

Research on Ship Berthing Monitoring Technology Based on 3D Laser Point Cloud Data

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Abstract—With the continuous development of maritime transportation, ships tend to be larger, alongside increase risk, in order to ensure the ship berthing more safe, high effective, various monitoring techniques have been applied, such as sonar, infrared, radar, etc. Although the two-dimensional laser has been used to monitor the ship berthing, there are some limitations in use. The 3D laser scanning technology has great advantages in accuracy, speed and scope, so it is necessary to be apply it to the ship berthing monitoring. The technology is based on full use of laser ranging efficiency and accuracy advantages on solving a two-dimensional laser monitoring system for its poor target berthing ability, resulting in the overall accuracy of the monitoring system is not high, and the technical approach for dealing with different berth, ship, bring new ideas to the development of ship monitoring technology.

Keywords—Ship berthing, three-dimensional laser, cloud data, berthing monitoring, monitoring system

I. INTRODUCTION

With the rapid development of maritime transportation, to improve transport efficiency, reduce cost, large-scale construction of marine ships, ore and other bulk cargo transport ship of 150 thousand tons have been the main types of maritime transport, 200 thousand tons and above at the port of our country has been very common. With the large-scale ship, damage caused by accidents or berthing speed by coincidence angle is too large and complex environmental factors, for instance, berthing pier have occurred. The pressure in the vessel berthing time mostly rely on the master or the pilot experience, the ship berthing attitude estimation, which are subjective deviation, bringing security risks to the ship berthing for the Department of management, safe berthing port, become urgent problems for the pilot and captain, so it is necessary to study the relevant prison regulations, install monitoring ship berthing speed and angle information in the dock equipment to help safe berthing of ships.

With the development of science and technology, many new technologies are applied to ship berthing monitoring, the monitoring accuracy is more and more high, more convenient to use, at the beginning, sonar, radar and infrared ranging technology development support system is widely used in monitoring the ship berthing, with laser ranging technology mature, and the installation of 2D point type distance measuring equipment in the terminal, application in the monitoring of ship berthing, further improve the monitoring accuracy, but the point location requirements of ship berthing must be fixed.

With the continuous progress of laser ranging technology, 3D laser scanning technology has become a common means of Surveying and mapping. It has been praised as a new technological revolution in the field of Surveying and mapping following GPS technology. Through a wide range of precision, from the reconstruction of real 3D scanning technology can scan, rapid acquisition of 3D laser point cloud data, without the need for calibration or any other processing of the scanned object surface, 3D laser point cloud data and scan the surface of a real data corresponding to a single point measurement, 3D laser scanning mode compared with the traditional technology, with high precision and speed and 3D point cloud data acquisition prototype approximation etc., in the future, 3D laser scanning technology will become one of the important technologies of ship berthing monitoring, and will play an important role in many aspects of security and safety management of port shipping.

II. 3D SCANNING LASER MONITORING OF SHIP BERTHING MODE

The ship berthing is divided into two ways, namely, self - berthing and tug - aided berthing according to the influence factors of the ship's drainage, the operating environment and the ship operator itself. Self reliance refers to the completion of berthing operation by means of control equipment installed by ship itself, such as thruster, energy and anchor. The self anchoring mode is suitable for small ships under ten thousand ton, and is limited to operate under hydrologic and meteorological conditions. The speed is lower, the greater the probability of ship out of control, and the tonnage is greater, the greater the risk control, therefore, in general, medium and large ships are used with tugs berthing way. Support berth can be divided into parallel berthing method and angle berthing method according to the close angle.

In reality, the parallel berthing method is an ideal state, due to the manipulation of environmental random changes caused by improper operation, sometimes in order to make the ship and parallel close to the pier, the blind use of force, which may lead to the end because of the speed caused by excessive deflection or rebound caused by ships and facilities damaged pier accident. Angle method is often used in the berthing of large ships berthing actual process, ship to ship as much as possible to ensure the small angle by coincidence, under this condition, one of the first ships alongside the wharf, after the completion of the other end or in the auxiliary tug thruster slowly by mask terminal.

The 3D laser scanner to monitor the ship berthing mode, general 3D laser scanner in the proper position of wharf shore, ensure the scanner viewpoint and scanning ship scanner link, adjust the scope of vision, so that the ship motion range as far as possible in the center of the field. When the laser scanner starts working, it can get the point cloud data at the interval time when the ship is in berthing. Every point in the point cloud represents the coordinate location of a ship on the scanner coordinate system.

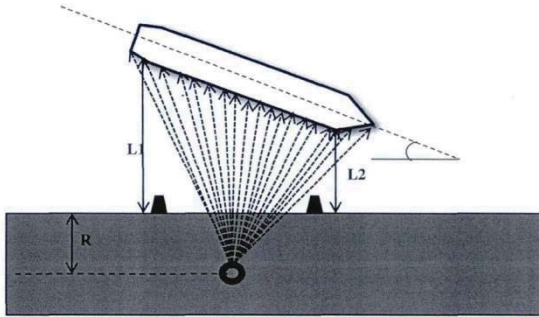


Figure 1. 3D laser scanner monitoring berthing

The mooring monitoring system consists of three parts: data acquisition, data processing and data release. Each part is connected by wired or wireless network. The 3D laser scanner belongs to the data acquisition part.

III. MODEL AND PROCESS OF SHIP BERTHING INFORMATION EXTRACTION ALGORITHM

The process of ship dynamic parameter information extraction includes two parts: data preprocessing and information extraction. First, we preprocess 3D laser point cloud data, including point cloud data format conversion, point cloud coordinate transformation and point cloud data denoising, which provide unified data for ship information extraction. The information extraction phase key to obtain the point cloud data through the three-dimensional point cloud data reconstruction, converting point cloud data into 2D plane in the two-dimensional plane distance threshold for abnormal noise of discrete point filter, by obtaining data on the two-dimensional smooth ship line data smoothing, the information can be obtained according to the section feature points on the boat. The last ship close angle information and the distance information is calculated according to the characteristics of ship section. Pressure

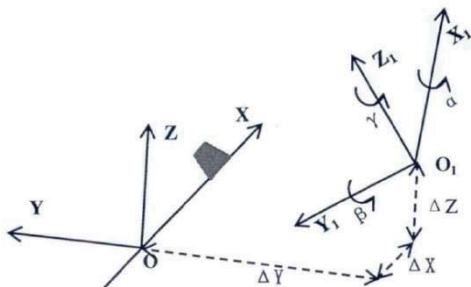


Figure 2. The transformation of coordinate system of berth and equipment coordinate system

After removing the fixed point cloud data, the residual point

cloud data is mainly scanning the ship information and a small amount of random noise point data. The random noise is due to the measured surface ship quality or the surrounding environment, such as "jump" or "point" of the abnormal data generated in the process of acquiring data, characteristics of this point is obvious from the point cloud, discrete distribution, less data, because in the process of data processing, not all random noise need to be resolved, so the 3D ship point cloud data reconstruction in post processing, conversion to two-dimensional set distance threshold filtering, to remove the noise.

The characteristic data refers to the key points the line can determine the ship motion parameters, such as ship and ship about string and string point. According to section W can get the shipping boats both offshore distance and bow to the ship berthing dynamic parameter information. The error of ship berthing information extraction is influenced by many factors. From the angle of error theory, the error includes system error, accidental error and gross error. The main defect of law caused by system error system error can be corrected by exploring the error law; comprehensive reflection of accidental error random errors, allocated by the adjustment theory; gross error is mainly in the process of irregularities caused, can be avoided completely.

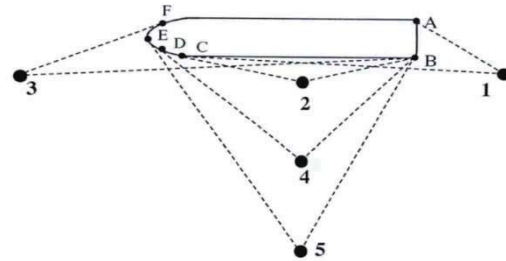


Figure 3. The relative position of the scanner with the ship

From data collection, processing information extraction process analysis, there are three main factors: artificial operation, instrument measurement and numerical simulation. Analyzing ship berthing information and extracting the errors in the whole process will help us establish standard operation rules and improve information extraction algorithm in practice.

A. Artificial operation

The ship berthing point cloud data acquisition, the 3D laser scanner is placed in the dock shore, and determine the position coordinates of berth, need relative distance artificial measurement scanner viewpoint and berth the origin, the artificial observation needs well aligned in the instrument balance process, in the process of manual measurement and observation are likely to cause errors in. Pressure

B. Instrument measurement

The instrument measurement error mainly refers to three aspects: the instrument error, the influence factors related to the reflection surface of the object mark and the influence caused by the external environment conditions.

C. Numerical simulation

Numerical simulation of error in model, need to abstract practical problems to mathematical problems, using

mathematical model in mathematics, known for processing, due to problems in the simulation process will be simplified, improve efficiency and other factors, often ignore a minor influence factors W. Get the ship berthing point cloud data in 3D laser scanner, ships are often kept in motion, and finally get the point cloud data is a collection of different time ship position in continuous movement in the process, because the scanner sweeps the ship for a short time, that is the point cloud data of the ship in a moment in the process.

IV. SYSTEM DESIGN AND IMPLEMENTATION

In order to make the user convenient to manage and use, so that it can monitor the moving posture of the mooring ship visually and intuitively, we need to design and implement the corresponding application system for data processing, and realize information extraction process, management and monitoring business. According to the system structure, it is divided into three modules: the data acquisition module, the data processing module and the information release module.

A. data acquisition module

In the process of ship berthing, besides the motion parameters of the ship itself, Hydrometeorological Information and port waters information have great influence on ship berthing operation. Therefore, in order to better monitor the berthing ships, besides providing a 3D laser scanner that directly monitors the motion parameters of berthing ships, other auxiliary sensors are needed. The data acquisition module of this system mainly includes: 3D laser scanning, 3D point cloud data is used to scan the berthing ship; meteorological and hydrological sensor, temperature, humidity and airflow to wave parameters such as real-time acquisition of information of the berth; video camera, real-time monitoring of video information from the berth, to grasp the overall situation more intuitive.

B. The data processing module pressure

The module is mainly to complete the extraction of ship motion information storage and other sensing data, firstly, 3D point cloud data of ship berthing of 3-D laser scanning information extraction, obtaining ship motion information, and motion parameter information written to the database in real time, the three-dimensional point cloud of a large amount of data, in order to save the storage space, three-dimensional laser the point cloud data we do not store the original. During processing and storing information of ship motion parameters, the collected meteorological and hydrological data are stored in the database synchronously, and at last, the user can provide access interfaces. Pressure

The port information terminal, divided into static and dynamic information, the static information refers to the information changes in a longer period of time will not, and relatively simple and easy to describe, such as berth direction, berth length, berth sign waters width, we only need in the system installed by the port management fill in the manual or regularly updated maintenance; dynamic information refers to the information is not regularly change or be described by several parameters, such as shield ship berths before this and other information, we use video monitoring mode to describe the dynamic information, directly to the video information application system.

C. Information release module

The system is used by port management personnel and the master and pilot, to facilitate the use of mobile handheld terminal and center server, two part of the ground.

Multi-source data conversion system, the system is in order to shield the bottom of the hardware system designed to solve a variety of problems in the sensor data acquisition system, data transmission of multiple sensor system in different ways, such as wireless transmission, serial transmission, so it is necessary to interface program in the system according to the transmission mode corresponding to each data source development the acquisition of sensor data, then data will get forwarded, and all interface program is developed according to the sensor decision.

The message queue system provides an asynchronous communication protocol, which means that the sender and receiver of the message do not need to keep in touch with the message at the same time. The message sent by the sender will be stored in the queue until the receiver gets it.

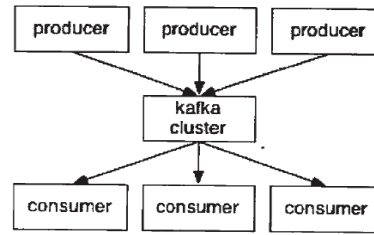


Figure 4. Kafka message queue schematic diagram

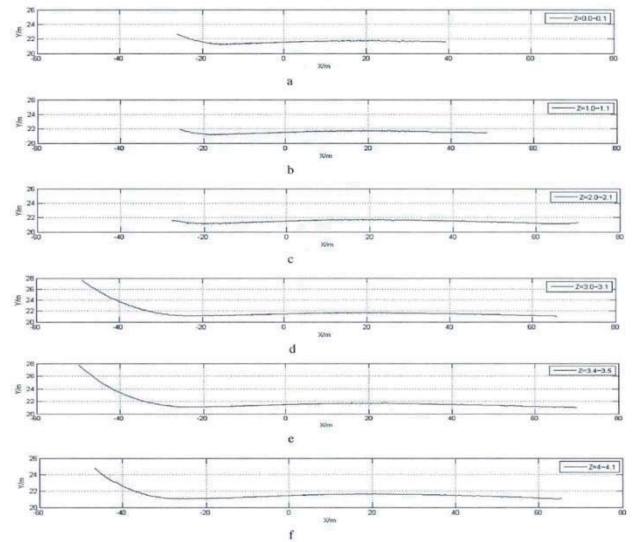


Figure 5. Comparison of the fitting line

The extraction of monitoring data after preprocessing of ship dynamic information, in order to carry out the direct analysis of the data, using Matlab for three-dimensional reconstruction of the 3D point cloud data visualization, as shown in Figure 5, processing of 3D point cloud data at a certain time in the scanning process as an example, through the comparison. Take the $Z=3.4-3.5$ to get the ideal rail line. Pressure

D. Database design pressure

The system database mainly uses relational database system MySQL as storage system, and the system is open source, so it doesn't need to pay extra cost. The system can handle large databases with massive data records, SQL data using the standard form of language, and supports a variety of language, because of its performance in speed, reliability and applicability of Noyes excellent, was a large number of Internet Co in many projects in the enterprise. Pressure

Database design is an abstract summary of the model entities contained in the system and the design of the relationship model. With the growing scale of the project, the amount of data in the database and the corresponding relations have also become more complex, table structure definition is reasonable or not directly affect the integrity of the data update data, so we must be in accordance with the relevant database management and design specifications, design table structure of the database, improve the storage efficiency in reducing Wu system database data at the same time, to ensure data integrity and scalability.

This system is mainly composed of the following 9 data tables:

(1) A user information table that stores the detailed information of the current system user.

(2) Role tables, store the roles assigned by the system, and the permission information that each role has.

(3) Menu function table, maintaining the mapping relationship between the system interface and function, the hierarchical relationship between various functions, and the description information of the style information of the menu.

(4) The laser set each information table, input the laser equipment information and the configuration information when the system is installed.

(5) The berth information table, storing the geographical and attribute information of the berth itself, as well as the laser equipment information that matches the berth.

(6) The historical record information table, storage system during operation after processing are the key points of the ship berthing real-time information and the corresponding pilot, laser equipment, shipbuilding and other information.

(7) Ship information table, the storage system of the ship's pre entry static property information, such as ship name, IMO number, Captain and other information.

(8) The pilot information table, personal information storage pilot's name, age, contact.

(9) A mobile message table that stores communication messages between the system and the mobile client.

Scanning range of the whole ship berthing during the experiment are included, so it can be H 3D laser point cloud data integrity of the ship berthing, compared with the monitoring technology of 2D point laser berthing, the technology to solve the two-dimensional point target detection technology for laser berthing capacity based on full use of high efficiency and accuracy of laser ranging, resulting in the overall accuracy of the monitoring system is not high, the technology has enhanced the applicability to different ship berths, and brought new ideas to the ship berthing monitoring technology.

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