Research on blind driving technology on inland rivers under complex meteorological conditions

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\textbf{Abstract.} Under complicated meteorological conditions such as fog, haze, rain and snow, as well as nighttime, especially in restricted waters such as inland rivers and ports, the perception and discrimination of ship’s officers of the traffic environment and the state of the ship are greatly hindered and restricted during the ship’s operation, which results in accidents or decrease of traffic efficiency. Ship’s blind driving technology on inland river can effectively integrate hydrology, topography and channel, traffic dynamics, ship driving and other information, visually present the channel traffic environment under complex weather conditions from multiple perspectives, all directions and multiple layers, to provide supplementary navigation for the ships under complex weather conditions.

\textbf{Background}

China's inland navigation is developed, and its ever-increasing capacity has played a huge role in promoting economic and social development. However, inland navigation and marine production activities are greatly affected by the weather. Storms, tornadoes, downbursts, dense fog and other meteorological disasters cause marine traffic safety accidents to occur from time to time. According to statistics, in the past ten years, the Yangtze River trunk has seen 83 accidents in marine traffic due to severe weather such as strong winds and fog, and 114 people have been missing\textsuperscript{[1]}.

Inland ship’s officers will face the natural environment such as meteorology, hydrology, underwater terrain, navigation conditions, hydraulic structures, navigation marks, other ships and own ship dynamics, as well as information provided by many shipborne navigation devices. This information with complexity and multi-source is necessary for safe driving of ships, but the collection, perception, screening, analysis, and utilization of such information are usually isolated and scattered\textsuperscript{[2]}.

\textbf{System introduction}

\textbf{The visualization of 3-D scene}

With the rapid development of science and technology, various drawing softwares are constantly emerging and constantly updated. The process of modeling stereoscopic models using actual data and geological model space images while using 3D graphics software is called 3-D visualization.
The system studied in this paper has the four major functions of real-time reflection of topography, river conditions, navigation aids, and hydraulic construction (Fig.1). The usage of these technologies makes the navigation of ships safer and brings great convenience to travelling and transportation.

Auxiliary navigation

The auxiliary navigation of the system can be divided into two major aspects. On the one hand, it is optimal navigation design based on real-time data, and on the other hand is navigation warning. Details are as follows:

1) Navigation design

Enter historical weather data of the channel, the location of the underwater obstacles, and the actual conditions of the ship and the time of passing the important area objects in the system. Based on the self-contained data input by these systems, the system then draws the optimal navigation route based on the actual weather conditions, and solves the dangerous way of judging the navigation route based on experience in the case of an emergency in the original voyage, making the weather in extreme weather. In the case of navigation, the possibility of safety accidents is greatly reduced, and the system can plan the best navigation route in a very short time.

2) Navigation warning

It is subdivided into water depth warning, steering tips and weather warning. The main performance is that the system automatically detects the water depth of the channel within the safe range according to the current driving position, and reaches the alarm inside the safety warning line to remind the officer to stay away from danger. In addition, if an emergent situation happens, such as encountering an obstacle, it will issue a warning and determine if it is safe ahead. Finally, basing on changes in air humidity and air pressure and combining historical data to estimate the weather conditions in the current environment, if it is estimated that the next weather will affect the next voyage, it will automatically issue an early warning to avoid unnecessary losses\(^3\).

Model establishment

Processing of basic data

In the process of basic data, it is necessary to process the following data: The visible part of the bank of the Yangtze River, the navigation channel, the ship body, the river, the embankment, the wharf, the bridge, the island river, the architectural landscape on both sides of the channel, the navigation mark, the water surface, the shore, the ship position, etc. (Note that large buildings and terminals need to be restored to ensure their authenticity and accuracy, and the supporting buildings maintain their data accuracy and texture rationality). Visualize the navigation mark, water depth and flow direction, and focus on the visual effects of the embankment construction, vegetation and
buildings. The elevation of the street building adopts real modeling, and the ordinary building adopts structure plus general modeling. Then enter all of these aspects into the modeling system.

For the collection and processing of spatial data, real and reliable data should be used, and the model should be visualized by WGS84/UTM projection and orthophoto method. Finally, draw the ground digital elevation map and digital line graph.

**Collection and processing of channel data**

The collection of navigation channel data is mainly divided into three parts: navigation channel data, hydrological data and hydraulic data collection, including the navigation channel area and line identification (two seasons of dry and flood), navigation light identification, and ship track (with annotation), anchorage, obstacle object identification, the performance of the bottom of the river, water surface, water depth, water flow field, pier number, wharf, formation of water flow map and water depth map[4], as shown in Fig.2 and Fig.3:

![Fig.2 Formation of water flow map](image)

![Fig.3 Water depth map](image)

**Ship data collection and modeling**

For the collection and processing of ship data, various ship models can be obtained by inputting the ship model and parameters and presetting the load conditions[5].

**Channel scene establishment**

According to the above steps, an intelligent system that can fully reflect the terrain and weather conditions of the ship in real time reflecting the position of the navigation during navigation and the early warning of weather conditions[6] is preliminarily established, and then further steps are needed to further improve the system. The design is enhanced to continuously detail the design of water depth lines, obstacles, river bottom terrain and water body perspective treatment, so that the entire channel can be made three-dimensional, and the officer can judge and proceed according to the model.

**Design of shipborne real-time early warning system for complex weather**

**Module building**

The main functions of the complex weather warning module include: real-time reception of meteorological information of each meteorological site, detection and processing of data, diagnosis and analysis of meteorological elements, automatic tracking alarm, and chart display. The complex weather warning module of the Yangtze River trunk includes two parts: the meteorological ship database and the weather warning service platform. The data stored in the database mainly include: meteorological forecast site information along the Yangtze River, geographic information of the Yangtze River trunk, real-time meteorological data, ship parameter data and early warning service information. The weather warning service platform is a real-time dynamic work platform based on ship positioning connected with the database, including real-time data screening and detection, early warning level evaluation and early warning information display. The overall framework of the
system is shown in Fig.4.

![Fig.4 Overall framework of the system](image)

**The establishment of database**

The meteorological ship’s information database is the basis of the entire complex weather warning system, including real-time weather database, weather warning service information database, ship’s parameter information database, and complex weather ship warning level database. The main functions are:

1. Real-time meteorological data collection: real-time collection of meteorological elements such as rainfall, wind speed, wind direction and visibility.
2. File screening: Check and filter the uploaded real-time files.
3. Graphic display: Display the spatial distribution and time change map of each early warning meteorological element.
4. Data backup: Back up the inbound data to ensure the security and high availability of the database.

**Design of Service Platform**

Before using the auxiliary navigation system, the recorded ship data (ship type, tonnage, loading status) is stored in the ship information database, and the received meteorological information is filtered and stored in the weather information database, and the tracking type is combined with the warning level for tracking. The warning is superimposed on the inland river three-dimensional electronic channel map and displayed, displaying information including wind level, wind direction, visibility, rainfall and corresponding warning level. The weather warning display interface is shown in Fig.5.

![Fig.5 The weather warning display interface](image)

**Conclusion**

The current virtual simulation technology is very mature and can be combined with real ship
driving, which enables the ship's officer to perceive the external environment obscured by complex weather conditions in the case of poor visibility caused by complex weather conditions, thus achieving “blind driving”. In this paper, a preliminary exploration of blind driving is made, in which the method of combining “virtual and real” is proposed and adopted. From the results, this method is feasible and provides a practical and feasible route for the realization of blind driving.

This paper demonstrates the water surface and underwater traffic environment by constructing three-dimensional waterway and coastal landforms, and then establishes parallel redundant data association model and integrated multi-source heterogeneous data fusion model to achieve the final shipborne auxiliary. The navigation system enhances the reliability, stability and accuracy of the ship's driver's perception of the traffic environment to a certain extent.

References