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Current Situation Analysis of Ship Simulator

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Abstract

The ship's R&D and design process is very large and complex. In order to improve the research and development efficiency of the ship and reduce the number of launching experiments in the shipbuilding process, the shipbuilding industry has invested a lot of effort in developing the ship simulation control platform. By simulating various sea conditions, the ship's attitude and motion in the ocean are simulated and simulated in the laboratory, thereby reducing development costs and cycles. Based on the current research situation and research results of ship simulators, this paper analyzes and summarizes the current fields of ship simulators and analyzes the future ship simulators.

Keywords

Analog controller; simulation; six degrees of freedom.

1. Introduction

Ship simulator refers to a device that simulates ship maneuvering in the laboratory by using electronic instruments, computer controls and display devices. The device simulates the reality of the ship's navigation at sea to develop the ability of seafarers to maneuver the ship at sea in the future. On the simulator, various ship handling faults and emergency treatment methods that often occur at sea can be preset. To train seafarers to be familiar with the characteristics of ships, to grasp the effects of vehicles and rudders, and to refer to objective conditions such as wind, waves, currents and waters, as well as to enter and exit ports, to leave the docks, to throw anchors, fishing areas, ice areas, narrow waterways and collision avoidance operations, etc. Improve the driver's operational skills. The ship simulator greatly reduces the cost of maritime risks and reduces the cost of simulating risks, improving safety and more scientifically solving maritime safety and sea driving problems.

2. Six Degrees of Freedom Simulation in Ship Simulation Controller

2.1. Design of Six Degrees of Freedom Simulation System in Ship Simulation Controller

2.1.1. Six Freedom Platform Introduction

The six-volume swinging table is mainly composed of an upper platform, a lower platform (fixed), six hydraulic cylinders, an electro-hydraulic servo valve, and 12 ball joints. The hydraulic cylinders connect the upper and lower platforms in parallel by ball joints, and realize the six degrees of freedom movement of the upper platform through the coordinated movement of six hydraulic cylinders - heave, sway, sway, pitch, roll Shake and shake. The laboratory's hydraulic six-degree swinging table is used to simulate the ship's rocking attitude under various sea conditions, and to check the reliability of the A-plate machine operating under the action of waves. The hydraulic six-degree parallel parallel rocking test bench is shown in Figure 1.

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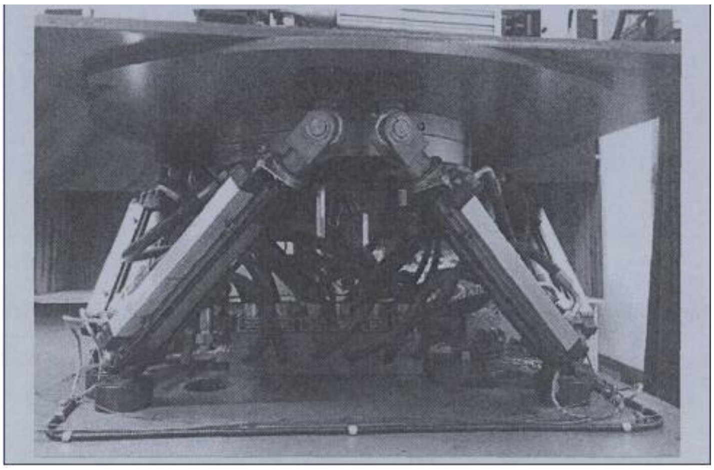

Figure 1. Hydraulic six-degree-freedom parallel swing test beach

2.1.2. The Establishment and Transformation of the Coordinate System

The coordinate analysis method is used to analyze the position of the upper platform (moving platform) of the six-degree-of-freedom swinging platform. The specific method is as follows: Firstly, the fixed coordinate system 0-XYZ is established on the lower platform (static platform), the coordinate origin 0 and the static platform The center of the circular surface of each of the upper driving rod hinge points coincides; then the moving coordinate system O ' -X' Y' Z ' is established on the upper platform (moving platform), the coordinate origin 0 ' is the circle with the hinge point of each driving rod of the upper platform The center of the face coincides. When the platform is in the initial state, the directions of the X, Y, and Z axes of the above two coordinate systems are the same, and the Z axis is coincident, as shown in Figure 2.From the projection of the Z-axis in Figure 2, we can get the distribution of the hinge points of the upper and lower platforms, as shown in Figure 3.

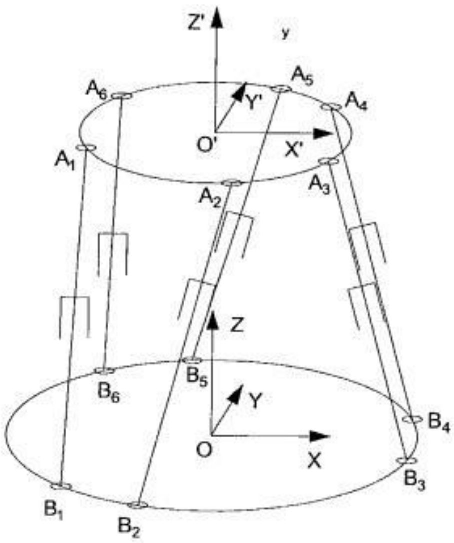

Figure 2. Platform coordinate system

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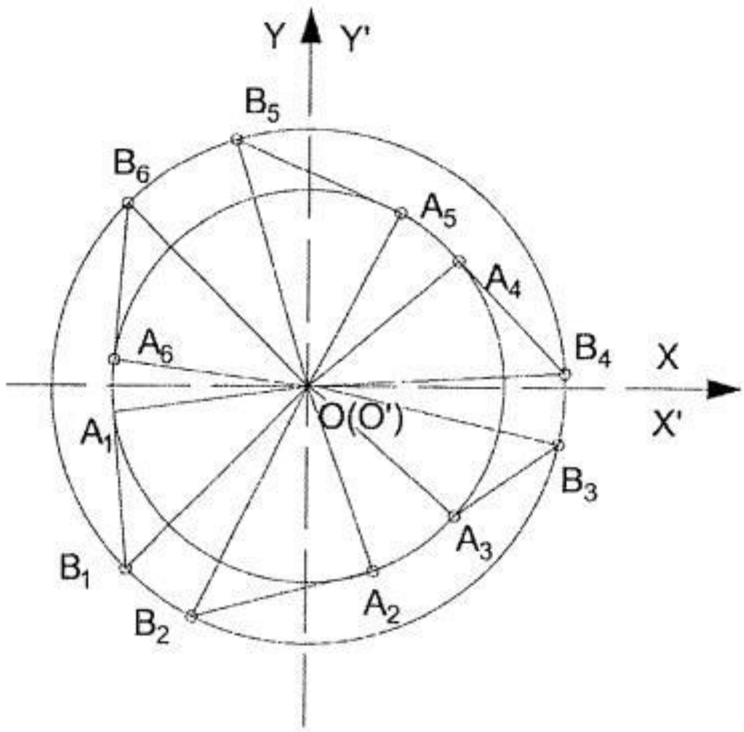

Figure 3. Upper and lower platform hinge point

For the analysis of the attitude motion of the six-degree-of-freedom platform, we often use the Euler angle method to describe the attitude of the moving coordinate system in the static coordinate system. First, the translation transformation is performed three times, and the static coordinate system is along the X-axis, the Y-axis, and the Z. The translational motion of the axis is further transformed by 3 rotations, that is, the rotation along the X axis, the Y axis, and the Z axis. Through the above process, the coordinate transformation matrix T from the static coordinate system to the moving coordinate system can be obtained.

$$T=\begin{bmatrix}\cos\beta\cos\gamma & \sin\alpha\sin\beta\cos\gamma-\cos\alpha\sin\gamma & \cos\alpha\sin\beta\cos\gamma+\sin\alpha\sin\beta & x_0\\ \cos\beta\sin\gamma & \sin\alpha\sin\beta\sin\gamma+\cos\alpha\cos\gamma & \cos\alpha\sin\beta\sin\gamma-\sin\alpha\cos\beta & y_0\\ -\sin\beta & \sin\alpha\cos\beta & \cos\alpha\cos\beta & z_0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

Because the platform is composed of two hydraulic cylinders connected by hinges to the upper and lower platforms, it is required to solve the movement parameters of the hydraulic cylinder, which is actually to find the coordinates of the end points of the hydraulic cylinders. We use Ai , Bi (i = l , 2 , . . . , 6) to represent the hinge points of the upper and lower platforms respectively, and use Ai ' = (Ai x ' Ai y / Ai z ') T to represent the hinge point of the upper platform in the moving coordinate system. Coordinates, the two hinge points of the same link are corresponding. The coordinates of the lower hinge point B i in the static coordinate system are expressed as Bi = (Bi X Bi y Bi z) T , and the coordinates of the upper hinge point in the static coordinate system after the pose transformation are expressed as Ai = (Ai x Ai y Ai z) T. When the platform moves, the formula for calculating the distance between the upper and lower hinge points is:

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$$l_i = \sqrt{(A_{ix} - B_{ix})^2 + (A_{iy} - B_{iy})^2 + (A_{iz} - B_{iz})^2}$$

The cylinder cylinder length is reduced by:

$$\Delta l_i = l_i - l_0$$

l_0 is the initial length of the hydraulic cylinder.

The degree of freedom refers to the number of independent motion parameters that the structure has when determining the motion. The calculation of the degree of freedom is very important for mechanical design.

The ship's R&D and design process is very large and complex. In order to improve the research and development efficiency of the ship and reduce the number of launching experiments in the shipbuilding process, the shipbuilding industry has invested a lot of effort in developing the ship simulation control platform. By simulating various sea conditions, the ship's attitude and motion in the ocean are simulated and simulated in the laboratory, thereby reducing development costs and cycles. The kinematics analysis of the ship's six-degree-of-freedom analog controller platform is carried out, and the simulation system of the ship's simulation controller is designed based on the motion model to simulate the ship's roll angle.

The ship motion simulation platform plays a very important role in the ship design and development process. In order to obtain a good simulation effect of the ship in the laboratory, this paper designs a degree of freedom motion simulation platform, which is combined with the function model and hydraulic system model of the platform. Matlab performed the motion simulation of the simulator.

2.2. Research on Nonlinear Modeling Simulation and Control Strategy of a 1.6-DOF Ship Motion Simulator

The ship motion simulator is used to reproduce the motion state of the ship in the laboratory, with advantages such as reliability, economy and controllability. The hydraulically driven ship motion simulator is affected by factors such as non-linearity of the hydraulic system, and has problems such as poor tracking accuracy and low system bandwidth. The traditional linear model-based control strategy does not fully meet the accuracy requirements of motion simulation systems. It mainly studies the joint simulation modeling problem of hydraulic six-degree-of-freedom platform system. Based on Matlab/simulink platform, the simulation model of asymmetric valve-controlled asymmetric cylinder dynamic mechanism is built. The three-dimensional model of the ship motion simulator mechanical system is constructed and imported into the ADAMS platform. The mechanical system simulation model is established and the joint simulation model of the ship motion simulator hydraulic six-degree-of-freedom platform is established, which lays a foundation for selecting appropriate control strategies.

The main research is on the hydraulic six-degree-of-freedom platform control strategy based on nonlinear model. Through the kinematics inverse analysis, the platform pose command is converted into displacement commands of six hydraulic cylinders. In order to meet the dynamic index requirements of motion simulator step and system bandwidth, a vibration control compensation and feedback linearization control strategy based on frequency characteristics is proposed. In the vibration control compensation method, based on the system transfer function, the feedforward correction controller is designed in the outer loop to correct the deviation of the response signal from the desired signal by correcting the drive signal, thereby improving the system bandwidth.

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3. Ship simulator for the relevant ship type

3.1. 1imulation of River Flow in 2.1 Inland Ship Simulator

The problem of the inland ship simulator is that the river flow in the river view is not real enough and requires real-time rendering. The method of stream function is used to solve the river surface velocity field for river modeling and real-time rendering. The method uses the real boundary value of the river channel, uses the inverse proportional interpolation algorithm to solve the flow function values of the river surface, and effectively obtains the distribution of the velocity field. The algorithm is suitable for solving the river velocity field with branch channels. The simulation results show that compared with the existing river modeling method in the inland river ship simulator, the method can reflect the river speed distribution more realistically, and can meet the real-time requirements of the river view, and enhance the environmental reality of the river view.

The simulation of river fluid in the inland ship simulator mainly focuses on three aspects: the simulation of river fluidity, the real-time requirements of simulation and the interactive simulation of rivers and ships. This paper comprehensively considers the real-time and environment of the river in the inland ship simulator. In terms of realism, a modeling method suitable for river flow velocity in the inland river ship simulator visual system is introduced. This method can construct a single river channel and a river velocity field with branch river channels, and the simulation effect is in line with expectations. River flow phenomenon.

3.2. Key Technology Research of Rescue Ship Simulator Prototype

In response to the requirements of the rescue training of rescue vessels under heavy wind and waves conditions, it is necessary to develop a maneuvering simulator for the rescue boat. Compared with the traditional general ship simulator, the rescue ship simulator prototype system introduces a six-degree-of-freedom platform motion system, and transmits the ship attitude data based on the UDP protocol to realize real-time somatosensory simulation function, which can simulate the ship shaking vigorously under the conditions of heavy wind and waves. The boat environment improves the realism of simulation training. In addition, the idea of introducing the rescue operation simulation module in the system can better evaluate and train the crew's ability to cooperate with other rescuers in the difficult sea conditions to complete the rescue mission, and improve the success rate and efficiency of the implementation of the rescue mission at sea.

In response to the special requirements of rescue boat driver training, this paper proposes two key technologies for the rescue ship simulator: the somatosensory simulation technology based on the motion platform and the rescue operation simulation module.

Somatosensory simulation is a real-time simulation system that uses computer software to generate a specific excitation signal to drive a six-degree-of-freedom motion system to generate motion phenomena in the actual operation of the rescue ship. It can provide the dynamic information that the crew can feel during the ship's navigation, and cooperate with the visual and maneuvering simulation to make the crew more realistic to experience the ship's swaying environment under the harsh sea conditions.

The rescue operation simulation module is integrated in the vision software. The essence of the rescue operation module is to separately render a view channel with a variable viewpoint position and a direction in addition to the bridge view. In this channel, the cable is connected. Visual simulation of rescue operations such as towing, fire fighting, etc. In this way, the ability of the crew to cooperate with the rescue mission can be visually evaluated, and the training program can be strengthened in a targeted manner.

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3.3. Icebreaker Six-Degree-of-Freedom Motion Modeling Simulation

Along with the global warming, the development and utilization of the Arctic waterway and the scientific investigation of the Arctic and Arctic regions, the icebreaker shoulders the important tasks of opening up transport channels, base material supplies, and polar scientific investigations. With the increasing development of the marine transportation industry in the ice region, the country is increasingly demanding icebreakers with superior performance. Due to the relatively complex physical and mechanical properties of sea ice and the special interaction process with sea ice during icebreaker ice-breaking operations, the theoretical research results of related parties are less. In order to study the interaction between the icebreaker and the sea ice during the “crash” ice-breaking operation, the theoretical and numerical simulation methods are used. The main research contents are as follows:

Through the in-depth study of the physical and mechanical properties of sea ice and the characteristics of icebreaker, the process of interaction between icebreaker and ice platoon and the failure mode of ice platoon are understood. Based on the theory of elastic mechanics, the suitable ice-breaking load is explored. Theoretical formula.

Using the solidworks software to establish the icebreaker ice-breaking model, combined with the simulation ideas and theoretical techniques of explicit nonlinear finite element, explore the material parameters and failure criteria suitable for simulating the mechanical properties of sea ice and icebreaker materials.

Using ANSYS/LS-DYNA finite element software to establish a six-degree-of-freedom ice-breaking model for icebreaker, and solve the optimal ice-breaking speed and optimal ice-breaking position of the icebreaker in the "crash" ice-breaking method, and then get the six freedom of the icebreaker. Degree of motion.

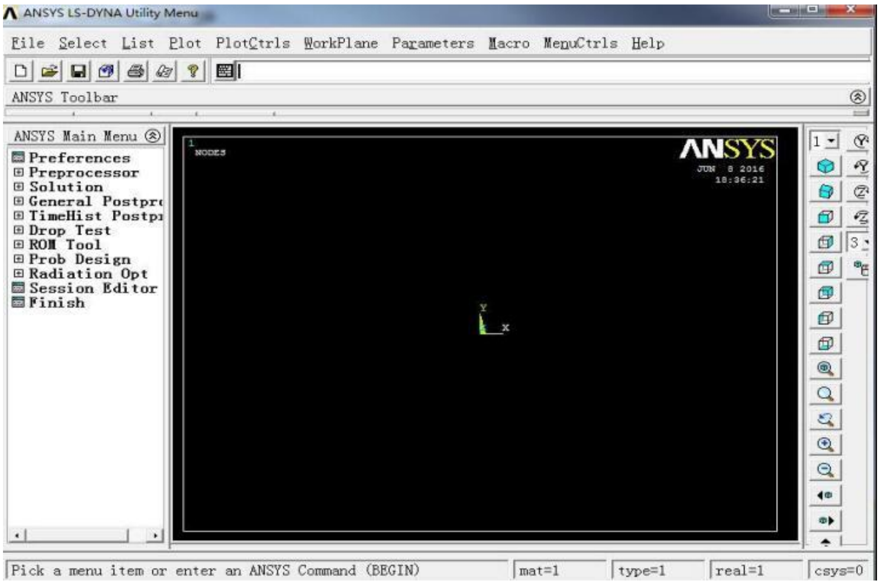

Figure 4. LS-DYNA software interface

4. 3D simulation of ship collision response based on OSG and Bullet

In the navigation simulator, there is a lack of 3D simulation of the ship's collision response, and a technical solution for adding the Bullet physics engine to the 3D view based on the open source scene graphics rendering engine in the navigation simulator is proposed. According to the rigid body dynamics, contact and collision dynamics and energy conservation law, the three-dimensional collision dynamics model of the ship is established based on the Bullet rigid body collision response model. The Projected Gauss-Seidel iterative algorithm is used to obtain

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the real-time six-degree-of-freedom position and attitude parameters of the ship after collision. According to the collision point position parameters obtained during the collision detection phase, draw scratches and add explosion effects in real time.

The main research method is to combine the OSG 3D rendering engine with the Bullet physics engine to solve the ship collision response problem in the navigation simulator. According to the theory of rigid body dynamics and the law of conservation of energy, based on the principle of rigid body collision response of Bullet, the ship collision dynamics model is introduced. The Projected Gauss-Seidel iterative method is used to calculate the collision according to the physical parameters such as speed and angular velocity before the collision. After the corresponding parameters, the position and attitude of the ship after collision are further estimated and updated in real time. In addition, according to the position of the collision point obtained in the collision detection stage, the scratches are added in real time and the explosion special effects are added, and the position and posture of the special effects are updated in real time to change with the movement position and posture of the ship.

5. Conclusion

At present, when developing new navigation simulation equipment, it has begun to consider the needs of the development of information technology and other latest technologies in the 21st century. Since the end of the century, human beings have made fundamental developments and major achievements in computer data processing, multimedia video and audio signal processing, data communication and transmission. In the new century, global computer networks and communication systems will be more Fast development. These new and technological revolutions have taken place and will make data processing and transmission faster and smoother, and their operating costs and reliability are more ideal, thus making a major breakthrough in the use of multimedia technologies such as video and audio. The development of these technologies will certainly have a major impact on future maritime safety and maritime security.

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