Comparison of multi-beam bathymetric system and 3D sonar system in underwater detection of beach obstacles

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Abstract. The instrument detection methods of underwater part of beach obstacle mainly include multi-beam bathymetric system and three-dimensional panoramic imaging sonar system. SeaBat T50-P multi-beam bathymetry and BV5000-1350 sonar system are widely used in the area of underwater detection. The underwater part of beach obstacles is measured and analyzed, and the application scope of both equipment is discussed. The results show that the BV5000-1350 sonar system can be used to detect underwater incomplete obstacles with wider application scope, high accuracy, convenient installation of instruments, and no auxiliary equipment such as navigation, positioning and attitude sensor is needed; SeaBat T50-P multi-beam bathymetric system has high requirements for the structure of the measured object, moderate accuracy, and is more suitable for large-scale underwater obstacle survey.

1. Introduction

It has become the focus of underwater terrain detection in special areas to measure and analyze the underwater part of the beach obstacles which hinder the ship landing. Due to the different structural forms of the underwater part of the beach obstacles, and there may be many obstacles in the vast waters, the traditional methods such as artificial underwater exploration and two-dimensional sonar active detection cannot meet the requirements. The development of multi-beam sounding system and three-dimensional sonar system provides a variety of solutions. The multi-beam bathymetric system adopts wide-angle transmission and multi-channel directional reception, which can obtain the three-dimensional point cloud image of underwater target. The three-dimensional sonar system can generate the three-dimensional image of the underwater target which is similar to the optical holography effect, and provide more details of the contour. Therefore, this paper compares and analyzes the characteristics of the two systems through the detection of underwater parts of beach obstacles [1-2].

2. System introduction

2.1. Introduction of multi-beam bathymetric system

SeaBat T50-P multi-beam bathymetric system consists of portable sonar processor, receiving/transmitting transducer, data acquisition computer, optical fiber compass motion sensor, acquisition and data processing software, etc. The working principle of multi-beam bathymetric system is to use the transmitting transducer array to transmit the sound wave with wide sector
coverage to the seabed, and use the receiving transducer array to receive the narrow beam, which can get the water depth values of hundreds of measured points, and quickly measure the size, shape and height changes of underwater targets in a certain range along the course direction, forming a three-dimensional point cloud image [3-4]. Relevant parameters of multi beam sounding system are shown in table 1.

Table 1. Main parameters of SeaBat T50-P multi-beam bathymetric

| Parameter name | VALUE |
|----------------|-------|
| Frequency      | 190 kHz ~ 420 kHz |
| Beam Angle     | 0.5° (Perpendicular to route) |
|                | 1.0° (Parallel to route) |
| Width          | 10° ~ 165° |
| Number of beam | 512    |
| Maximum range  | 500 m  |
| Emission rate  | 75 Hz  |
| Pulse length   | 30 µs ~ 10 ms |

2.2. Introduction of 3D sonar system

BV5000-1350 three-dimensional sonar system consists of scanning sonar head, PTZ, PTZ sonar junction box, cable, software control platform, power supply, etc. The working principle of three-dimensional sonar system is that firstly, the sonar emits a pulse signal with a frequency of 1.35MHz, and the transmitting interval is 25ms, forming a sector scan area of 45° x 1°. Each pulse contains 256 acoustic beams. After receiving the signal reflected by the target, the system converts it into an electrical signal, which is then transmitted to the sonar control unit. Combined with beam forming, beam pointing, amplitude and phase detection technology, the information scanned by the sonar head is generated into a 2D image, and then the computer controls the pan tilt to rotate in the horizontal direction by 360°[5]. Rotation is used to detect the position information of different parts of the object, and the final 3D structure image is generated. The main technical parameters of 3D sonar system are shown in table 2.

Table 2. Main parameters of BV5000-1350 3D sonar

| Parameter name         | VALUE               |
|------------------------|---------------------|
| Sonar perspective      | 1° x 45°            |
| Scan range             | 45° ~ 360°          |
| Tilt angle range       | -65° ~ 65°          |
| Update frequency       | 40 Hz               |
| Beam frequency         | 1.35MHz             |
| Maximum range          | 30 m                |
| Number of beam         | 256                 |
| Beam width             | 1° x 1°             |
| Beam spacing           | 0.178°              |
| Time resolution        | 0.031m              |

3. System installation

3.1. Installation of multi-beam bathymetric system

In order to minimize the comprehensive noise level and avoid installation near the stern, it is selected to be on the starboard side 1 / 2 of the hull length from the bow with a draft of 1.21m; The optical fiber compass sensor is installed at the lower position of the center of gravity in the middle of the ship, on
the fore and aft lines of the ship, and the compass points to the bow in the north direction, which can accurately reflect the position of the attitude of the ship or the multi beam transducer. After installation, the direction line is parallel to the fore and aft lines of the ship. Accurately measure the installation coordinates of each equipment, and set them in the navigation and acquisition software. The parameters of multi beam system need to be calibrated include roll, pitch and yaw. The specific measures are as follows.

Roll calibration: A survey line is set up in calm waters, and the survey ship sails back and forth on the survey line once at the same speed.

Pitch calibration: A survey line is set up directly above the target, and the survey ship sails back and forth on the survey line once at the same speed.

Yaw calibration: Select the characteristic landform of the seabed and set two lines parallel on both sides of the line. The line spacing shall cover the track of the other line with the edge beam of one line. The survey ship collects two sets of data along the two survey lines at the same speed in the opposite direction.

3.2. Installation of 3D sonar system
The working mode of BV5000-1350 sonar system is fixed station type. The sonar head and pan tilt are installed and fixed on the triangular support, and sink into the water at the specific station position. Since BV5000-1350 can effectively measure a distance of 30 meters, the instrument must be placed in a suitable position to get satisfactory data. It is difficult for a 3D sonar scanner to scan the whole target from one direction at a time. It usually needs to set up multiple scanning stations to obtain several scanning images. The position of the station and the target should be designed according to the position, shape and size of the underwater target in advance. The measurement results of the adjacent stations should include at least three non collinear targets with the same name. There should be scanning overlap between the two adjacent stations, and the overlap should not be less than 10% of the whole image.

4. Underwater part detection of beach obstacles
In this paper, the characteristics of the two systems are discussed and analyzed by taking the underwater part of square cement platform obstacle and cylindrical obstacle as examples.

4.1. Test results of multi-beam bathymetric system
The multi-beam bathymetric system detects the obstacles of the square cement platform, and the results are shown in figure 1 and figure 2. Due to the slow speed of the multi beam scanning and the best parameter adjustment, it can also distinguish the features about 10 cm, and the effect is ideal. The key point of detecting the obstacle part of square cement platform is to detect the distance and dislocation of deformation joints. According to the detection results of expansion joints, the multi-beam bathymetric system has a good detection effect on the underwater part of the vertical wall square cement platform obstacle, which can clearly distinguish the expansion joints with a spacing of 10 cm or more, and the dislocation detection effect on the square cement platform obstacle is also ideal. It can be seen that the square cement platform obstacles are placed in different positions, and there is dislocation.

Through the detection of the underwater part of the square cement platform by the multi-beam bathymetric system, it can be concluded that the multi beam sounding system adopts the walking working mode and has high detection efficiency, which is suitable for the detection of the underwater part of the obstacle of the square cement platform on the large vertical wall. The coverage angle of the beam should be adjusted to a large extent for the underwater part of the square cement platform obstacle. The resolution of the three-dimensional point cloud image will be relatively reduced, and the accuracy is moderate, so it is suitable for the general survey of a large range of underwater obstacles.
4.2. Test results of 3D sonar system

The three-dimensional sonar system detects the pile and connecting beam of cylindrical obstacle. The tripod is used as the fixed platform, and a measuring station is set on site. The single angle scanning mode is adopted. The horizontal rotation angle and speed of sonar are set to 360° and 0.5 °/ s, and the scan results are shown in figure 3.

According to the scanning results, the three-dimensional underwater structure of cylindrical obstacle can be seen intuitively and clearly: the underwater structure of the cylindrical obstacle is basically intact, without obvious deformation, but there are some defects, including the fracture defect of the connecting beam between the two piles on the right.

The working mode of BV5000-1350 sonar system is fixed station type, and several stations need to be set for large underwater structure, so the detection efficiency is relatively low. The sonar head of the system can rotate 360° horizontally, and the opening angle of the vertical plane can reach -65° ~ 65°. The angle of detection range is large, the limitation of underwater obstacle structure is low, and the application range is wide. The detection accuracy is high, and it is a reliable means of detail inspection.
5. Summary
BV5000-1350 sonar system has a wide range of application and high accuracy for underwater obstacle structure detection. The instrument is easy to install, without navigation, positioning and attitude sensors and other auxiliary equipment. SeaBat T50-P multi-beam bathymetric system has high requirements for the structure form of objects, moderate accuracy, and is more suitable for the underwater structure survey of large structures. With the help of three-dimensional display technology, the three-dimensional sonar system can provide more detailed information, which is a commonly used means of underwater detail structure detection. With the further development and improvement of technology, the system will be more widely used if it adopts the walking working mode.

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