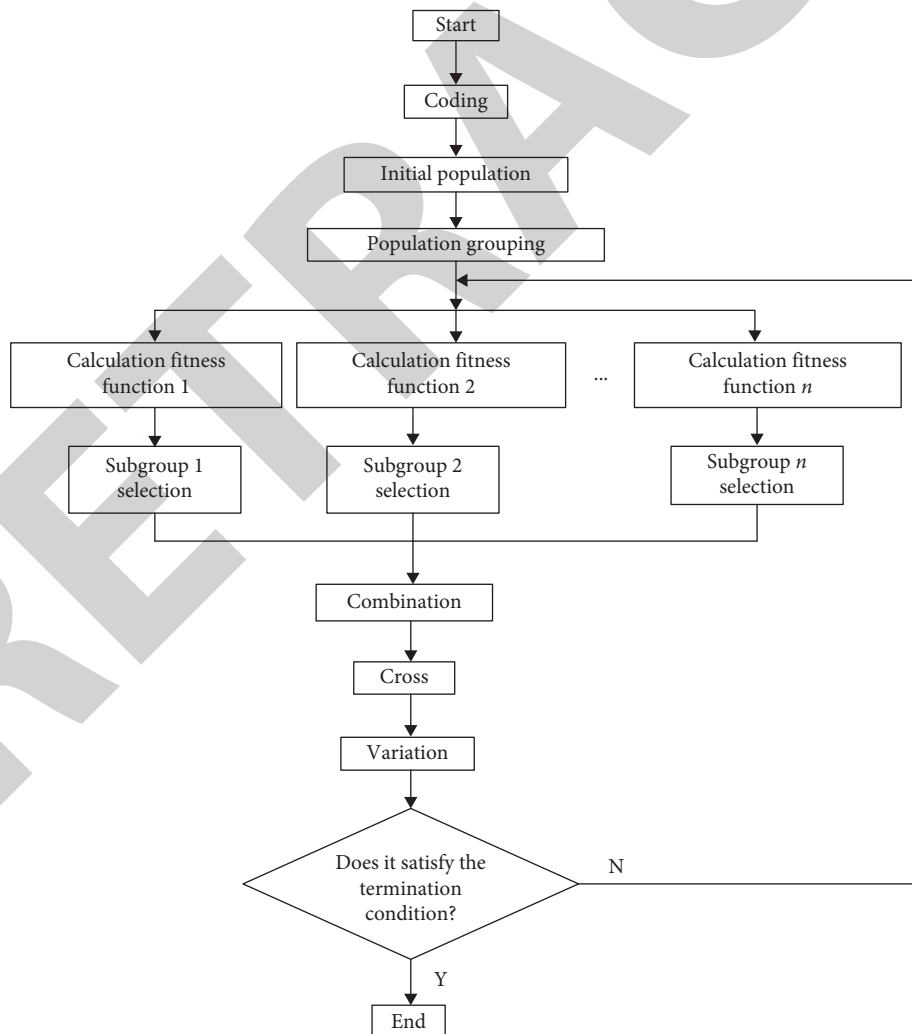


FIGURE 9: Flowchart of parallel selection genetic algorithm after deconstruction and reconstruction.

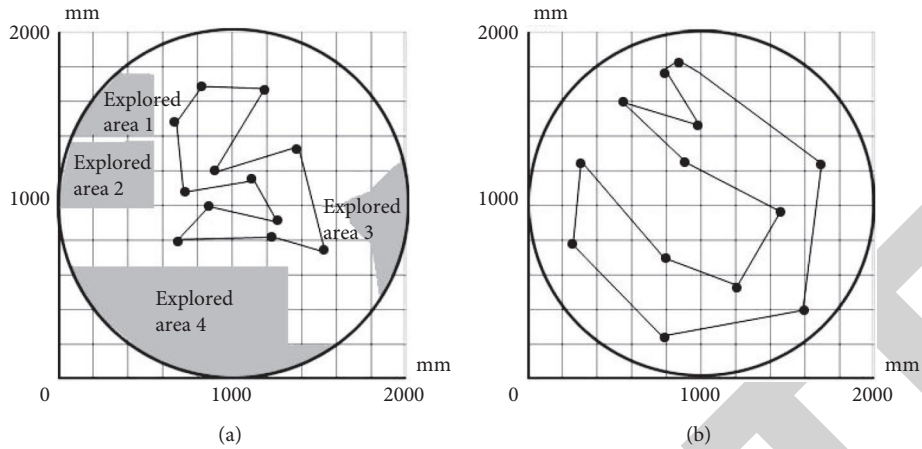


FIGURE 10: Comparison of search area after deconstruction and reconstruction with the random search area. (a) Search trajectory of improved parallel selection genetic algorithm. (b) Search trajectory of random search.

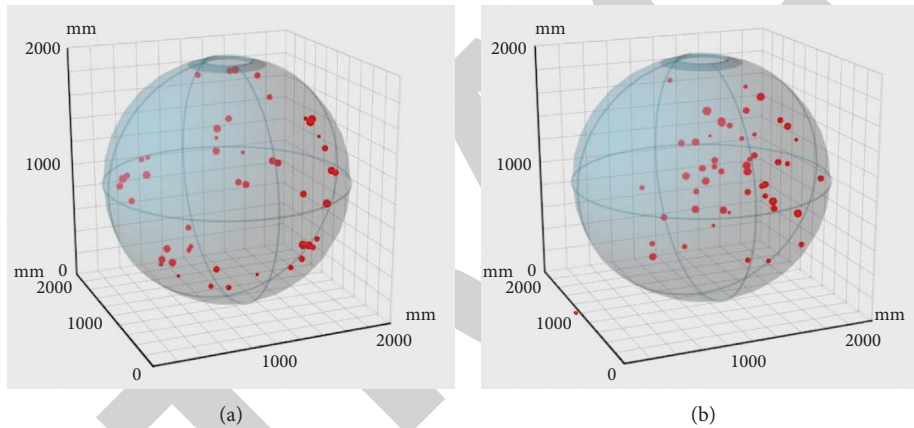


FIGURE 11: Results of multiobjective genetic algorithm for manned submersible cabin layout. (a) Optimization of equipment with low overlapping weight in the cabin. (b) Optimization of equipment with high overlapping weight in the cabin.

equipment and equipment. With the progress of the multiobjective genetic algorithm, the number of collisions (interference amount) in the cabin is gradually reduced, the equipment (small red dots) gradually moves to the center of the sphere and the inner wall, and the distance between equipment and equipment becomes larger, making the activity space of equipment with low overlapping weight scatter on the spherical wall; Figure 11(a) proves that the multiobjective genetic algorithm conforms to the rationality of optimized layout of equipment with low overlapping weight after deconstruction and reconstruction.

As for Figure 11(b), optimization of equipment with high overlapping weight in the cabin, the initial objects are randomly arranged with large activity space, so there is a large amount of interference between equipment and equipment, such as the interference between the activity space of the three submersible pilots and the equipment in the cabin, and between the tasks and the equipment. After deconstruction and reconstruction, with the progress of the multiobjective genetic algorithm, the equipment

(small red dots) gradually moves to the front of the cabin, and the amount of interference decreases after optimization of the distance between equipment and equipment, thus making the equipment with high overlapping weight move in the front of the cabin. Figure 11(b) proves that the multiobjective genetic algorithm conforms to the rationality of the optimized layout of equipment with high overlapping weight after deconstruction and reconstruction.

The results of multiobjective genetic algorithm indicate that when the total interference of equipment in the cabin (f_I) is 0, the equipment with low overlapping weight should be fixed on the wall of the cabin; those with high overlapping weight should be fixed in the front of the cabin. In the Jiaolong manned submersible cabin, energy and common tools are arranged in the rear and lower parts of the cabin, the submersible pilots are arranged in the front part of the cabin, and those with high operating and viewing frequency should be placed within the accessibility and visibility range of the 3 submersible pilots.

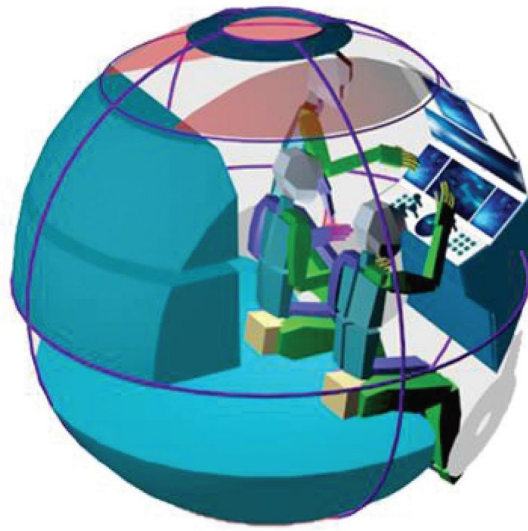


FIGURE 12: Cabin layout optimized by genetic algorithm after deconstruction and reconstruction.

Figure 12 is an effect diagram of cabin layout optimized by genetic algorithm after deconstruction and reconstruction; Pareto optimal solution of the optimized mathematical model is the one obtained with the total interference of equipment $f_I = 0$. The human-machine integrated evaluation system for manned submersibles can select a relatively reasonable layout scheme from the optimal solution. As shown in Figure 12, there is no interference in cabin layout optimized by genetic algorithm after deconstruction and reconstruction, indicating a reasonable optimization process.

5. Conclusion

The optimization of the cabin layout of manned submersible is of great importance to improve human reliability. In this paper, the manned submersible cabin layout is optimized based on deconstruction and reconstruction thinking from the cross-disciplinary cultural perspective in accordance with the design requirements of manned submersible Jiaolong, combined with ergonomic to constraint conditions on the space layout, so as to establish an optimized mathematical model for cabin layout of manned submersible Jiaolong. After deconstruction and reconstruction, this paper finally obtains a better layout scheme combined with the multiobjective genetic algorithm; the main conclusions are as follows:

- (1) Deconstruction and reconstruction of manned submersible cabin space from an interdisciplinary cultural perspective is a new method of cabin layout optimization, which reflects the advantages of cross-field and multidiscipline combination optimization.
- (2) The manned submersible cabin layout is optimized by combining the aesthetic principles of deconstruction and reconstruction with man-machine ergonomics and other conditions. The same type of

activities and equipment with the same nature are combined to save the cabin space; at the same time, weight combined with multiobjective genetic algorithm is introduced to provide a more scientific scheme for the layout of cabin equipment.

- (3) Based on the aesthetic principle of deconstruction and reconstruction and multiobjective genetic algorithm, the cabin layout optimization model of manned submersible reduces the random search area and finally makes the total interference of cabin equipment approach zero as soon as possible, which can accelerate the progress of the scheme.

However, the optimization mathematical model needs to be further refined in more in-depth subject analysis and calculation tool research. In the next step, static and dynamic dimensions of submarine pilots are added, and virtual simulation and bionic algorithm are applied to improve its engineering practicality.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This study was supported by the National Key Research and Development Program of China “General Design, Construction, and Sea trial of Full Ocean deep Manned Submersible” (2016YFC0300600); Central University Basic Scientific Research Operating Expenses Subsidy Project (31020190504007); and Research on Optimization Design

Method of Deep-Sea Manned Vehicle Cabin under the Support of Composite Simulation Mechanism.

References

- [1] C. Alppay and N. Bayazit, "An ergonomics based design research method for the arrangement of helicopter flight instrument panels," *Applied Ergonomics*, vol. 51, pp. 85–101, 2015.
- [2] C. Vogt, C. Mergl, and H. Bubb, "Interior layout design of passenger vehicles with RAMSIS," *Human Factors and Ergonomics in Manufacturing*, vol. 15, no. 2, pp. 197–212, 2005.
- [3] Y. Ren, B. Liu, Z. Ding et al., "Research on the current status and development trend of manned submersibles," *Journal of Marine Technology*, vol. 37, no. 2, pp. 114–122, 2018.
- [4] W. Liu, *Application of MDO Method to 7000 m HOV General Design*, Shanghai Jiao Tong University, Shanghai, China, 2007.
- [5] D. Han, H. Han, F. Liu, and X. B. Wang, "Research on 3D layout optimization of HOV cabin," *Ship Engineering*, vol. 35, no. 1, pp. 76–80, 2013.
- [6] D. Chen, Yu Fan, S. Zhang et al., "Manned submersible cabin layout design method under cabin function system constraints and ergonomic constraints," *Chinese Naval Research*, vol. 2, pp. 41–50, 2018.
- [7] Y. Gu, Q. He, X. Fan et al., "Motion planning and intelligent optimization of virtual human arm for narrow space assembly simulation task," *Computer Integrated Manufacturing System*, vol. 22, no. 6, pp. 1447–1455, 2016.
- [8] H. U. Yao, Z. Jiang, Z. Xiong et al., "Warship cabin layout design optimization based on an improved genetic algorithm," *Chinese Naval Research*, vol. 9, no. 1, pp. 20–30, 2014.
- [9] W. Wu, L. Ye, X. Shao, and H. Liu, "Working posture simulation method for virtual human based on multi-objective genetic algorithm," *Computer Integrated Manufacturing System*, vol. 25, no. 1, pp. 155–164, 2018.
- [10] A. Cao, *Multidisciplinary Design Optimization Method and its Application in HOV Design*, Shanghai Jiao Tong University, Shanghai, China, 2008.
- [11] Y. Wang, C. Wang, Z. Ji, and X. G. Zhao, "A study on intelligent layout design of ship cabin," *Shipbuilding in China*, vol. 54, no. 3, pp. 139–146, 2013.
- [12] W. Wang, S. Zhang, and S. Yu, "Image restoration by BP neural based on PSO," *Xibei Gongye Daxue Xuebao/Journal of Northwestern Polytechnical University*, vol. 36, no. 4, pp. 709–714, 2018, in Chinese.
- [13] Y. E. Cong, L. Zong, and D. Chen, "Research and application on virtual design in cabin layout design of deep-sea submersible," *Mechanical Design*, vol. 1, pp. 6–12, 2015.
- [14] J. Jiang, J. Zhao, and X. Zang, "Coordinated multi-robot exploration based on parallelism selection genetic algorithm," *Computer Engineering and Design*, vol. 29, no. 5, pp. 1218–1221, 2008.