SBL localization based on Extended Kalman Filter

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Abstract

According to the receiving array size, the underwater acoustic positioning system can be divided into three positioning systems: long baseline (LBL), short baseline (SBL) and ultra-short baseline (USBL). Acoustic detection and positioning technology based on ultra-short baseline is the most effective means to collect and transmit information, and is an effective way to solve the positioning accuracy of underwater vehicles. In this paper, the short baseline positioning and navigation system is studied deeply, and an underwater acoustic positioning algorithm based on extended Kalman filter is proposed. By fusing the information of pressure gauge, digital compass and accelerometer of the robot, the positioning accuracy is improved and the influence of underwater channel multipath effect on the system is reduced.

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Abstract:According to the receiving array size, the underwater acoustic positioning system can be divided into three positioning systems: long baseline (LBL), short baseline (SBL) and ultra-short baseline (USBL). Acoustic detection and positioning technology based on ultra-short baseline is the most effective means to collect and transmit information, and is an effective way to solve the positioning accuracy of underwater vehicles. In this paper, the short baseline positioning and navigation system is studied deeply, and an underwater acoustic positioning algorithm based on extended Kalman filter is proposed. By fusing the information of pressure gauge, digital compass and accelerometer of the robot, the positioning accuracy is improved and the influence of underwater channel multipath effect on the system is reduced.

Key words:Short baseline positioning system; Extended Kalman filter; Underwater vehicle; Underwater acoustic positioning technolog;Underwater robot.

1.INTRODUCTION

This section mainly introduces the positioning of underwater robots based on short baseline positioning. At this stage, underwater positioning is mostly used to locate underwater relatively stationary or stationary targets, and the positioning method is single. It can not achieve the expected positioning accuracy and positioning solution effect, so the positioning system is more rapid, simple and high-precision.

This paper mainly studies the marine enviroment analysis of underwater acoustic positioning.Use MTALAB analysis Extended Kalman filter of underwater vehicle based on short baseline positioning.The main methods are comparison, induction, analysis of data, combination of numbers and shapes,and induction and comparison in statistics.After fusing the information of the robot's own pressure gauge, digital compass and accelerometer, the positioning result is obtained. These measurement results have better positioning results than using SBL solution alone. The utilization and exploration of marine internal resources often need to explore underwater targets such as underwater robots and underwater detectors with new technologies. Compared with the traditional single positioning system, the accuracy of the new measurement is improved, and the requirements and ability of underwater target positioning settlement are also improved. At present, the research is only aimed at the variable-speed circular motion of underwater targets, and other underwater related fields are still under discussion.Underwater not only contains a large number of natural resources, the utilization and development of underwater resources is the guarantee for the sustainable development of national economy, and the sea and other waters also play an important role in military affairs[1].The 18th CPC National Congress clearly proposed to "improve the ability to develop marine resources, develop the marine economy, protect the ecological environment, resolutely safeguard China's marine rights and interests and build a marine power.[3]" The research of underwater positioning technology is of great significance to improve the utilization of marine resources[5]. In the early 20th century, the United States invented the first echo sounder based on underwater acoustic technology equipment[6-7]. However, in the 1950s, more countries used underwater acoustics to locate and navigate underwater vehicles[8]. In 2000, the pilot short baseline positioning system of American desert star series was widely used in civil product level, mainly in shore terminals and ships[9].

This paper mainly studies the MATLAB simulation analysis of Extended Kalman filter of underwater vehicle based on short baseline positioning. The positioning results are obtained by fusing the information of the robot's own pressure gauge, digital compass and accelerometer. These measurement results have better positioning results than using SBL solution alone. SBL is widely used because of its small array size. It is composed of more than three elements[24]. The length of SBL baseline is usually several meters to tens of meters, which is arranged on the bottom or side of the ship. It is calculated by calculating the propagation time of acoustic signal between the element and the target, and the azimuth and distance information of underwater target are calculated and displayed in the form of coordinates. Compared with the long baseline, the system is simpler and easy to move and operate[25].Compared with ultra short baseline, it has higher positioning accuracy and does not need installation error calibration. The disadvantage of SBL is that the tracking range is small, and the tracking range needs to be expanded by increasing the number of arrays[26].

II. System experimental results

In order to compare the effect of single SBL and LBL test with the positioning results of the test data in this paper, the test is specially selected under the same test conditions. Finally, make a comparison.In this chapter, we continuously test 800-1000 times at a certain point through simulation, count three groups of data from the statistical analysis theory, and evaluate the performance of the positioning system. First, the short baseline positioning test is carried out, and then the circular motion simulation of the robot is carried out.

A.Short baseline positioning accuracy test

In this experiment, the accuracy of the underwater acoustic positioning system of the detection robot is tested to simulate the near water area. The position array enters the water vertically to ensure that the array plane is facing the robot and perpendicular to the water surface.

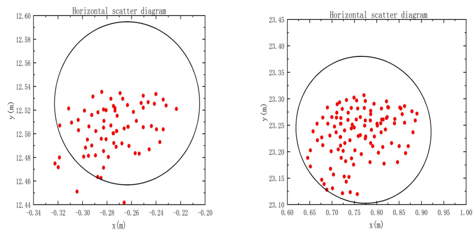

Fig.6. Horizontal scatter diagram

It can be seen from the Figure 6 that LBL is on the left and SBL is on the right. Obviously, SBL positioning accuracy is more accurate.Horizon scatter diagram that the probability of scatter distribution of positioning measurement value within the error range of 0.5% is 99%, 98% and 80% respectively. The concentrated area where the measuring points fall is between 0.78m and 0.84M in the X direction and between 6.72m and 6.78m in the Y direction.The concentration area where the measuring points fall is between 3.8m and 3.95MAll or most of the three measurement results are better than the preset value (positioning error 0.5%).

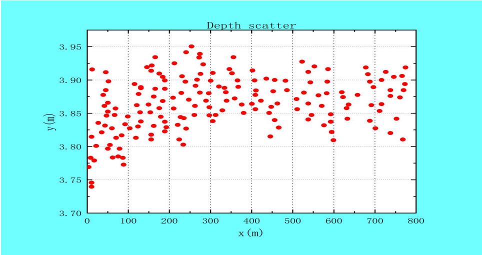

Fig.7. Depth scatter of single system

As can be seen from the Figure7 that in the depth direction, the concentration area of the measuring point is between 3.7 and 3.75m. It can be seen from the chart that the probability of scattered point distribution of positioning measurement value within the error range of 0.5% is 80% respectively.It can be seen from the table that the error of the test results increases with the increase of distance.

As can be seen from the Figure8 that SBL is more accuraty.The reason for the difference between the third test results and the first two is that the channel environment is different due to the change of position, but the three results basically meet the system requirements, the accuracy is within 0.5%, and the test results are stable and reliable.It can be seen from the chart that the probability of scattered point distribution of positioning measurement value within the error range of 0.5% is 98% respectively.

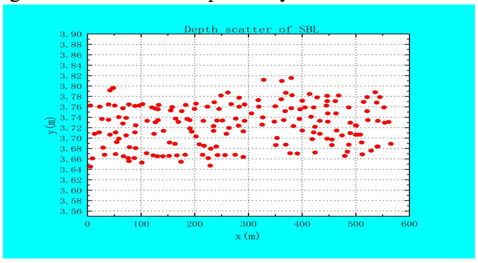

Fig.8. Depth scatter of single system of SBL

B.EKF filter test

In this experiment, the test and Simulation of two position variable speed circular motion of underwater acoustic positioning system of exploration robot are carried out to simulate the far sea area. The fusion simulation of positioning data and efk positioning data is carried out. It is assumed that the robot runs in a two-dimensional plane within the specified depth.It is evaluated from the aspects of robot trajectory, short baseline positioning solution, different acoustic array trajectory and EKF estimated position. The heading angle direction, heading angular velocity and heading angular acceleration of the underwater vehicle are measured respectively. The multi-path effect caused by underwater target movement on the system, the distance ambiguity caused by high data refresh rate, and the distance effect caused by different distances between different targets and the receiving array in multi-target positioning are tested.

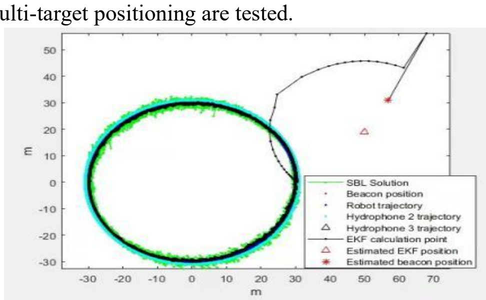

Fig.9. Two position trajectory diagram of underwater vehicle

As shown in the Figure9, it can be seen that the position of SBL solution in the green part coincides with the position estimated by efk by 90%. The angle represents the beacon position, and the asterisk represents the starting point of calculation. It can be seen that the position information calculated by SBL is more inclined to the uncertain divergence mode, and the position information calculated by efk is more inclined to the determined trajectory. The fusion of the two verifies the improvement of the accuracy and optimization effect of the algorithm.

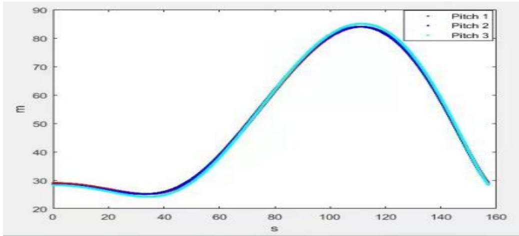

Fig.10. Under different measurement accuracy conditions

The Figure10 shows that the slope data is sampled into the data of the specified rate, the sampling interval of the measured value of the inclined distance is calculated, which is directly solved by SBL, and the efk is used for filtering estimation. It can be seen that under the conditions of three different measured values of the press, the addition of Gaussian white noise under three actual conditions, and the accuracy of three digital compasses. The trend of oblique distance of the three is basically the same.

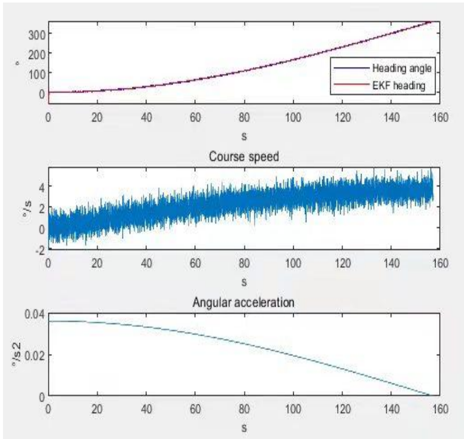

Fig.11. Robot heading parameters of Kalman

As shown in the Figure11, it shows the curve of heading, heading angular velocity and heading angular acceleration of underwater vehicle. It can be seen from the figure that efk is more accurate and detailed than the original heading angle and efk heading angle, and the two curves are just fused, which further verifies the accuracy of efk. The heading angular velocity presents a regular wavy chart and presents a gradual increasing mode. It shows that the robot adopts variable speed acceleration. The heading angular acceleration shows a decreasing mode.

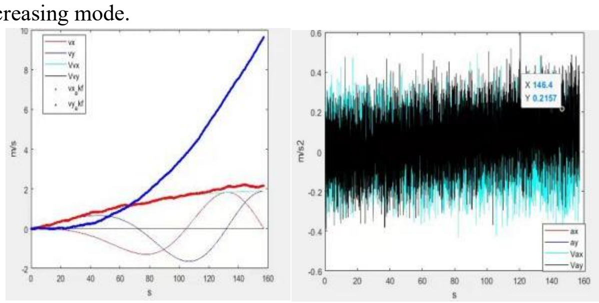

Fig.12. Velocity of robot in global coordinate system of Kalman

The Figure12 shows us the speed and acceleration of the robot in different coordinate systems. As you can see,The figure shows us the speed and acceleration of the robot in different coordinate systems. It shows that the robot does the corresponding motion in the two-dimensional plane. The other two curves show that the robot does two-dimensional variable speed circular motion. The acceleration of the robot in different coordinate systems presents regular waves At the same time, it also verifies the authenticity of its horizontal operation. The acceleration in other directions is also within the sampling interval, which shows that the simulated motion effect of the underwater vehicle reaches the expectation

III. Conclusion

The above experimental results and data show that the improved method can effectively deal with the state of underwater target movement. And the positioning accuracy is improved, so compared with other single systems, this method is more practical. This paper mainly uses the marine environment for testing and data recording.Through the MATLAB analysis of Extended Kalman filter of underwater vehicle based on short baseline positioning. The positioning results are obtained by fusing the information of the robot's own pressure gauge, digital compass and accelerometer. It is proved that the positioning accuracy of underwater target is improved under the optimization of EKF fusion SBL algorithm.Compared with the original SBL solution,the EKF fusion SBL algorithm is more practical and accurate. At the same time, it explains that the SBL algorithm based on EKF algorithm has greatly improved in terms of the impact of multi-path effect on the system caused by underwater target movement, the distance ambiguity caused by high data refresh rate, and the distance effect caused by different distances between different targets and the receiving array. Based on the review of the development history, current situation and application of underwater positioning and tracking system,a high-speed target trajectory measurement system based on short baseline is designed. However, it is still necessary to continue to improve the hardware processing level of the system and the optimization of the algorithm in the future work, so that the target trajectory can be given in real time with a higher refresh rate.

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