Research on Quality and Safety Intelligent System under Ship Navigation

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Abstract. This paper first analysed the importance of integrated ship control systems’ researches and developments, and find out why quality and safety plays an important role as the ship industry and the ship automation research develops. Then the paper introduced the ideas, theoretical basis, and the system structure of the whole system design, with the implementation steps of the quality and safety intelligent system followed. Finally, a simulation was executed on the system, and the data is persuasive.

Keywords: Waterway transportation, quality ship system, design, ship navigation, quality safety system, ship.

1. Introduction
Normal ships without special modifications have many hidden safety hazards, such as bilge flooding, fire, damage to sea pipelines, etc. If those problems are not managed and handled in the right time with the right methods, damage control (referred to as "damage management") will affect the ship's standard navigation system and may even cause a shipwreck accident in severe cases. Therefore, how to quickly and accurately locate damage hazards and take corresponding effective measures in time to prevent additional damages is a problem that needs to be solved as soon as possible.

Along with the comprehensive development of marine resources, countries’ strategic plan on developing the shipbuilding industry has also becomes a plan on top of the countries’ To-do list. But only when shipowners realized the development of of the automation technology can they finally make their ships meet the marine development needs [1]. The application of intelligent control technology to the monitoring system of ships on the water can effectively improve ship driving. It can be seen that in-depth research and analysis of the intelligent control technology of the maritime ship monitoring system has particular practical significance.

2. Ship quality and safety control system
2.1. Overall system design
There are many types of ship equipment, and the connections between various devices are complicated. In general, according to its functions and logical relationships, the ship integrated control system can be divided into the following subsystems: integrated ship bridge system, engine room control system, and damage control centralized control system (referred to as damage management centralized control system), etc. As shown in Figure 1:
Figure 1. The overall layout of the ship integrated control system

Integrated ship bridge system, located in the bridge of the ship bridge, mainly includes an
tegrated navigation system and dynamic positioning system; among them, the integrated navigation
system is composed of electronic chart system, ARPA radar system, main engine remote control, and
steering control workstation and loss management centralized control System workstations and other
components. The modern integrated ship bridge system's primary functions include ship driving,
navigation, positioning and monitoring, and remote operation of its leading equipment [2]. The engine
room control system, located in the ship engine room, is the core of the ship’s integrated control
system; it mainly includes primary engine control system, steering control system, power station
control system, auxiliary engine control system, and other subsystems; for the main engine, steering
gear, generator set, clutch, Air compressors, and other essential engine room equipment and related
instruments for monitoring and control.

The damage management centralized control system mainly includes a fire alarm monitoring
system and bilge drainage system, etc. It consists of detectors, sensors, actuators, and controllers
located in the centralized control room distributed throughout the ship. The system monitors the
operating parameters and status of the ship’s equipment and instruments according to the importance
of the ship’s equipment and instruments; if there are abnormal conditions such as parameter violations,
equipment or instruments operating abnormally, a fire in the engine room, or water in the cabin, it will
promptly alarm. The alarm signal is transmitted to the chief engineer, the residence of the engineer on
duty and the public places of the whole ship; thus, it can help the ship safety management personnel to
deal with disaster events and manage the safety resources of the whole ship so that the crew can make
timely, effective and reasonable judgments based on the damage situation and decision-making.

2.2. Real-time data analysis of the engine room
It can be seen from Figure 2 that in addition to real-time monitoring, another primary function of the
intelligent monitoring system is that the data it collects can be analyzed and compared by cabin
managers.
Figure 2. System software structure diagram

Figure 2 is a structural diagram of the software. The display software mainly completes the real-time display of various data and alarms in the engine room and the query function of historical data. It is mainly composed of three parts: host and auxiliary system display, power station and related system display, and navigation data display. The main engine and auxiliary system's display are divided into the fuel system, lubricating oil system, cooling water system, supercharging system, compressed air system, etc. Each part is designed as a friendly man-machine interface, convenient for the operation of the cabin management personnel [3]. There is a real-time graphic display system for the main engine and auxiliary systems' essential parameters to facilitate the cabin management personnel's comparison and analysis. Simultaneously, there are real-time curves for these crucial parameters. Drawing is convenient for engine room managers to compare different cylinders' parameter values at different times, which brings a lot of conveniences to ship engine room managers' work.

2.3. Design of sensor interface

The SLAVEIIC technology is applied to the ultrasonic sensor interface design process, and under the synergistic effect of ultrasonic, comprehensive measurement of obstacles can be implemented. Among them, the KS103 ultrasonic can achieve goals such as multi-range detection and temperature compensation technology, and intelligent recognition after detection. The KS103 chooses the IIC interface to communicate with the host; multiple devices can use the bus simultaneously and then automatically respond to the host's IIC control commands [4]. With the help of the IIC bus, the host and the slave can communicate effectively. In processing the attitude sensor data, the tilt angle must be calculated. Among them, the calculation formula of the heel angle is:

\[
\varphi = \begin{cases} 
\arcsin \left( \frac{a_t}{g} \right) \\
180 - \arcsin \left( \frac{a_t}{g} \right) \\
-180 - \arcsin \left( \frac{a_t}{g} \right)
\end{cases}
\] (1)

In the marine ship monitoring system, intelligent control is generally realized by independently configuring each device. Therefore, it can be assumed that there is a parameter \( l_1, l_2, \ldots, l_n \) in the intelligent control system [5]. The above \( n \) parameters can achieve adequate control of multiple devices. The average value \( \bar{x} \) of this parameter is:

\[
\bar{x} = \frac{l_1 + l_2 + \ldots + l_n}{n}
\] (2)
Because there is a certain probability of errors in the data transmission between the monitoring equipment, during the control process, the control parameter changes are shown in Figure 3, and the relevant control parameters must be corrected.

![Figure 3. Changes in control parameters](image)

2.4. Hardware design

The damage control monitoring station comprises a H/JYX-155Z reinforcement machine, PLC embedded control unit, the video integrated processing control unit, standard display unit, and communication unit, power supply module, etc. The hardware principle of the damage control monitoring station is shown in Figure 4. The monitoring station is used to display the status of damaged pipes such as cabin water ingress, fire, and sea pipeline damage in real-time, and send out alarm signals in the form of sound and light alarms and remind commanders to issue operating instructions, thereby deploying rescue personnel.

![Figure 4. The hardware principle block diagram of the damage control monitoring station](image)
The ruggedized computer mainly completes the functions of video signal processing, data display, human-computer interaction, and communication; the video integrated processing control unit mainly outputs the monitoring signal to the display screen of the ruggedized machine, and the communication unit is connected to the communication network of intercom and outcome. It provides a platform for command output and resource allocation of command personnel during damage management; the embedded control unit processes the data transmitted from the control and protection module and transmits it to the reinforcement machine for display; the dedicated control unit is hard-wired to control. It is directly connected with the control device of the protection module to realize the actuator's remote control; the dedicated display unit feedback and displays the status of the actuator after the action is in place.

3. Simulation experiment analysis
The feasibility of the proposed large-scale ship power communication network security intelligent early warning system is simulated and tested. The test will compare the proposed design system with the traditional power communication security system. The comparison item is the identification and interception warning of abnormal nodes [6]. The specific test steps are as follows: The test terminal sends simulated power abnormal data to the test machine equipped with two power communication safety systems, two systems identify the abnormal data, and the test host records the correct warning numbers of the two systems. The test sets ten test data packets, and the specific test parameters are shown in Table 1.

| Test package traditional system | Abnormal design system | Exception test package traditional system | Abnormal design system | Abnormal sequence number node | Warning result |
|--------------------------------|-----------------------|-------------------------------------------|-----------------------|-------------------------------|----------------|
| 1                              | ×                     | √                                         | 6                     | √                             | √              |
| 2                              | ×                     | √                                         | 7                     | √                             | √              |
| 3                              | ×                     | √                                         | 8                     | √                             | √              |
| 4                              | √                     | √                                         | 9                     | ×                             | √              |
| 5                              | ×                     | √                                         | 10                    | ×                             | √              |

It can be seen from Table 1 that in the simulation test of abnormal node identification and early warning of the proposed system, the number of times of correct identification of abnormal nodes in early warning communication is ten times, and the number of correct warning times of traditional power communication network security early warning system is four times. In comparison, the proposed design of the large-scale ship power communication network security intelligent early warning system is significantly better than the traditional power communication security system. It can be fully proved that the feasibility test of the proposed large-scale ship power communication network security intelligent early warning system has passed, and the stability is good.

4. Conclusion
The quality ship system is an essential manifestation of the combination of scientific and effective maritime safety management. The establishment of the quality ship system requires accumulating, processing, and exchanging a large amount of ship safety and quality data. The development of computer data processing technology and modern communication technology, especially network technology, has laid an essential foundation for establishing a quality ship system. The ship engine room's intelligent monitoring system is easy to implement, low cost, and good scalability. Each functional module can be applied to various types of ships and related shore departments. The application of this system can improve the efficiency and accuracy of ship engine room monitoring.
and free ship managers from heavy-duty inspections, thereby improving the safety of ship production and operation and the efficiency of ship transportation.

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