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Research on Intelligent Sensing Technology of Traffic Volume in Yancheng Inland Trunk Waterway

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Abstract: In order to solve the problems that the existing channel traffic monitoring methods for ships in Yancheng City cannot meet the actual monitoring needs and the existing channel traffic monitoring methods cannot meet the requirements of development planning. This paper realizes automatic collection and accurate acquisition of channel traffic data by using intelligent sensing technologies such as AIS, video surveillance and lidar, and builds an integrated channel traffic monitoring system platform which integrates multi-dimensional perception, fusion processing and statistical analysis.

Keywords: Channel traffic volume; AIS; Video surveillance; Lidar; Intelligent Perception.

1. Introduction

Channel traffic monitoring is an indispensable part of the channel development strategy, which provides important basis for the future development and positioning of the channel, the determination of the scale of channel infrastructure construction and the formulation of channel management strategy. Guided by the top-level design of smart harbor and navigation in the whole province and guided by high-quality development such as digitalization, intelligence and intelligence, we will deepen the deep integration of new generation of information technology in the field of harbor and navigation, strengthen scientific and technological tackling of key fields and key links, advance the digitalization of harbor and navigation elements and the intelligence of management and operation, and support the construction of modern harbor and navigation.

Real-time monitoring data of ship traffic flow is an important part of intelligent channel construction and the most basic measure to characterize the water traffic condition of a certain section of water. Only when the inland ship traffic volume is reasonably determined can the scale, safety level and navigation capacity of the ship traffic in the channel or waters be known and reliable basis for channel planning and construction be provided.

With the widening of navigation channel and the increasing of navigation route, the distribution of water traffic flow field is changed[2–3].In order to improve the efficiency of ship's cargo transportation and ship's shipping capacity, many people in the industry apply computer, sensor and image processing technology to the field of water transportation[4–5].Therefore, it is very urgent to establish a perfect channel traffic flow acquisition system, which is of great significance to realize the intelligence of water supervision.

2. Current situation of demand analysis for traffic monitoring observation

This paper takes Yancheng navigation channel traffic observation as an example. River ditches are longitudinally and horizontally in Yancheng City, with dense water network. There are 12 large rivers over 50km long. Ship flows are large, route distances are long, and personnel are especially inadequate. The accuracy of manual observation is not high.

Investigations into existing methods of observation reveal the following problems：

(1) Existing channel traffic monitoring methods cannot monitor actual demand.

At present, the monitoring points of Yancheng waterway traffic volume are still mainly manual monitoring mode (visual monitoring + registration). As shown in the table below, the data accuracy and continuity need to be improved, and the contradiction between large workload of manual monitoring and insufficient monitoring personnel is becoming increasingly prominent.

(2) Existing channel traffic monitoring methods cannot meet the requirements of development planning.

In the document "Fourteenth Five-Year Plan" Development of Yancheng Port and Navigation (No. 2021, Yanshijiao Port), it is clearly pointed out that the construction of port and navigation "perception" capability should be accelerated, the layout and construction of monitoring equipment in key areas such as traffic monitoring points, water level stations, video monitoring points and locks should be improved, and information data collection, such as channel facilities, ship traffic volume, ship density, water level and lock flow should be strengthened. Transmission and Intelligent Analysis.

Based on the above conditions, in response to the requirements of the Fourteenth Five-Year Plan of Yancheng Port and Navigation, the construction requirements of trunk traffic flow monitoring facilities along the Yancheng area are proposed, and the ship traffic flow operating parameters and relevant basic information at the monitoring points along the line are collected in real time to master the ship running situation of the trunk channel.

This monitoring facility construction is helpful for the management department to grasp the basic information of navigating ships more intuitively and to promote the modernization level of navigation channels in Yancheng City. By 2035, a provincial "two longitudinal and five horizontal" trunk navigation network system with smooth networking and reasonable layout will be basically built, thus realizing all the objectives of this round planning.

3. Overall System Architecture

As shown in the diagram below, the system architecture is mainly divided into support layer of foundation, algorithm platform layer and application layer. The equipment layer is divided into outfield equipment and infield equipment, outfield equipment includes ship monitoring perception camera, AIS equipment, lidar, and infield equipment includes application server, database server and algorithm server. The network layer is mainly composed of communication network and private optical fiber network. The algorithm platform layer includes ship flow statistics, ship type identification, ship cargo type identification, ship speed identification, ship registration and ship number identification, ship direction identification, ship size identification, ship draught identification, ship three-dimensional modeling, hydrological scale identification video review, video storage, video push-flow, video live broadcasting; The application layer includes flow statistical analysis, channel ship hot spot map, ship transit record, etc. and provides interfaces with relevant systems of Harbor and Navigation Development Center of Jiangsu Transportation Department.

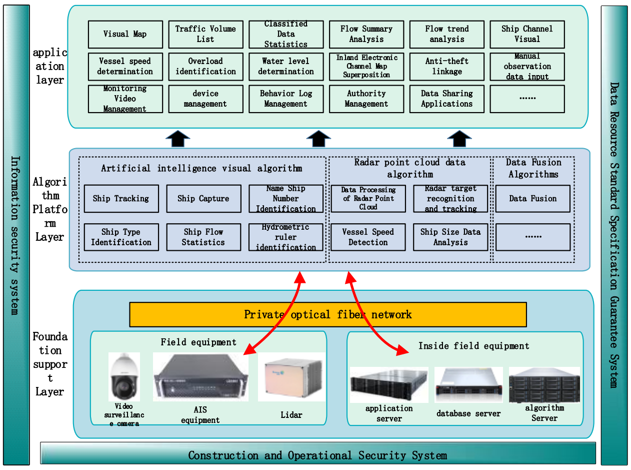

Fig.1 Overall structure diagram of channel traffic monitoring system design

4. Design of Analysis Module for Platform Artificial Intelligence Algorithms

4.1. Visual algorithm

Identification of ship number. The OCR character recognition algorithm is used to identify the ship's registered ship number, and then the ship number is output and recorded compared with the ship information database and AIS information of Provincial Channel Center. The effect of ship number identification is as follows:

Fig.2 Ship Identification Effect Diagram

(1) Ship type identification.

The model of depth learning algorithm is used to identify the ship appearance in the image which has been connected to the visual acquisition equipment, and output the ship appearance color, ship type (such as dangerous chemicals ship, passenger and cargo ship, container ship, oil ship, etc.).

(2) Direction resolution of ships.

The depth learning algorithm model is used to analyze the ship's trajectory in the images which have been connected to the visual acquisition equipment so as to distinguish the upstream and downstream of the ship and provide data support for channel traffic statistics.

(3) Ship trajectory tracking.

By using image trajectory analysis algorithm and machine intelligent learning, real-time monitoring and recording information such as real-time position, course, speed and trajectory of past ships, and combining electronic map and ferry warning zone to forecast the ship's navigation situation.

(4) Channel traffic statistics.

The algorithm model identifies all vessels in the image which have been connected to the visual acquisition equipment and carries out feature numbering and tracking, which achieves all vessels in the effective statistical cycle and avoids the situations of repeated counting and omission.

(5) Hydrological scale identification.

Using depth learning algorithm and OCR character recognition algorithm, the hydrological scale along the bank is analyzed to obtain remote real-time water level information.

(6) AIS data fusion.

Integration and output of ship information comparison between AIS transceiver data and visual acquisition terminal data by artificial intelligence algorithm.

4.2. Lidar algorithm

(1) Three-dimensional ship modeling.

The position coordinates of transit ships at different times can be obtained by scanning transit ships with lidar, so that the three-dimensional effect of ships can be restored by point cloud at image level. Provide data support for identification of ship speed, size and waterline.

(2) Vessel speed identification.

The target ship is scanned by the rotation mirror method of the lidar, and the position coordinates of the ship at different positions are obtained by reflecting the information at different points while traveling, so that the speed of the target ship can be calculated in real time.

(3) Ship size identification.

Three-dimensional modeling of ship is used to obtain ship dimensions. If the ship is long, wide and high on the water, it will provide data for calculating the ship's draught line.

(4) Ship draught line identification.

Drainage line of target ship can be calculated based on three-dimensional ship modeling, ship size identification and water level identification in this area.

Radar 3D modeling results are shown in the following illustrations.

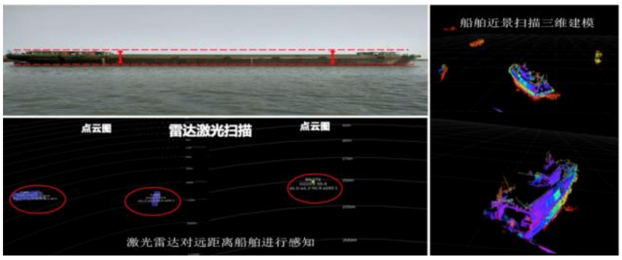

Fig.3 Effects of 3-D Lidar Modeling

5. Design of database deployment architecture

The database and channel traffic monitoring platform are uniformly deployed in Yancheng Port and Navigation Center. The data are divided into three categories: basic data of channel flow monitoring, statistical data and video data according to volume, as shown in the following table:

Table 1. Database Design of Channel Flow Monitoring System

Data Class	Data Set	Data Sources
Basic Data	Channel basic data, ship basic data, route basic data, etc.	Port and Shipping Center
Statistical Data	Ship traffic volume data, channel throughput data, hydrological scale data, etc.	AIS、Lidar
Video Data	Video camera basic data, video data, etc.	Monitoring Video

Basic database includes static data such as channel basic data, ship basic data and route basic data, which is mainly used to provide basic data support for application layer. The statistical database is mainly dynamic data uploaded by AIS, Lidar and other equipment, which is convenient for external data reporting (including data transmission to provincial, port and navigation centers, etc.), local record storage and platform application. Video database includes video camera basic data, video data, etc. Video data needs to be stored separately because of its large volume and large bandwidth occupancy when calling.

6. Conclusion

Based on the current situation of channel traffic volume monitoring in Yancheng City, this paper constructs a channel traffic volume monitoring system according to the problems that the existing channel monitoring means cannot meet the future channel development planning in Yancheng City. Through the construction of the ship information perception terminal and the combination of artificial intelligence visual algorithm, radar point cloud data analysis algorithm, data fusion algorithm and other algorithm platforms, the credibility, accuracy and quality of the ship information data are greatly improved. The final recognition accuracy of ship track, ship name, ship number and ship type: no less than 90%; The rate of ship missing inspection: no more than 10%; After data fusion, the accuracy of ship type and cargo type shall not be less than 92%.

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