Research on Information Security System of Ship Platform Based on Cloud Computing

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Abstract. To improve ship positioning identification and implementation monitoring, ensure the safe navigation of ships, and optimize ship information retrieval design, the paper proposes a ship information retrieval system based on cloud computing technology. It adopts the fuzzy C-means clustering method for ships, the classification and processing of the subordinate characteristics of the information, the design of the ship network video monitoring system, some study of the critical technology of cloud computing technology, and the algorithm of the video image detection. The simulation results show that this system has a significant improvement on accuracy and recall rate of ship navigation safety information monitoring. The system is a ship-shore integrated monitoring platform that meets maritime safety requirements and the needs of low-carbon management with outstanding efficiency.

1. Introduction
As the Chinese "13th Five-Year Plan" indicates, the implementation and development of cloud computing technology has become a vital research direction. During the past few years, many provincial and municipal government departments have successively built a considerable amount of cloud computing platforms and strengthened their applications. Some domestic enterprises and scientific research institutions also actively engaged in developing cloud computing-related projects and related standards to promote domestic cloud computing development. Alibaba Cloud successfully founded the "Flying" platform in December 2013, which is a healthier cloud computing eco-system from multiple perspectives such as products, services, prices, and third-party cooperation; Baidu officially initiated its cloud computing platform September 2011, which also focused on providing cloud computing services to developers, scientists and institutions. In few years, cloud platforms will continually grow with IaaS, PaaS, and SaaS services, including cloud storage, cloud integration, maps, and open APIs. In other words, it's safe to suggest the cloud computing technology will undoubtedly play a vital role in human history.

Although there are so many applications of the cloud computing technology on lands, there are only few on the sea. From the day a ship touches the water, the ship's navigation data, weather conditions, navigation coordinates, ship status, and other relevant data must be recorded one by one for future reference and recall. After the radio's birth and its application to ships, the ship's voyage data is no longer caged in local recording devices. The wireless remote transmission of voyage data allows interactions between remote locations [1]. With the rapid development of network technology, the interaction between data has become more frequent and significant. Each accurate interactive feedback of data is
related to the safety and stability of ship operations. This paper studies the key technologies of cloud computing and its application in ship network video surveillance systems and proposes a detection algorithm for moving targets. Finally, a simulation experiment is carried out, and results are analysed.

2. Ship information storage data and motion algorithms

2.1. Ship information storage data structure model
To achieve optimal retrieval of a ship’s information, it is necessary to construct the ship information database’s relative state structure model.

Suppose R is the distribution state relationship structure of the quadruple \((E_i, E_j, a, l)\) of the ship information storage data structure \([2]\). The distribution data set is \(X = \{x_1, x_2, ..., x_n\}\). In the semantic ontology model of ship information feature distribution, the data set \(X\) contains \(c\) categories. The feature matching processing of ship information is performed on the ontology generalization map \(f(k)\). The ship information retrieval optimization problem is generally determined by a multivariate decision-making problem consisting of \(n\) statistical variables and \(m\) dependent variables, the mathematical model of information classification for ship information retrieval is expressed as follows:

\[
\min F(x) = (f_i(x), f_j(x), ..., f_l(x))^T
\]

\[g_i \leq 0, i = 1, 2, ..., q\]

\[h_j = 0, j = 1, 2, ..., p\]

In the heterogeneous mode of cloud storage, the high-order moment \(\sigma(W)\) of ship information storage is a two-dimensional matrix of \(p \times p\). For the \(q\) sample in the \(j\) category of the ship information distribution, the inter-domain clustering threshold \(z^* = z > 25\) is expressed by The conjugate transpose vector, the feedforward coefficient of the ship information distribution satisfies \(a_i < a_2 < ... < a_y\), and the characteristic quantity the heterogeneous state of the ship information satisfies \(N(z^*) = N(z)\). For the convenience of discussion, considering only the frequency domain feature \(z^*\) of ship information distribution, the probability distribution model of ship information fusion can be expressed as:

\[K_i = key_{i \in W_i}, i = 0, 1, ..., 15\]

\[p_i (S_i - S_{i-1}) + p_{i+1} (S_i - S_{i-1}) = p_i (S_i - S_{i-1})\]

Through the analysis above, the unsupervised learning method can be constructed to analyze ship information storage's data structure to improve the accuracy of ship information retrieval.

2.2. Ship motion monitoring algorithm
Based on the HSV background subtraction method and the time difference method, this paper proposes a motion detection algorithm based on HSV. This algorithm believes that the brightness, saturation, and chroma of the color contribute differently to the image. Among them, the shadow and light cause the change of \(S\) and \(V\), and the chroma causes \(H\)'s change. In the voting part of the algorithm, the AND-OR operation is combined. The way to highlight the role of chroma. The algorithm flow is shown in Figure 1.
First, use the median method to model the background, remove the noise, calculate the absolute difference between the current frame and background. Then use threshold filtering to separate the HSV channels. Finally, the binary image is obtained through the AND or operation, and it realizes the detection of motion areas. Since the background image and the moving target in the current frame are different in color or gray, the pixel value should be different, and will be compared with the preset threshold after the subtraction operation. When the pixel value is greater than the threshold, it is determined that there is a moving target in the current frame. Otherwise, it is determined that there is no moving target [3]. The algorithm is calculated as follows:

\[
D(x, y) = \begin{cases} 
1, & \text{if } |P_k(x, y) - B_k(x, y)| \geq T \\
0, & \text{otherwise} 
\end{cases}
\]  

(4)

In the formula: \(P_k(x, y)\) is the current frame with moving objects or sudden noise; \(B_k(x, y)\) is the background reference image; \(T\) is the preset threshold.

3. Monitoring system architecture based on the Hadoop platform

3.1. System requirements

3.1.1. Ship information management. Ship information management is mainly responsible for registering, inquiring, updating, and modifying necessary ship information. Basic information includes ship data, voyage information, cargo information, etc. Ship information mainly includes IMO code, call sign, ship name, nationality, ship size, type, ship operator information, and cargo type. Voyage information includes necessary shipping information, such as each shipping route, security check records, crew list, crew certificates, etc. Cargo information mainly includes the type of goods and the weight of the goods, etc.

3.1.2. Crew information management. Crew information management includes the necessary data registration of captain, chief engineer, pilot, engineer, etc., registration of job records, registration for approval, shift record, comprehensive inquiry and analysis, crew shift management, and statistics. All tasks related to the process control of ship crew [4].

3.1.3. Real-time monitoring of ships. Through the network electronic chart technology, the establishment of real-time display of dynamic ship information, tracking of ship position, display of speed, marking, route and other information, and dynamic navigation information such as dynamic ship type and ship course, ship speed, position, etc. are displayed on the electronic chart. Ship static information such as ship name, call sign, MMSI, cargo type, etc.
3.1.4. Playback of ship's trajectory. According to needs, check the ship's trajectory within a certain period, support download playback, support zoom in (zoom out), frame zoom (zoom out), scale setting, specific monitoring area setting, and other functions.

3.1.5. Ship remote communication control. Realize ship-to-shore data exchange and shore-to-ship control.

3.1.6. Electronic chart data processing. It mainly includes chart display, chart calculation tools, plotting tools, chart printing, information classification display, etc. It supports zoom in (zoom out), frame zoom (zoom out), and scale setting.

3.1.7. Weather data processing. Manage weather, tides, ocean currents, and other information, including weather analysis, situation forecasts, forecasts for offshore areas, and forecasts for offshore areas.

3.1.8. Fuel control data processing. Monitor the fuel consumption during ship operation, mainly responsible for the completion of the oil product quota (fuel oil, lubricating oil), oil consumption (daily, voyage report), fuel-saving statistics, oil product inspection, equipment oil trend analysis, and equipment oil product management and other tasks provide reliable data support for reducing shipping costs, energy-saving and emission reduction [5].

3.2. System structure design
The remote ship monitoring system based on the cloud platform mainly solves the distributed processing and parallel computing of big data. It should possess characteristics of real-time, large-scale concurrency, and fast query, it also needs good scalability to deal with different amount of data. The architecture of the remote real-time monitoring system for marine ships based on the Hadoop cloud platform is shown in Figure 2.

Figure 2. Ship remote real-time monitoring system architecture
The remote real-time monitoring system for marine ships based on Hadoop distribution is divided into the following 3 layers: 1) The lowest-level data storage uses a distributed storage architecture to save a large amount of the remote's video acquisition data captured by the real-time monitoring system of ships. It provides interactive queries for the upper layer. 2) The middle layer is the core of the entire system, used to process massive monitoring data and process specific algorithms based on distributed computing resources [6]. Use the database interface and storage layer to obtain data while providing information output results for the upper layer. 3) The upper-level application is mainly for users, displaying required information for different users.

4. Simulation Design
The paper will experiment with the designed high-density information security storage method of ship cloud computing data center in the Matlab environment [7]. Set up 100 storage nodes in the simulation environment, the storage capacity of each storage node pair is 5TB, and the information storage channel is 500Mbit/s.

4.1. Load balance
The load balance is mainly described by node load capacity. The comparison of load balance obtained through experiments is shown in Figure 3. It can be seen that the load balance of the proposed method is much higher than that of the existing method, and its maximum value can reach 86%.

4.2. Storage efficiency
The comparison of storage efficiency obtained through experiments is shown in Table 1. It can be seen that the storage efficiency of the proposed method is much higher than that of the existing method, and its maximum value can reach 94%. The test results show that the proposed high-density information security storage method for ship cloud computing data center significantly improves load balance and storage efficiency, which fully demonstrates that the proposed high-density information security storage method for ship cloud computing data center has better storage effects.
Table 1. Comparison of storage efficiency

| Number of nodes | Suggest away | Existing method |
|-----------------|--------------|-----------------|
| 10              | 79           | 46              |
| 20              | 88           | 42              |
| 30              | 81           | 51              |
| 40              | 86           | 63              |
| 50              | 84           | 75              |
| 60              | 89           | 66              |
| 70              | 91           | 55              |
| 80              | 93           | 49              |
| 90              | 94           | 43              |
| 100             | 90           | 58              |

4.3. Algorithm simulation effect
Experiments were carried out on the clustering algorithm, motion monitoring, and improved HSV algorithm of the ship information security system. The data sets of the maritime ship monitoring system were successively searched, and the query time of each algorithm was calculated and compared. The final result can be found that as the value of k increases, the resulting lower bound value becomes smaller, the number of data interactions between the central node and each distributed node increases, and the system response time becomes longer [8]. Simultaneously, the value generated by the improved motion monitoring is the most reasonable, leading to the least number of data interactions between the central node and each distributed node among the three algorithms, and the real-time performance is the best. The final simulation result is shown in Figure 4.

Figure 4. The time-consuming query curve of three algorithms

5. Conclusion
This paper studied the existing monitoring system technical solutions, then designed a monitoring system architecture based on a distributed cloud platform, which focuses on the analysis based on distributed data query algorithms, uses a histogram strategy to improve the algorithm, and proposes an improved algorithm. Finally, The algorithm was simulated, and the system is proved feasible.
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